A broad typology of dry rainforests on the western slopes of New South Wales

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Abstract: Dry rainforests are those communities that have floristic and structural affinities to mesic rainforests and occur in parts of eastern and northern Australia where rainfall is comparatively low and often highly seasonal. The dry rainforests of the western slopes of New South Wales are poorly-understood compared to other dry rainforests in Australia, due to a lack of regional scale studies. This paper attempts to redress this by deriving a broad floristic and structural typology for this vegetation type. Phytogeographical analysis followed full floristic surveys conducted on 400 m^2 plots located within dry rainforest across the western slopes of NSW. Cluster analysis and ordination of 208 plots identified six floristic groups. Unlike in some other regional studies of dry rainforest these groups were readily assigned to Webb structural types, based on leaf size classes, leaf retention classes and canopy height. Five community types were described using both floristic and structural data: 1) *Ficus rubiginosa–Notelaea microcarpa* notophyll vine thicket, 2) *Ficus rubiginosa–Alectryon subcinereus–Notelaea microcarpa* notophyll vine forest, 3) *Elaeodendron australe–Notelaea microcarpa–Geijera parviflora* notophyll vine thicket, 4) *Notelaea microcarpa–Geijera parviflora–Ehretia membranifolia* semi-evergreen vine thicket, and 5) *Cadellia pentastylis* low microphyll vine forest. Floristic groupings were consistent with those described by previous quantitative studies which examined smaller portions of this study area. There was also general agreement between the present analytical study and a previous intuitive classification of dry rainforest vegetation throughout the study area, but little concurrence with a continental scale floristic classification of rainforest.

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Introduction

Dry rainforest refers to those communities that have floristic and structural affinities to mesic rainforests (Floyd 1990), and occur in parts of eastern and northern Australia where rainfall is comparatively low and highly seasonal (Gillison 1987; McDonald 1996). Dry rainforest communities in inland Queensland were recorded in the 19th century when the explorer Thomas Mitchell observed bottle tree (*Brachychiton* spp.) scrubs (Mitchell 1848). Dry rainforest was well known to the Gamilaraay people of northern NSW; evident from numerous references, in Aboriginal oral history of the Gunnedah area, to the occurrence of 'hop-vine scrub' in locations which currently support dry rainforest (O'Rourke 2005; Curran 2006). However, it was not until the 1960s, during a CSIRO investigation of the land systems of the Hunter Valley (Story 1963a; 1963b), that dry rainforests were formally documented on the western slopes of NSW 'non-eucalyptus [sic] trees and shrubs in closed communities are common on rocky hilltops and in ravines' (Story 1963b; p. 27). A later study focused on the vine thicket vegetation at Brushy Hill Range, near Scone (Turner 1976), which was considered to support the largest stands of such vegetation in the upper Hunter Valley. From 1967 onwards, John B. Williams of the Department of Botany, University of New England, Armidale, undertook many inspections of patches of dry rainforest (mainly semi-evergreen vine thicket – SEVT) on the North Western Slopes of NSW (J.B. Williams, unpub. data; Williams & Guymer 1977; Williams 1983). His work, following on from Baur (1957; 1965) and Webb's (1959; 1968) work at state and continental scales, culminated in an increased awareness of dry rainforest on the North Western Slopes (Holmes 1979; Beadle 1981; Benson 1983; Pulsford 1983; 1984). Hereafter reference to dry rainforest on the North Western Slopes is used in a general sense: it also refers to stands in adjacent botanical subdivisions such as the eastern parts of the North Western Plains and the spur of Northern Tablelands that comprises the Nandewar Range.

Beadle (1981, p. 181) recognised two types of dry rainforest on the North Western Slopes of NSW: *Cadellia pentastylis* Alliance and Mixed Stands. These two types broadly equated to the low microphyll vine forest (LMVF) and SEVT structural types of Webb (1968; 1978), respectively. Data from some stands of dry rainforest of the western slopes of

NSW (J.B. Williams unpub. data) were included in a floristic classification of Australian rainforests based on numerical analysis of species distributions (Webb & Tracey 1981; Webb et al. 1984). These stands were grouped into the C_2 ecofloristic province, which represented patches of rainforest that occur in a sub–humid warm subtropical climate (Webb et al. 1984). Most stands in this group occur in southern and central Queensland, but it includes stands from northern NSW (Webb et al. 1984).

In the 1980s, Australian governments initiated the National Rainforests Conservation Program, which fostered renewed interest in rainforests throughout Australia. During the 1980s and 1990s there were several important studies of the dry rainforests of western NSW. Floyd (1987) examined the conservation status of rainforest in northern NSW, and subsequently broadened this work to classify rainforests throughout NSW, including the western slopes (Floyd 1990). The rainforests of NSW were delineated into four structural subformations (subtropical, dry, warm temperate, and cool temperate; *sensu* Baur 1957) and then intuitively classified into 13 alliances and 57 suballiances on the basis of floristics (Floyd 1990). Additionally, two groups of suballiances were described based on structure rather than assigned to a floristic alliance. One of these, the microphyll vine thicket group, which was placed in the dry rainforest subformation, included suballiances No. 31 *Alectryon forsythii–Alectryon subdentatus–Notelaea microcarpa* and No. 32 *Notelaea microcarpa–Ehretia membranifolia–Geijera parviflora*. Suballiance No. 31 is found in the deeply dissected Guy Fawkes–Macleay Gorges on the eastern edge of the Great Dividing Range in northern NSW (Floyd 1990), although communities similar to this suballiance, dominated by *Ficus rubiginosa–Alectryon forsythii–Notelaea microcarpa*, are found in the Melville Ranges south-west of Tamworth (Banks 2001) and hills near Tamworth (Hosking 1990). Suballiance No. 32 is found on the western slopes of NSW and was equated to SEVT (Floyd 1990). This suballiance includes: (1) SEVT communities (*sensu* Webb et al. 1984) that occur on basalt-derived soils and which are dominated (in addition to those species that describe the suballiance) by *Pouteria cotinifolia* var. *pubescens* and *Elaeodendron australe* var. *integrifolia*; (2) communities which occur on sandstone and which are dominated by *Cadellia pentastylis*; and (3) communities from the upper Hunter Valley which occur on several substrates and which are co-dominated by species such as *Ficus rubiginosa* and *Melia azedarach*.

Subsequent floristic surveys have examined these community types of Floyd's (1990) suballiance No. 32. *Cadellia pentastylis* stands throughout NSW were surveyed by Benson (1993) and found to be variable in their floristic composition, but generally restricted to lithic sandstone or conglomerate substrates. Curran and Curran (2005),

Table 1. Summary of results of studies which described dry rainforest communities on the western slopes on NSW based on numerical analysis of floristic data.
Results presented are those undertaken using an unweighted pair-group arithmetic averaging (UPGMA) clustering strategy. Cluster analysis using TWINSPAN (two-way indicator species analysis) produced slightly different results.

Study	Dry rainforest communities described
McDonald 1996#	*Cadellia pentastylis* community
	SEVT, stands from northern NSW and the upper Hunter Valley
DLWC 2002	Dry Rainforest of gorges and gullies of the Nandewar Ranges
	Communities dominated by *Cadellia pentastylis* on sandstone
	SEVT on basalt hills
	'Dry Scrubs' on volcanic substrates. This community is a shrubby eucalypt woodland, with scattered dry rainforest species throughout, which in some places coalesce to form small stands of vine thicket
DEC 2004a	SEVT on a variety of substrates
	Cadellia pentastylis forest on sediments
	Rusty Fig Dry Rainforest, which occurs on steep rocky sites predominantly in the southern part of the Bioregion, such as the Melville Range
	Alectryon/Rusty Fig/Mock Olive Dry Rainforest, which occurs on steep slopes, such as the gorges of the Nandewar Ranges
Peake 2006	Hunter Valley Vine Thicket
	Upper Hunter Depauperate Dry Rainforest
	Lower Hunter Dry Rainforest
	Upper Hunter Narrabeen Gully Ironwood Dry Rainforest

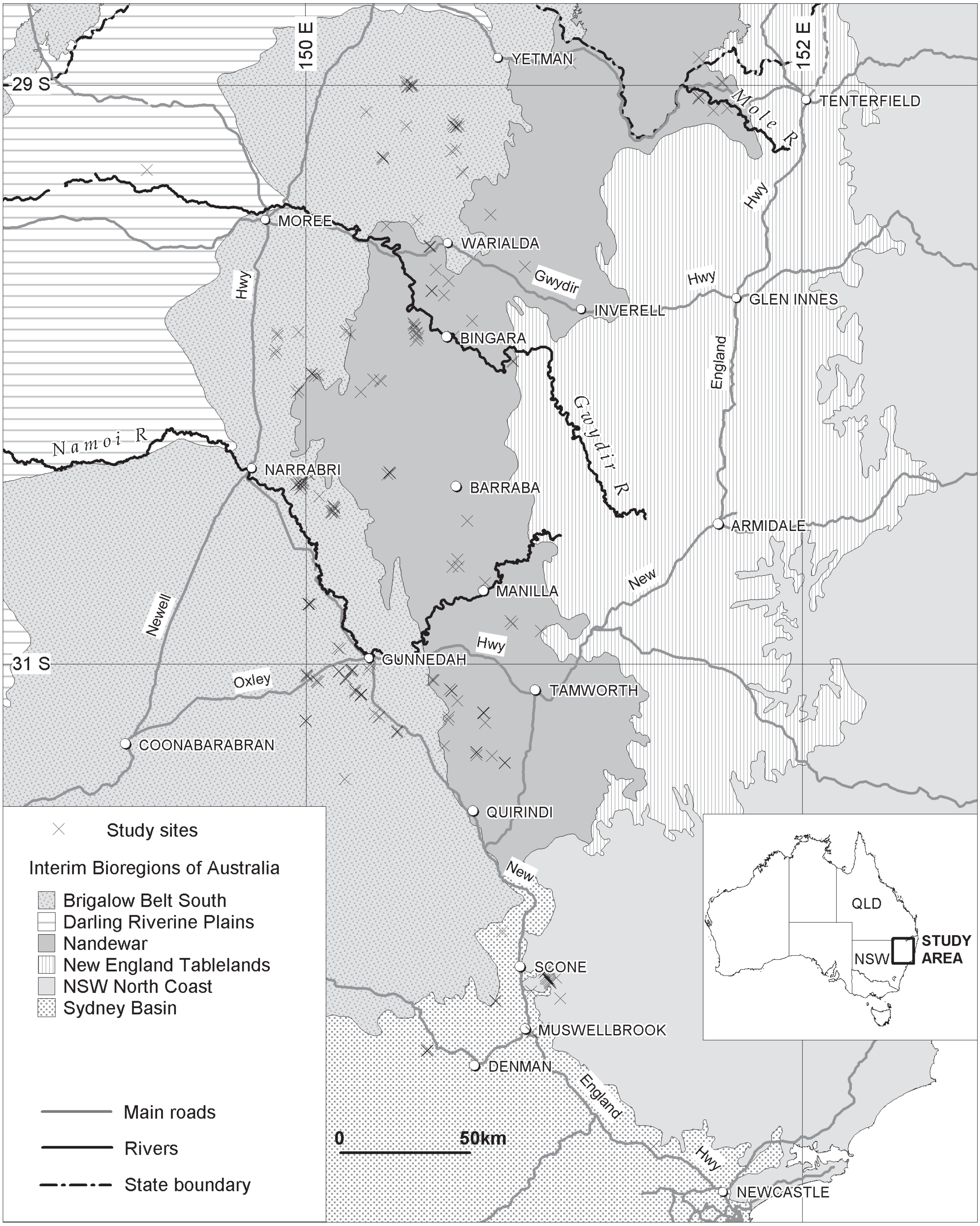

Fig. 1. Location of survey sites and Interim Bioregions of Australia (Version 6.1 © 2004 Department of Environment and Heritage). Base Map data © 2004 Geosciences Australia.

who reported on several stands of *Cadellia pentastylis* not surveyed by Benson (1993), further demonstrated the high fidelity of this community for sandstone or conglomerate lithology, although one stand does occur on acid volcanics. The floristic composition of SEVT at Derra Derra Ridge, a large stand near Bingara, in northern NSW, was shown to be analogous to stands further north in NSW and has similar preferences for basalt-derived loam soils (Benson et al. 1996). A community on granite at Kwiambal National Park near Ashford in northern NSW was equated by Hunter et al. (1999) with the Mixed Stands of the Beadle (1981) typology. However, it would more correctly be described as a dry sclerophyll woodland with some dry rainforest species, as it lacks the richness of dry rainforest species and occasional closed canopy structure needed to class it as either Mixed Stand or SEVT.

Four studies have used numerical classification methods to delineate different types of dry rainforest on the western slopes of NSW (Table 1). The first of these (McDonald 1996) used species lists (J.B. Williams unpub. data; Floyd 1990; Benson 1993) from eight dry rainforest stands in NSW to analyse the floristic composition of vine thicket of the entire Brigalow Belt Bioregion (*sensu* Thackway and Cresswell 1995), including floristic sites from Queensland. The second study (DLWC 2002) mapped vegetation on four 1:100 000 scale map sheets in northern NSW, based on aerial photograph interpretation and analysis of quantitative floristic data from 20 x 20 m quadrats. The third study (DEC 2004a) modelled vegetation across the Nandewar Bioregion of NSW based on quantitative plot data, including some collected for this paper. There was considerable concurrence in the dry rainforest communities identified by these three studies (Table 1). Each of these three studies identified separate SEVT and *Cadellia pentastylis* communities, and a dry rainforest community which occurs in gorges and gullies of the Nandewar Ranges was reported for the two studies that sampled plots from that area (DLWC 2002; DEC 2004a). A fourth study, which focused on the central Hunter Valley (Peake 2006), identified four types of dry rainforest in that study area (Table 1). One of these, Hunter Valley Vine Thicket, included stands at Brushy Hill, near Scone, which were described in Suballiance No. 32 by Floyd (1990).

A recent statewide synthesis of quantitative floristic data (Keith 2004) described 99 vegetation classes, groups of vegetation defined mainly by floristic similarities, throughout NSW. Nine classes of rainforest were identified. Two of these classes occur on the western slopes of NSW: Dry Rainforest, which was described from data from DLWC (2002) and Western Vine Thickets as described by Benson et al. (1996) and DLWC (2002). The Western Vine Thickets class included both SEVT and *Cadellia pentastylis* communities (Keith 2004).

The aim of this paper is to identify the main floristic and structural groups of dry rainforests on the western slopes of NSW and to relate these groups and dry rainforest vegetation of the western slopes as a whole to existing NSW and Australian rainforest typologies.

Firstly, this will entail classifying floristic data using numerical methods. Based on previous numerical studies of dry rainforest on the western slopes, it is expected that four types of dry rainforest would be identified: SEVT (including vine thickets from the upper Hunter Valley); a *Cadellia pentastylis*–dominated community; a dry rainforest community that occurs in gorges and gullies of the Nandewar Ranges; and a dry rainforest community that occurs on steep rocky slopes, predominantly in the southern part of the Nandewar Bioregion. Secondly, the diagnostic species of the floristic groups and dry rainforest vegetation as a whole will be compared with those of continental (Webb et al. 1984) and state-wide (Floyd 1990) floristic typologies, and leaf size classes and canopy heights of floristic groups will be used to assign these groups to structural types (*sensu* Webb 1959; 1978).

Methods

Study area

The study area for this paper primarily comprises the western slopes and plains of New South Wales, north from the Liverpool Range to the Queensland border. This includes major towns such as Quirindi, Gunnedah, Tamworth, Manilla, Narrabri, Moree, Bingara and Warialda. There is also a disjunct part of the study area located in the upper Hunter Valley near the towns of Denman, Muswellbrook and Scone. The study area represents the region identified by Floyd (1990) as encompassing the distribution of dry rainforest on the western slopes of NSW.

Table 2. Summary of climatic data for weather stations in the study area. GUN = Gunnedah Soil Conservation Service, NAR = Narrabri Bowling Club, MOR = Moree Post Office, BIN = Bingara Post Office, BAR = Barraba Post Office, TAM = Tamworth Airport, SCO = Scone Soil Conservation Service. Source: Bureau of Meteorology (2004).

Variable	**Weather station**						
	GUN	**NAR**	**MOR**	**BIN**	**BAR**	**TAM**	**SCO**
Mean annual precipitation (mm)	636	643	579	744	689	673	650
Mean max. monthly temp. hottest month (Jan) °C	31.8	35.3	34.8	33.6	31.5	31.9	30.8
Mean min. monthly temp. coldest month (July) °C	4.6	3.4	3.4	2.2	0.2	2.9	4.6

The study area comprises parts of several NSW Botanical Subdivisions (Harden 1990) and Australian Bioregions (Thackway and Cresswell 1995; Figure 1). The majority of the study area is considered part of the North Western Slopes botanical subdivision, although the areas around Narrabri and Moree are in the North Western Plains subdivision and the Nandewar Range is in the Northern Tablelands subdivision (Harden 1990). The upper Hunter Valley is in the Central Western Slopes subdivision (Harden 1990), although some stands that were sampled were in the North Coast subdivision. The eastern part of the Brigalow Belt South (BBS) Bioregion (encompassing towns such as Gunnedah, Narrabri and Moree) forms the western part of the study area and the western part of the Nandewar (NAN) Bioregion (Tamworth, Manilla, Bingara) forms the eastern part of the study area (Figure 1). The upper Hunter Valley is located in the NSW North Coast (NNC) and Sydney Basin (SB) Bioregions (Thackway and Cresswell 1995).

The principle land uses in the study area are cropping (particularly in flatter areas of the BBS) and livestock grazing. Only a small proportion of the study area is located in conservation reserves (Benson 1999). The largest reserve in the northern part of the study area is Mt Kaputar National Park (36 800 ha; DEC 2004b), although there are several smaller reserves. In the upper Hunter Valley there are large reserves (Goulburn River National Park and Wollemi National Park) on the edge or just beyond the boundary of the study area, and only a few small reserves in the study area. The study area has been heavily modified since European settlement: 60% of the BBS and 66% of the NAN Bioregions (Benson 1999) and approximately 70% of the upper Hunter Valley (HCMT 2003) have been cleared.

Those parts of the study area that occur within the BBS Bioregion have a subtropical climate, according to the modified Köppen classification system used by the Bureau of Meteorology (2005), while the Nandewar Bioregion and the upper Hunter Valley have either subtropical or temperate climates, depending on elevation (Bureau of Meteorology 2005). Mean monthly rainfall follows the same broad pattern at each of the climate stations throughout the study area: that of summer and late spring predominance (Figure 2). Mean annual precipitation ranges from 744 mm at Bingara to 579 mm at Moree (Table 2).

Temperatures are hot during summer and cold during winter (Table 2). Moree and Narrabri have the highest mean monthly temperatures of the hottest month (34.8°C and 35.3°C respectively), while those stations in the Nandewar Bioregion (Tamworth, Bingara and Barraba) have the lowest mean minimum temperatures of the coldest month (2.9°C, 2.2°C, 0.2°C respectively) (Table 2).

The geology of the study area is a complex mixture of volcanic, sedimentary and metamorphic rocks. In the northern parts of the study area the geology is dominated by volcanic features, such as the Kaputar volcano (near Narrabri), the Inverell basalt flows east of Warialda, and the Quaternary alluvium derived from Tertiary basalts on the Liverpool Plains (between Quirindi and Narrabri) and the plains to the north and west of Warialda and north and north-east of Narrabri, and the sediments, shales and volcanics of the New England Fold Belt, which runs from

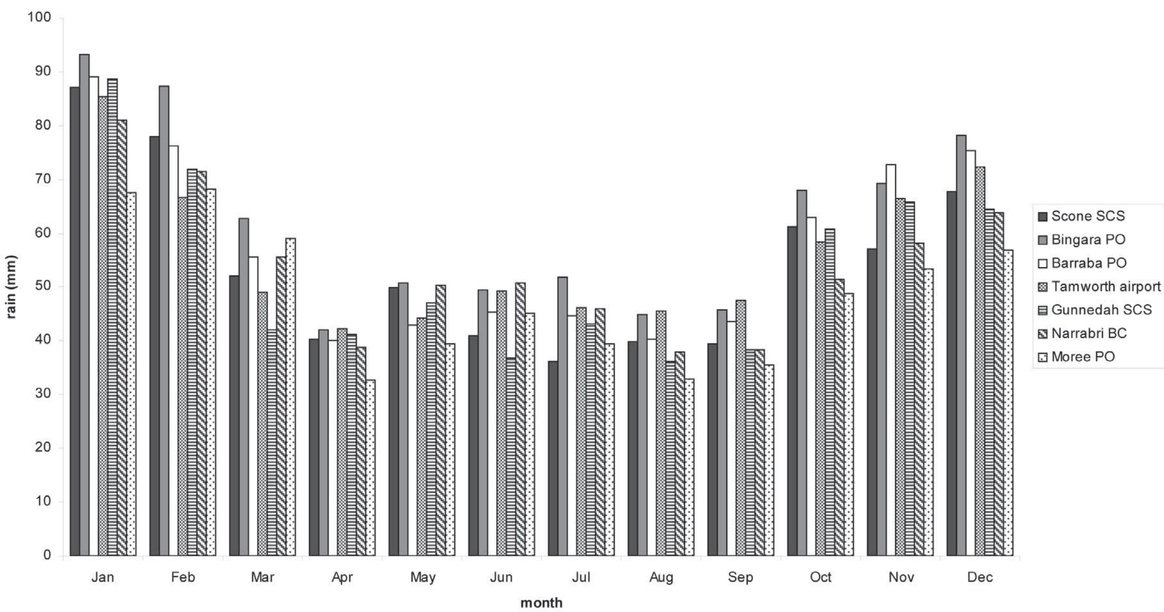

Fig. 2. Mean monthly rainfall at each of seven climate stations throughout the study area. SCS=Soil Conservation Station, PO=Post Office, BC=Bowling Club. Source: Bureau of Meteorology (2004).

the Hunter Valley to Warialda (NSW NPWS 2003). There is localised outcropping of Permian, Triassic and Jurassic sandstones among the basalts and Quaternary alluvium as well as scattered outcropping of serpentinite and limestone along the New England Fold Belt (NSW NPWS 2003). The upper Hunter Valley part of the study area largely comprises sedimentary rocks of Carboniferous or Permian age, with some volcanic intrusions (HCMT 2003).

The geomorphology of the study area includes alluvial plains (altitudes 200–300 m) along major river systems. These plains are often interspersed with low hills, while there are steep hills along the New England Fold Belt (some areas over 1000 m asl) and on the Kaputar volcano (areas over 1500 m asl).

Due to this diversity of geology and geomorphology, there is a wide range of soils in the study area (NSW NPWS 2003). Alluvial soils derived from basalt are usually deep, often heavy, black loams and clays of high fertility. The soils on basalt hills also are high nutrient clays and loams, usually red or brown in colour and stony or skeletal on the hill tops, increasing in depth further down slope. Sedimentary hills often have low nutrient, shallow soils on hill tops, grading to texture contrast soils further down slope. Dark, alkaline clays are usually formed from limestone.

The predominant vegetation of the study area is eucalypt woodland. In the BBS Bioregion, this mainly comprises grassy box woodland, dominated by *Eucalyptus albens*, *Eucalyptus populnea* or *Eucalyptus pilligaensis*, often with several species of ironbark eucalypts (Benson 1999). These equate to the Western Slopes Grassy Woodlands class of Keith (2004). Benson (1999) notes that there are also extensive stands of *Callitris glaucophylla* dominated woodland (Western Slopes Dry Sclerophyll Forests and Yetman Dry Sclerophyll Forests *sensu* Keith 2004), and more restricted patches of *Casuarina cristata* and *Acacia harpophylla* (Brigalow Clay Plain Woodlands *sensu* Keith 2004). The NAN Bioregion and hilly terrain of the BBS Bioregion are dominated by North-West Slopes Dry Sclerophyll Woodlands (Keith 2004). The woodlands of the upper Hunter are often dominated by *Eucalyptus moluccana*, *Eucalyptus albens* or *Eucalyptus crebra* (HCMT 2003) and comprise the Coastal Valley Grassy Woodlands, Hunter Macleay Dry Sclerophyll Forests and North-west Slopes Dry Sclerophyll Woodlands classes of Keith (2004).

Dry rainforest (in this sense encompassing both the Dry Rainforest and Western Vine Thickets classes of Keith 2004) occurs only patchily throughout the study area, and rarely occurs in large contiguous stands. However, in many situations dry rainforest (particularly SEVT) forms a transition with adjacent vegetation, particularly North-west Slopes Dry Sclerophyll Woodlands, and to a much lesser extent Brigalow Clay Plain Woodlands (Keith 2004). At a regional scale, it is not feasible to map the very small patches of dry rainforest within this larger transitional vegetation type. DLWC (2002) provided a suitable means of dealing with this circumstance by describing the vegetation community Dry Scrubs (Table 1).

Sampling design

The usual method of identifying sites for sampling for regional floristic surveys is via a stratification process which incorporates a range of environmental variables, such as parent material (geology), elevation (surrogate for climate and rainfall) and terrain (Keith and Bedward 1999; Benson and Ashby 2000). However, it is difficult to use such methods when undertaking targeted surveys of a particular vegetation community, especially when the distribution of that community is not completely known and it can be difficult to detect via aerial photography. Prober and Thiele (2004) encountered a similar problem when conducting their survey of grassy box woodlands. They sought sites with a predominately intact native understorey, which were very rare in their study area. Consequently, they conducted little *a priori* stratification (land use and overstorey composition only) and subjectively chose sites within land use classes as random sampling would have resulted in the survey of weedy, highly disturbed sites.

A similar approach was adopted for this survey of the dry rainforests of the western slopes of NSW, albeit without the additional caveat of not sampling highly weedy sites. Early trials at identifying dry rainforest from aerial photography showed that while this method was of considerable utility in reliably detecting certain types of dry rainforest (e.g. dry rainforest of gullies, gorges and scree slopes), it produced variable results for other types, particularly SEVT. In some instances known patches of SEVT were not discernible on aerial photographs, and sometimes patches of vegetation that showed promising structure, colour and texture on aerial photographs proved, upon field inspection, to be other types of vegetation (dense *Acacia* spp. thickets or dense shrub layers). Several government vegetation mapping programs were being undertaken during the course of this study, and it was not possible to borrow or view complete aerial photograph coverage for the study area. Hence, it was not possible to undertake *a priori* stratification of dry rainforest sites. Instead, dry rainforest sites were identified using the various means outlined below and subsequently sampled. Every effort was made to establish good coverage of the study area, similar to the aim of Prober and Thiele (2004), and to sample all of the geological and landscape systems that support dry rainforest. This concords with the goal of Russell-Smith (1991) who aimed to sample as many rainforest patches as possible in the Northern Territory over the full geographical and ecological extent of the vegetation type.

Potential dry rainforest survey sites were identified in a number of different ways. The primary means of site selection was interpretation of aerial photographs. This entailed viewing stereo pairs of the latest 1:25 000 scale colour photographs for parts of the study area where coverage was available. Potential sites were assigned a priority code on a three-point scale, based on the likelihood of the sites being dry rainforest. Due to incomplete coverage of the study area—many aerial photographs were not available because of other mapping programs—aerial photograph interpretation was undertaken only for the following 1:100 000 scale map sheets: Curlewis, Boggabri, Tamworth, Manilla, Horton, and Bingara.

Aerial photograph interpretation was then complemented via the means listed below. Firstly, a literature search (both published literature and unpublished species lists) was undertaken to identify potential sites. This included reports by Story (1963a), Turner (1976), Holmes (1979), Beadle (1981); Pulsford (1983), Williams (1983), Floyd (1990), Benson (1993), Benson et al. (1996), McDonald (1996) and Cooper & McAllen (1999). All documented occurrences of dry rainforest were identified as potential study sites. These were usually visited prior to survey to confirm the existence of dry rainforest. Secondly, advantage was taken of any opportunistic encounters with dry rainforest patches identified during vehicle and foot traverses across the study area. In some instances, potential sites identified by other means (e.g. aerial photograph interpretation) were cross-referenced with observations from these traverses to confirm their designation as potential study sites. Finally, where fine-scale vegetation mapping had been undertaken across the study area, this was used to further identify potential study sites. Two approaches were used: 1) in instances where large stands of dry rainforest were identified and mapped (e.g. Peasley and Walsh 2001; DLWC 2002), these were logged as survey sites and subsequently sampled; and 2) following liaison with botanists and cartographers involved with the production of these maps, other areas of potential dry rainforest (usually too small to be shown as polygons on the mapping) were identified for future survey.

Sampling methods

Vegetation was sampled in 0.04 ha quadrats, which is a standard size used by the National Herbarium of NSW, the NSW National Parks and Wildlife Service (now Department of Environment and Climate Change), State Forests of NSW and the Department of Infrastructure and Planning and Natural Resources (now Department of Natural Resources) for full floristic surveys in NSW (Keith and Bedward 1999; Benson and Ashby 2000; DLWC 2002). Quadrats were mostly square in alignment (20 x 20 m), except where the configuration of dry rainforest patches precluded this. In such instances the dimensions and alignment of the plot were adjusted to ensure that the area of the quadrat was located within dry rainforest vegetation and totalled 0.04 ha.

All vascular plant taxa evident in each quadrat at the time of sampling were recorded. During some survey periods, e.g. the drought of 2002, certain plant life forms (e.g. forbs and grasses) either lacked aboveground parts or could not be identified due to lack of reproductive organs. Voucher specimens were collected, generally at least one from each taxon, for deposition in the N.C.W. Beadle Herbarium (NE) and/or to confirm identity. The identity of specimens was checked against material contained in NE, usually in collaboration with relevant specialists from NE. Nomenclature in this study follows the Flora of NSW (Harden 1990–1993; 2002; Harden and Murray 2000) or more recent treatments of rainforest flora (Harden et al. 2006) or grasses (Wheeler et al. 2002) with some exceptions following recent literature in line with the curation of NE; families generally follow Stevens (2001 onwards).

Each taxon present was allocated a cover-abundance score based on a modified six-point Braun-Blanquet scale (Poore 1955). The categories used for this scale were slightly different to those used by Keith and Bedward (1999) and Benson and Ashby (2000), but were the same as those of Austin et al. (2000) and DEC (2004a); viz: 1=cover <5% site and uncommon; 2=cover <5% and common; 3=6–20%; 4=21–50%; 5=51–75%; 6=76–100%.

The structure of the vegetation at each site was described by estimating the height and percentage crown cover (Walker and Hopkins 1990) of each of up to four vegetation strata: emergent, tallest canopy stratum, mid-stratum, ground cover up to 1m height.

Table 3. Sources of floristic data used in analyses for this paper

Source	Description	Site labels
This paper	Dry rainforest of the North Western Slopes of NSW	TC003–134
Peake (2006) and Peake and Curran (unpub.)	Vegetation of the Central Hunter Valley: sites from dry rainforest	GNG56–58; RBR01; GRETA2; Q002, 012, 037–038, 037–038, 045, 053–54; WLA04–05; SCN19–24, 26–28, 31–35
DEC (2004a)	Vegetation of the Nandewar Bioregion: sites from dry rainforest	NBAFF0184, 0256, 0329, 0388–0389, 0402, 0436, 0444, 1336, 1346
Benson *et al*. (1996)	Semi-evergreen vine thicket vegetation at Derra Derra Ridge	MVT001–005, MVT007
Benson (1993)	*Cadellia pentastylis* vegetation in NSW	OOL01–32

Most sampling of quadrats was undertaken between June 2001 and September 2002, although one quadrat was sampled in each of March and April 2004.

Additional data and data compatibility

To complement the dry rainforest data collected for this study, data on dry rainforest vegetation for the study area were obtained from several other sources (Table 3). Firstly, dry rainforest data from the Hunter Valley from Peake (2006) were included. These data were from dry rainforest communities identified by Peake (2006) and from Peake and Curran (unpub.) from dry rainforest communities at Brushy Hill near Scone and Mt Dangar in Goulburn River National Park. Secondly, ten sites, sampled by several different operators for DEC (2004a) in the Nandewar Bioregion and assigned to dry rainforest communities were included. Thirdly, six of the seven sites sampled at Derra Derra Ridge near Bingara by Benson et al. (1996) were included. The site that was omitted was a *Triodia*–dominated hummock grassland. Finally, data collected by Benson (1993) from sites in *Cadellia pentastylis* dominated forest on the North Western Slopes of NSW, including one site from Ooline Gorge, Sundown National Park, Queensland were added.

The use of data from different sources meant that the combined data set had to be made compatible. All sources used a modified Braun–Blanquet scale to estimate the cover–abundance of taxa recorded in sites of 400 m^2 area. DEC (2004a) used the same cover–abundance scale as this study, so no adjustment was required. Benson et al. (1996) used a slightly different scale based on Benson (1994): a score of 3 on this scale represented cover from 5–25% and a score of 4 a cover of 26–50%. However, it was not possible to adjust data to the scale used in this study, so data from Benson et al. (1996) were used without change. Peake (2006) also used a slightly different scale, a score of 5 reflected cover of 50–70% and a score of 6 represented cover of 70–100%, which also was not adjusted. Benson (1993) used a seven-point scale, with plants with only one individual scored 1, and other categories similar to Benson (1994), so scores were amended by combining scores of 1 and 2 in Benson (1993) to a score of 1 for analysis. Benson (1993) also provided counts of individuals for all *Cadellia pentastylis* in all plots and for some other taxa in some plots in lieu of cover–abundance scores. These counts were converted to cover–abundance scores by the following scheme: 0–5 individuals=cover–abundance score 3; 6–15 individuals=score 4; 16–25 individuals=score 5; 25+ individuals=score 6.

All taxa that could not be identified to species level were removed from the data set. Any taxa that were identified to different levels of specificity, e.g. identified to species in one source and to subspecies level by another source, were reconciled. Where species level taxa could reliably be assigned to a subspecies or variety (e.g. only one subspecies is known from the study area or from the state) this was done, otherwise all entries were assigned to the species level. For instance, all specimens of *Elaeodendron australe* that were sampled on the North Western Slopes and North Western Plains were identified as *Elaeodendron australe* var. *integrifolium*. However, in the Upper Hunter Valley both *Elaeodendron australe* var. *integrifolium* and *Elaeodendron australe* var. *australe* occur and were sometimes both found in the same plot. Indeed, as Peake (2006) noted, some individuals had leaf morphology characteristics of both varieties. Consequently, all records of *Elaeodendron australe* were assigned to the species level for analysis. Specimens of three taxa comprised amalgamation of two species each; *Austrostipa ramosissima*/*A. verticillata,* which comprised two closely related species that can only be differentiated when in fruit, and *Pellaea falcata*/*P. nana* and *Adiantum aethiopicum*/*A. atroviride,* where specimens could not be consistently reconciled with current separate treatments of the respective species.

Two species recorded by Benson (1993) were amended according to the rules used by DEC (2004a): *Acalphya capillipes* was removed as a possible misidentification and *Croton insularis* was changed to *Croton phebalioides*, reflecting the more likely taxon on the North Western Slopes of NSW. Two additional changes were made: *Olearia viscosa* was included in *Olearia* sp. aff. *elliptica* and *Canthium oleifolium* was subsumed in *Canthium odoratum* (now *Psydrax odorata*).

Statistical analyses

Data were explored using multivariate classification and ordination techniques. Classification was undertaken using the PATN computer program (Belbin 1993a). An unweighted pair-group arithmetic averaging (UPGMA) clustering strategy was applied to association matrices derived from the symmetric form of the Kulczynski similarity measure. This similarity measure is considered to be the most suitable with which to analyse ecological data (Belbin 1993b), because dissimilarity between sites is calculated on the basis of shared species, not species absences (Benson and Ashby 2000). Consequently this measure is more suitable in circumstances where species might be absent from sites for reasons (e.g. season of sampling) other than habitat preferences (Benson and Ashby 2000). Default options were used for the UPGMA: there was no adjacency constraint, no order of the output of the association matrix, and beta was set at -0.1. Ordination of the species and sites matrix, using Detrended Correspondence Analysis (DCA) in the package CANOCO (ter Braak and Šmilauer 1998), was undertaken to complement and aid interpretation of the cluster analysis.

Description of floristic groups

Floristic groups were described from summaries of floristic data, and by using the diagnostic species approach modified from Keith and Bedward (1999). This approach identifies species which delineate the target assemblage from the residual vegetation (all remaining sites) in the study area

Fig. 3. Summary dendrogram of cluster analysis on cover-abundance scores for all native species using the Kulczynski similarity coefficient. Scores above and below the dendrogram are the dissimilarity levels.

```
            0.2090      0.4552      0.7014      0.9476      1.1938      1.4400
                 |           |           |           |           |           |
Floristic Group 1_____________________________________________
Floristic Group 2____________________________________________|_______________
Floristic Group 3_________________________________________                   |
Floristic Group 4________________________________________|__________         |
Floristic Group 5__________________________________________________|____     |
Floristic Group 6______________________________________________________|____|
                 |           |           |           |           |           |
            0.2090      0.4552      0.7014      0.9476      1.1938      1.4400
```

(Table 4). Four categories of species are identified (Table 4): 1) positive diagnostic species, which are more likely to be found in the target assemblage than in other assemblages; 2) negative diagnostic species, which are common in residual vegetation but rare in the target assemblage; 3) frequent species, which are common in all assemblages; and 4) uninformative species, which do not show clear distributional patterns in either target or residual assemblages (Keith and Bedward 1999). The thresholds used to distinguish types of diagnostic species in this project differ from those of Keith and Bedward (1999): a frequency of 0.35 is used instead of 0.5 as the upper threshold for the target assemblage and a frequency of 0.05 is used instead of 0 for the lower frequency threshold.

Plant attribute categorisation

Each taxon was assigned to a growth form group (trees, shrubs, vines, herbs, parasites, cycads or ferns) based on the Flora of NSW (Harden 1990–93). All trees, except exotic species, were further categorized as non-rainforest (all members of the genera *Acacia*, *Angophora*, *Callitris*, *Casuarina*, *Corymbia*, and *Eucalyptus*) or rainforest. All rainforest trees were then assigned to a leaf size class based on Webb (1959; 1968) using data from the Flora of NSW (Harden 1990–1993) or collected by Curran (2006). For trees with compound leaves, leaflet size was used to assign size classes. For each group the proportion of tree species in a given leaf size or leaf retention category was calculated based on either total rainforest tree species richness or proportion of importance index for that floristic group. The importance index gave a measure of species abundance and was derived as the product of median cover-abundance score and target frequency.

The height of the rainforest canopy for each site was derived from the midpoint of the estimated upper and lower height ranges of the canopy. No data were available for the sites from Benson et al. (1996), for the sites from DEC (2004a) or for sites RBR01, SCN31–35. Data from these sites were not used in the calculations of mean canopy height.

Results

Floristic composition

The final data set comprised 498 taxa from 208 sites. Of these, 73 taxa (14.7%) were naturalised exotics, not native to the study area, and were excluded from analyses. Of the remaining 425 taxa, 90 (21.2%) are singletons, taxa that occur in only one site. Analyses were conducted both with singletons retained and removed to test the robustness of the results of the cluster analysis. This had little effect on results; those presented here are with singletons retained.

These 498 taxa are from 99 families, including five families of pteridophytes, two families of gymnosperms and 92 families of angiosperms. The families with the highest number of taxa are: Poaceae (74 taxa), Asteraceae (44), Fabaceae (40), Myrtaceae (17), Solanaceae (16), Chenopodiaceae (14), Cyperaceae (13), Malvaceae (13), Eupomatiaceae (12), Asclepiadaceae (11), and Sapindaceae (9).

The most common taxon was *Notelaea microcarpa* var. *microcarpa*, which occurred in 195 (94%) of the 208 sites.

Table 4. Explanation of diagnostic species (modified from Keith and Bedward 1999). C/A=cover–abundance, Freq=frequency.

		Residual assemblages		
		Freq≥0.5 & C/A≥2	**Freq<0.5 or C/A<2**	**Freq≤0.05**
Target assemblages	**Freq≥0.35 & C/A≥2**	Frequent	Positive diagnostic	Positive diagnostic
	Freq<0.35 or C/A<2	Uninformative	Uninformative	Positive diagnostic
	Freq≤0.05	Negative diagnostic	Uninformative	-

Table 5. Leaf size classes and leaf phenology of the rainforest trees sampled in the study area. Leaf size classes follow Webb (1959; 1968).

Taxon	Leaf size class	Deciduous?
Alectryon forsythii	Microphyll	No
Alectryon oleifolius subsp. *elongatus*	Notophyll	No
Alectryon subcinereus	Notophyll	No
Alectryon subdentatus f. *subdentatus*	Microphyll	No
Alphitonia excelsa	Microphyll	No
Alstonia constricta	Notophyll	No
Atalaya hemiglauca	Notophyll	No
Backhousia myrtifolia	Microphyll	No
Brachychiton populneus subsp. *populneus*	Microphyll	No
Cadellia pentastylis	Microphyll	No
Capparis mitchellii	Microphyll	No
Claoxylon australe	Notophyll	No
Clerodendrum tomentosum	Notophyll	No
Codonocarpus attenuatus	Notophyll	No
Daphnandra apatela	Notophyll	No
Dysoxylum fraserianum	Notophyll	No
Ehretia acuminata var. *acuminata*	Notophyll	Yes
Ehretia membranifolia	Microphyll	Yes
Elaeocarpus obovatus	Notophyll	No
Elaeodendron australe	Microphyll	No
Eremophila mitchellii	Microphyll	No
Eupomatia laurina	Notophyll	No
Exocarpos cupressiformis	Nanophyll	No
Ficus coronata	Notophyll	No
Ficus rubiginosa	Notophyll	No
Geijera parviflora	Notophyll	No
Geijera salicifolia var. *salicifolia*	Notophyll	No
Hymenosporum flavum	Notophyll	No
Maytenus bilocularis	Microphyll	No
Melia azedarach	Microphyll	Yes
Melicope micrococca	Notophyll	No
Myrsine howittiana	Notophyll	No
Myrsine variabilis	Microphyll	No
Notelaea microcarpa var. *microcarpa*	Microphyll	No
Notelaea microcarpa var. *velutina*	Microphyll	No
Notelaea venosa	Notophyll	No
Owenia acidula	Microphyll	No
Owenia X reliqua	Microphyll	No
Pararchidendron pruinosum var. *pruinosum*	Microphyll	No
Pittosporum angustifolium	Notophyll	No
Pittosporum spinescens	Nanophyll	No
Pittosporum undulatum	Notophyll	No
Pouteria cotinifolia var. *pubescens*	Microphyll	No
Santalum lanceolatum	Microphyll	No
Streblus brunonianus	Microphyll	No
Trema tomentosa var. *viridis*	Microphyll	No
Ventilago viminalis	Notophyll	No

Other common taxa were: *Pandorea pandorana* (152 sites 73%), *Spartothamnella juncea* (143 sites, 69%), *Austrostipa* spp. (*A. verticillata/A. ramosissima)* (133 sites, 63.9%) and *Geijera parviflora* (129 sites, 62.0%). *Opuntia stricta* var. *stricta* was the most commonly recorded exotic taxon (102 sites, 49%), while other common exotic taxa included: *Malvastrum americanum* (46 sites, 22%), *Bidens pilosa* (37 sites, 18%), *Sonchus oleraceus* (20 sites, 10%) and *Bidens subalternans* and *Opuntia aurantiaca* (each 18 sites, 9%).

The mean richness of the 208 sites was 31.6, while the median richness was 31. The lowest richness was 11 taxa at OOL31 and TC081, while the highest was 69 taxa at TC047.

Three of the 47 rainforest tree species are deciduous, the remainder being evergreen (Table 5). Twenty two of these tree species have microphyll leaf size, 23 are notophyll and two are nanophyll leaf size.

Floristic classification

The results of the cluster analysis are summarized in Figure 3. Removal or inclusion of singletons had no effect on the outcome of analyses, so results here represent analyses on all native species. Six floristic groups were delineated, all at a high level of dissimilarity (>1.0). The first split in the dendrogram (at a dissimilarity level of 1.44) separated Floristic Groups 1 and 2 from Floristic Groups 3, 4, 5 and 6. In this latter cluster, Floristic Group 6 separated from the remaining groups at a dissimilarity level >1.3. Floristic Group 5 separated at a dissimilarity level >1.2, leaving groups 3 and 4 as the most similar of all groups delineated in this study.

The results of the ordination using DCA largely support the categorization of sites using cluster analysis (Figure 4). Several groups delineated in the cluster analysis, particularly Groups 2, 5 and 6, are clearly separate in ordination space.

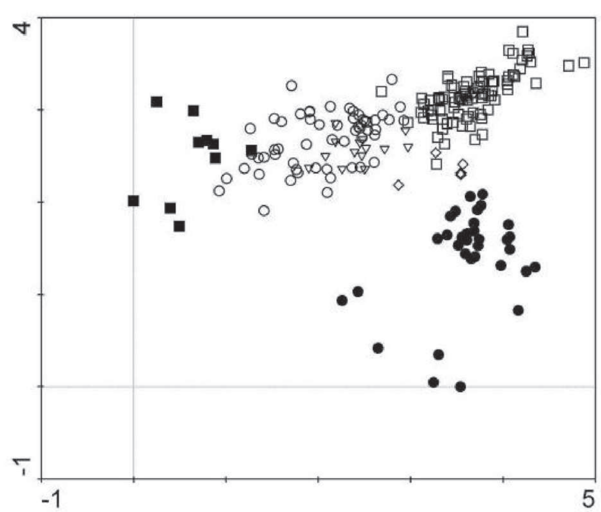

Fig. 4. Biplot showing the relationship of the sites to each other on the first two axes of the DCA ordination. Sites are denoted by symbols reflecting their grouping in the cluster analysis: ○=Group 1; ■ =Group 2; ◇=Group 3; ▽=Group 4; □=Group 5; ● =Group 6.

Group 3, with only six sites, is also generally separate from other groups. However, there is substantial overlap between sites from Groups 1 and 4 (Figure 4)

Each floristic group is described below.

Floristic Group 1

This floristic group (Figures 5–8) is dominated by *Notelaea microcarpa* var. *microcarpa* and *Ficus rubiginosa* (Table 6), with occasional *Eucalyptus albens* or *Angophora floribunda* as emergents. Other rainforest canopy species include *Brachychiton populneus* subsp. *populneus*, *Alectryon subdentatus* f. *subdentatus*, *Alphitonia excelsa*, and *Alectryon forsythii*. The shrub layer is dominated by *Pimelea neo-anglica*, *Abutilon oxycarpum*, *Olearia* sp. aff. *elliptica*, and *Spartothamnella juncea*, while *Melicytus dentatus* is found in this floristic group much more frequently than in other floristic groups. *Pandorea pandorana*, *Eustrephus latifolius*, *Glycine tabacina* and *Clematis glycinoides* var. *glycinoides* are the dominant vines, while *Cayratia clematidea* and *Celastrus australis* are characteristic vines of this group. The ground layer is dominated by herbs such as *Microlaena stipoides* var. *stipoides*, *Urtica incisa*, *Austrostipa verticillata*/*A. ramosissima*, *Dichondra* species A, *Oplismenus aemulus* and *Rumex brownii* and ferns such as *Adiantum aethiopicum*/*A. atroviride* and *Pellaea calidirupium*.

There were 56 plots in Floristic Group 1. The mean species richness for a 0.04 ha plot in this group was 32 ± 1. The lowest richness was 11 taxa in plot TC081 and the highest 59 taxa in plot NBAFF0436.

Table 6. Diagnostic species of Floristic Group 1. CA=cover-abundance.

Species	Growth form	Target frequency	Target CA	Residual frequency	Residual CA	Fidelity class
Notelaea microcarpa var. *microcarpa*	tree	0.98	3	0.93	3	frequent
Ficus rubiginosa	tree	0.82	3.5	0.07	3	positive diagnostic
Brachychiton populneus subsp. *populneus*	tree	0.41	1	0.18	1	positive diagnostic
Alectryon subdentatus f. *subdentatus*	tree	0.36	3	0.11	2.5	positive diagnostic
Alphitonia excelsa	tree	0.36	1	0.20	1.5	positive diagnostic
Alectryon forsythii	tree	0.29	3	0.00	0	positive diagnostic
Pimelea neo-anglica	shrub	0.55	1	0.39	1	uninformative
Abutilon oxycarpum	shrub	0.48	1	0.48	1	uninformative
Olearia sp. aff. *elliptica*	shrub	0.45	1	0.37	2	uninformative
Spartothamnella juncea	shrub	0.43	1	0.79	2	uninformative
Solanum parvifolium	shrub	0.39	2	0.56	1	positive diagnostic
Melicytus dentatus	shrub	0.27	1	0.05	2	positive diagnostic
Pandorea pandorana	vine	0.86	2	0.69	2	frequent
Eustrephus latifolius	vine	0.52	1	0.13	1.5	uninformative
Glycine tabacina	vine	0.48	1	0.42	1	uninformative
Clematis glycinoides var. *glycinoides*	vine	0.43	1	0.11	1	uninformative
Cayratia clematidea	vine	0.39	2	0.15	2	positive diagnostic
Celastrus australis	vine	0.27	2	0.03	2	positive diagnostic
Microlaena stipoides var. *stipoides*	herb	0.77	2	0.07	1	positive diagnostic
Urtica incisa	herb	0.70	1	0.23	1	uninformative
Austrostipa verticillata/*A. ramosissima*	herb	0.55	1	0.68	2	uninformative
Dichondra species A	herb	0.54	1	0.31	1	uninformative
Oplismenus aemulus	herb	0.46	2	0.04	1	positive diagnostic
Rumex brownii	herb	0.45	1	0.04	1.5	positive diagnostic
Scleria mackaviensis	herb	0.43	1	0.21	1	uninformative
Arthropodium species B	herb	0.39	1	0.03	1	positive diagnostic
Elymus scaber	herb	0.36	1	0.02	1	positive diagnostic
Geranium solanderi var. *solanderi*	herb	0.27	1	0.04	2	positive diagnostic
Adiantum aethiopicum/*A. atroviride*	fern	0.48	2	0.04	2.5	positive diagnostic
Pellaea calidirupium	fern	0.45	2	0.02	1	positive diagnostic
Asplenium flabellifolium	fern	0.23	1	0.04	1	positive diagnostic

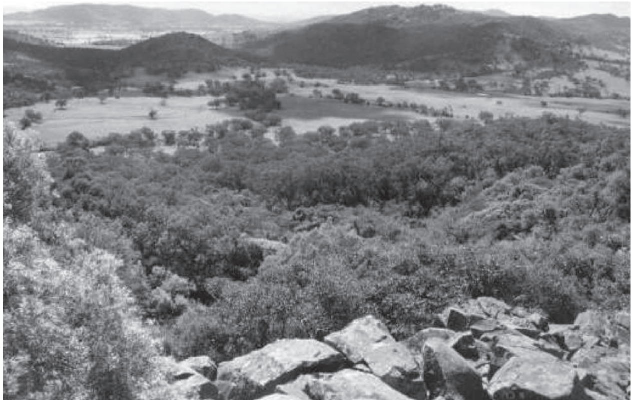

Fig. 5. *Ficus rubiginosa–Notelaea microcarpa* notophyll vine thicket (Floristic Group 1) on an andesite scree slope, Duri Mountain, near Currabubula, south of Tamworth. The low height of the vine thicket can be seen in comparison to the adjacent eucalypt woodland in the middle ground. The scree slope demarcates these two communities.

Fig. 6. Interior of *Ficus rubiginosa–Notelaea microcarp***a** notophyll vine thicket (Floristic Group 1) stand, Duri Mountain. *Alectryon forsythii* and *Ficus rubiginosa* dominate the canopy and there is a dense layer of moss on the scree boulders.

Fig. 7. *Ficus rubiginosa–Notelaea microcarpa* notophyll vine thicket (Floristic Group 1) in a gully on a trachyte outcrop, Yulludunida Crater, Mt Kaputar National Park, near Narrabri.

Fig. 8. Interior of *Ficus rubiginosa–Notelaea microcarpa* notophyll vine thicket (Floristic Group 1) in a trachyte gorge, Waa Gorge, Mount Kaputar National Park.

Floristic Group 2

Ficus rubiginosa, *Alectryon subcinereus*, *Notelaea microcarpa* var. *microcarpa* and *Clerodendrum tomentosum* dominate this community (Table 7; Figures 9 & 10), with *Casuarina cunninghamiana* subsp. *cunninghamiana* an occasional emergent in creekline stands. Other characteristic tree species are *Melia azedarach*, *Backhousia myrtifolia*, *Daphnandra apatela*, *Ficus coronata*, *Myrsine variabilis* and *Claoxylon australe*. The shrub layer is dominated by *Melicytus dentatus*, *Breynia oblongifolia* and *Spartothamnella juncea*. Common vines are *Eustrephus latifolius*, *Pandorea pandorana*, *Cissus antarctica*, *Cayratia clematidea* and *Clematis glycinoides* var. *glycinoides*, with *Aphanopetalum resinosum* among the characteristic vine species. The ground layer is dominated by herbs such as *Urtica incisa*, *Nyssanthes diffusa*, *Geranium solanderi* var. *solanderi*, *Gahnia aspera* and *Solenogyne bellioides* and ferns such as *Pellaea falcata*/*P. nana* and *Adiantum formosum*.

Fig. 9. *Ficus rubiginosa–Alectryon subcinereus–Notelaea microcarpa* notophyll vine forest (Floristic Group 2) on a scree slope of Carboniferous volcanics at Segenhoe Mountain, near Aberdeen, upper Hunter Valley. The deciduous tree is *Melia azedarach*.

Table 7. Diagnostic species of Floristic Group 2.

Species	Growth form	Target frequency	Target CA	Residual frequency	Residual CA	Fidelity class
Ficus rubiginosa	tree	0.8	3	0.247	4	positive diagnostic
Alectryon subcinereus	tree	0.8	3	0.010	1.5	positive diagnostic
Notelaea microcarpa var. *microcarpa*	tree	0.8	2	0.944	3	frequent
Clerodendrum tomentosum	tree	0.8	1	0.051	1.5	uninformative
Melia azedarach	tree	0.4	2	0.030	1	positive diagnostic
Backhousia myrtifolia	tree	0.3	3	0.000	0	positive diagnostic
Daphnandra apatela	tree	0.3	2	0.000	0	positive diagnostic
Ficus coronata	tree	0.3	3	0.005	3	positive diagnostic
Myrsine variabilis	tree	0.3	2	0.010	1.5	positive diagnostic
Claoxylon australe	tree	0.3	1	0.010	3	positive diagnostic
Casuarina cunninghamiana subsp. *cunninghamiana*	tree	0.2	3	0.000	0	positive diagnostic
Hymenosporum flavum	tree	0.2	2.5	0.000	0	positive diagnostic
Geijera salicifolia var. *salicifolia*	tree	0.2	1.5	0.015	1	positive diagnostic
Myrsine howittiana	tree	0.2	1.5	0.000	0	positive diagnostic
Melicytus dentatus	shrub	0.8	2	0.076	1	positive diagnostic
Breynia oblongifolia	shrub	0.4	2.5	0.333	1	uninformative
Spartothamnella juncea	shrub	0.4	1	0.702	2	uninformative
Eustrephus latifolius	vine	0.9	2	0.202	1	positive diagnostic
Pandorea pandorana	vine	0.8	2	0.727	2	frequent
Cissus antarctica	vine	0.7	3	0.005	2	positive diagnostic
Cayratia clematidea	vine	0.6	2	0.197	2	positive diagnostic
Clematis glycinoides var. *glycinoides*	vine	0.6	2	0.172	1	positive diagnostic
Aphanopetalum resinosum	vine	0.4	2	0.005	3	positive diagnostic
Legnephora moorei	vine	0.2	2	0.000	0	positive diagnostic
Clematis aristata	vine	0.2	1.5	0.000	0	positive diagnostic
Urtica incisa	herb	0.8	2	0.328	1	positive diagnostic
Nyssanthes diffusa	herb	0.7	2	0.096	2	positive diagnostic
Geranium solanderi var. *solanderi*	herb	0.4	2	0.086	1	positive diagnostic
Gahnia aspera	herb	0.4	2	0.040	1	positive diagnostic
Solenogyne bellioides	herb	0.4	2	0.005	1	positive diagnostic
Cotula australis	herb	0.2	2	0.000	0	positive diagnostic
Lomandra longifolia	herb	0.2	2	0.040	1.5	positive diagnostic
Pratia purpurascens	herb	0.2	2	0.015	2	positive diagnostic
Dichondra species A	herb	0.2	2	0.379	1	uninformative
Ripogonum album	herb	0.2	2	0.000	0	positive diagnostic
Arctotheca calendula	herb	0.2	1.5	0.000	0	positive diagnostic
Echinopogon ovatus	herb	0.2	1.5	0.000	0	positive diagnostic
Pellaea falcata/P. nana	fern	0.7	2	0.101	2	positive diagnostic
Adiantum formosum	fern	0.5	2	0.000	0	positive diagnostic
Pyrrosia rupestris	fern	0.3	2	0.000	0	positive diagnostic

Fig. 10. Interior of *Ficus rubiginosa–Alectryon subcinereus–Notelaea microcarpa* notophyll vine forest (Floristic Group 2) on basalt scree at Lake Glenbawn, upper Hunter Valley. This community supports many vines, such as *Cissus antarctica* (to the left of Travis Peake).

There were 10 plots in Floristic Group 2. The mean species richness for a 0.04 ha plot in this group was 34 ± 3. The lowest richness was 16 taxa in plot GRETA2 and the highest 53 taxa in plot Q038.

Floristic Group 3

Floristic Group 3 is dominated by *Elaeodendron australe*, *Geijera parviflora* and *Notelaea microcarpa* var. *microcarpa*, with emergent species such as *Acacia salicina*, *Acacia cheelii*, *Callitris glaucophylla* and *Eucalyptus melanophloia* (Table 8). *Carissa ovata* and *Pimelea neo-anglica* are the most common shrubs along with *Beyeria viscosa*, *Correa glabra*, *Cryptandra longistaminea*, *Indigofera brevidens*, *Phyllanthus subcrenulatus* and *Spartothamnella juncea*. *Parsonsia eucalyptophylla* and *Pandorea pandorana* are the dominant vines. The ground layer is dominated by the herbs *Aristida ramosa*, *Dichondra repens* and *Thellungia advena* and the fern *Cheilanthes sieberi* subsp. *sieberi*.

Table 8. Diagnostic species of Floristic Group 3.

Species	Growth form	Target frequency	Target CA	Residual frequency	Residual CA	Fidelity class
Elaeodendron australe	tree	1.00	2.5	0.40	3	positive diagnostic
Geijera parviflora	tree	0.83	2	0.61	3	frequent
Notelaea microcarpa var. *microcarpa*	tree	0.83	2	0.94	3	frequent
Acacia salicina	tree	0.67	1	0.02	2	uninformative
Acacia cheelii	tree	0.50	1	0.01	1	uninformative
Callitris glaucophylla	tree	0.50	2	0.14	1	positive diagnostic
Eucalyptus melanophloia	tree	0.50	2	0.05	3	positive diagnostic
Carissa ovata	shrub	1.00	3	0.30	3	positive diagnostic
Pimelea neo-anglica	shrub	1.00	1	0.42	1	uninformative
Beyeria viscosa	shrub	0.67	1.5	0.41	2	uninformative
Correa glabra	shrub	0.50	2	0.00	0	positive diagnostic
Cryptandra longistaminea	shrub	0.50	2	0.00	0	positive diagnostic
Indigofera brevidens	shrub	0.50	1	0.08	1	uninformative
Phyllanthus subcrenulatus	shrub	0.50	1	0.20	1	uninformative
Spartothamnella juncea	shrub	0.50	1	0.69	2	uninformative
Parsonsia eucalyptophylla	vine	0.83	1	0.30	1	uninformative
Pandorea pandorana	vine	0.67	1	0.73	2	uninformative
Aristida ramosa	herb	1.00	2.5	0.14	1	positive diagnostic
Dichondra repens	herb	0.83	1	0.14	2	uninformative
Thellungia advena	herb	0.67	2	0.00	0	positive diagnostic
Boerhavia dominii	herb	0.50	1	0.04	1	positive diagnostic
Gahnia aspera	herb	0.50	1	0.04	1	positive diagnostic
Poa sieberiana var. *sieberiana*	herb	0.50	3	0.01	2.5	positive diagnostic
Carex breviculmis	herb	0.33	1	0.00	2	positive diagnostic
Chloris truncata	herb	0.33	1	0.03	1	positive diagnostic
Dianella revoluta	herb	0.33	1.5	0.03	1	positive diagnostic
Lomandra multiflora	herb	0.33	1	0.00	1	positive diagnostic
Cheilanthes sieberi subsp. *sieberi*	fern	0.67	1	0.37	1	uninformative

There were 6 plots in Floristic Group 3. The mean species richness for a 0.04 ha plot in this group was 28 ± 3. The lowest richness was 15 taxa in plot MVT007 and the highest 40 taxa in plot MVT003.

Floristic Group 4

This floristic group is dominated by *Elaeodendron australe*, *Geijera parviflora* and *Notelaea microcarpa* var. *microcarpa*, with *Alectryon oleifolius* subsp. *elongatus*, *Clerodendrum tomentosum* and, to a lesser extent *Melia azedarach*, the other important tree species (Table 9; Figures 11 & 12). *Eucalyptus albens* is commonly an emergent above this vine thicket canopy. The shrub layer is dominated by *Olearia* sp. aff. *elliptica*, *Rhagodia parabolica* and *Spartothamnella juncea*, with *Solanum brownii* and *Beyeria viscosa* also common. Vines are commonly encountered, particularly *Clematicissus opaca*, *Marsdenia flavescens*, *Parsonsia eucalyptophylla*, *Pandorea pandorana*, *Clematis glycinoides* var. *glycinoides*, *Parsonsia lanceolata* and *Tylophora grandiflora*. The

Fig. 11. *Elaeodendron australe–Notelaea microcarpa–Geijera parviflora* notophyll vine thicket (Floristic Group 4 middle ground on the photo) on the slopes of Brushy Hill, Lake Glenbawn, upper Hunter Valley. The shrub layer at the front is dominated by *Rhagodia parabolica*, a very common shrub in this community.

Table 9. Diagnostic species of Floristic Group 4.

Species	Growth form	Target frequency	Target CA	Residual frequency	Residual CA	Fidelity class
Elaeodendron australe	tree	1.00	3	0.37	3	positive diagnostic
Geijera parviflora	tree	0.93	3	0.60	3	frequent
Notelaea microcarpa var. *microcarpa*	tree	0.86	2	0.94	3	frequent
Alectryon oleifolius subsp. *elongatus*	tree	0.71	3	0.23	1	positive diagnostic
Clerodendrum tomentosum	tree	0.71	1.5	0.04	1	positive diagnostic
Eucalyptus albens	tree	0.71	3	0.14	3	positive diagnostic
Melia azedarach	tree	0.36	1	0.03	3	positive diagnostic
Olearia sp. aff. *elliptica*	shrub	1.00	3.5	0.35	1	positive diagnostic
Rhagodia parabolica	shrub	1.00	2.5	0.22	1	positive diagnostic
Spartothamnella juncea	shrub	1.00	2	0.66	1	positive diagnostic
Solanum brownii	shrub	0.71	2	0.03	2	positive diagnostic
Beyeria viscosa	shrub	0.57	2	0.40	2	positive diagnostic
Breynia oblongifolia	shrub	0.36	1	0.34	1	uninformative
Pysdrax odorata forma *buxifolia*	shrub	0.21	1	0.01	1	positive diagnostic
Clematicissus opaca	vine	0.93	2	0.12	2	positive diagnostic
Marsdenia flavescens	vine	0.93	3	0.00	0	positive diagnostic
Parsonsia eucalyptophylla	vine	0.79	1	0.28	1	uninformative
Pandorea pandorana	vine	0.71	2	0.73	2	frequent
Clematis glycinoides var. *glycinoides*	vine	0.64	1	0.16	1	uninformative
Parsonsia lanceolata	vine	0.57	1	0.28	1	uninformative
Tylophora grandiflora	vine	0.57	1	0.00	0	uninformative
Urtica incisa	herb	0.79	1	0.32	1	uninformative
Austrostipa verticillata/A. ramosissima	herb	0.64	2	0.64	1	positive diagnostic
Austrodanthonia fulva	herb	0.43	2	0.01	1	positive diagnostic
Stellaria flaccida	herb	0.29	1.5	0.00	0	positive diagnostic
Oxalis exilis	herb	0.21	1	0.02	1	positive diagnostic
Vittadinia sulcata	herb	0.21	1	0.02	1	positive diagnostic
Macrozamia concinna	cycad	0.43	1	0.00	0	positive diagnostic

Fig. 12. Interior of *Elaeodendron australe–Notelaea microcarpa–Geijera parviflora* notophyll vine thicket (Floristic Group 4) on the slopes of Brushy Hill, Lake Glenbawn (see left background), upper Hunter Valley. *Notelaea microcarpa* and *Geijera parviflora* dominate the canopy here, while the main shrub is *Olearia* sp. aff. *elliptica,* a characteristic component of this community.

dominant herbs are *Urtica incisa*, *Austrostipa verticillata*/*A. ramosissima* and *Austrodanthonia fulva*. The cycad *Macrozamia concinna* is also occasionally encountered.

There were 14 plots in Floristic Group 4. The mean species richness for a 0.04 ha plot in this group was 34 ± 2. The lowest richness was 27 taxa in plot SCN020 and the highest 48 taxa in plot Q012.

Floristic Group 5

This group is consistently dominated by *Notelaea microcarpa* var. *microcarpa*, *Geijera parviflora* and *Ehretia membranifolia* (Table 10; Figures 13–15). *Elaeodendron australe* var. *integrifolia* and *Ventilago viminalis* become important components of the canopy north from Narrabri, and north from Yallaroi *Pouteria cotinifolia* var. *pubescens* and *Pittosporum spinescens* are co-dominants (Figure 14). The common shrubs are *Spartothamnella juncea*, *Solanum parvifolium*, *Abutilon oxycarpum*, *Beyeria viscosa*, *Rhagodia parabolica* and, north from Narrabri, *Carissa ovata*. Other characteristic shrubs include *Solanum mitchellianum* and *Enchylaena tomentosa*. The most common vines are *Clematis microphylla* var. *microphylla*, *Pandorea pandorana*, *Glycine tabacina*, *Jasminum lineare*, *Desmodium brachypodum*, *Parsonsia eucalyptophylla*, and *Parsonsia lanceolata*, while *Marsdenia viridiflora*, *Capparis lasiantha* and *Marsdenia pleiadenia* are particularly characteristic of this community. Herbs such *Austrostipa verticillata*/*A. ramosissima*, *Paspalidium gracile*, *Austrostipa scabra* subsp. *scabra*, *Leptochloa ciliolata*, and *Dichondra* species A, and the fern *Cheilanthes sieberi* subsp. *sieberi* dominate the ground layer, while herbs such as *Panicum queenslandicum* var. *queenslandicum*, *Chloris ventricosa*, *Austrodanthonia bipartita* and *Cymbopogon refractus* are characteristic of this floristic group.

Fig. 13. *Notelaea microcarpa–Geijera parviflora–Ehretia membranifolia* semi evergreen vine thicket (Floristic Group 5) on a basalt hill, Derra Derra Ridge, near Bingara.

Fig. 14. Interior of *Notelaea microcarpa–Geijera parviflora–Ehretia membranifolia* semi-evergreen vine thicket (Floristic Group 5) on a basalt hill, near North Star, north–west of Warialda. Northern stands, such as this one are more complex in floristic composition, with *Pouteria cotinifolia* var. *pubescens* and *Pittosporum spinescens* co-dominants. *Carissa ovata* is a common shrub (middle background).

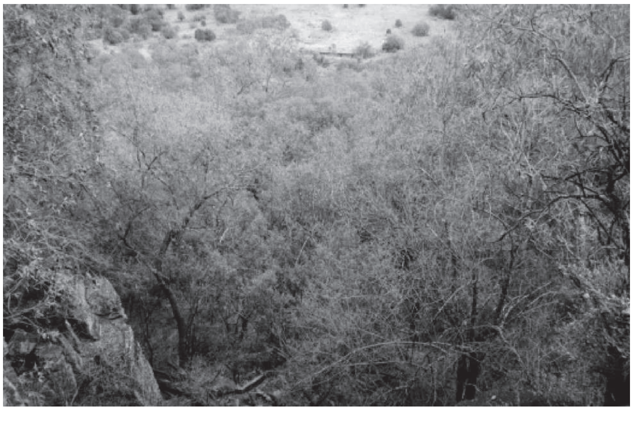

Fig. 15. Canopy of *Notelaea microcarpa–Geijera parviflora–Ehretia membranifolia* semi-evergreen vine thicket (Floristic Group 5) on Porcupine Hill, near Gunnedah. The deciduous tree in the canopy is *E. membranifolia*.

Table 10. Diagnostic species of Floristic Group 5.

Species	Growth form	Target frequency	Target CA	Residual frequency	Residual CA	Fidelity class
Notelaea microcarpa var. *microcarpa*	tree	0.97	3	0.92	3	frequent
Geijera parviflora	tree	0.92	3	0.39	1	positive diagnostic
Ehretia membranifolia	tree	0.79	3	0.09	1	positive diagnostic
Capparis mitchellii	tree	0.61	1	0.18	1	uninformative
Elaeodendron australe	tree	0.52	3	0.34	2	positive diagnostic
Alectryon oleifolius subsp. *elongatus*	tree	0.43	1	0.13	2	uninformative
Alstonia constricta	tree	0.34	2	0.24	1	uninformative
Ventilago viminalis	tree	0.33	2	0.01	1	positive diagnostic
Pittosporum spinescens	tree	0.15	2	0.00	0	positive diagnostic
Pouteria cotinifolia var. *pubescens*	tree	0.12	3	0.00	0	positive diagnostic
Spartothamnella juncea	shrub	0.87	1	0.55	1.5	uninformative
Solanum parvifolium	shrub	0.70	1	0.38	2	uninformative
Abutilon oxycarpum	shrub	0.60	1	0.39	2	uninformative
Beyeria viscosa	shrub	0.56	1	0.30	3	uninformative
Carissa ovata	shrub	0.52	3	0.17	3	positive diagnostic
Rhagodia parabolica	shrub	0.47	1	0.12	2.5	uninformative
Breynia oblongifolia	shrub	0.44	1	0.26	1	uninformative
Olearia sp. aff. *elliptica*	shrub	0.43	1	0.36	1	uninformative
Dodonaea viscosa	shrub	0.36	1	0.15	1	uninformative
Solanum mitchellianum	shrub	0.36	1	0.01	1	positive diagnostic
Enchylaena tomentosa	shrub	0.22	1	0.00	0	positive diagnostic
Clematis microphylla var. *microphylla*	vine	0.79	1	0.16	1	uninformative
Pandorea pandorana	vine	0.74	2	0.72	2	frequent
Glycine tabacina	vine	0.67	1	0.26	1	uninformative
Jasminum lineare	vine	0.61	2	0.18	1	positive diagnostic
Desmodium brachypodum	vine	0.42	1	0.18	1	uninformative
Parsonsia eucalyptophylla	vine	0.42	1	0.24	1	uninformative
Parsonsia lanceolata	vine	0.40	1	0.22	1	uninformative
Marsdenia viridiflora	vine	0.34	1	0.03	1	positive diagnostic
Capparis lasiantha	vine	0.26	2	0.00	0	positive diagnostic
Marsdenia pleiadenia	vine	0.22	1	0.02	1.5	positive diagnostic
Austrostipa verticillata/*A. ramosissima*	herb	0.85	1	0.48	2	uninformative
Paspalidium gracile	herb	0.61	1	0.07	1	uninformative
Austrostipa scabra subsp. *scabra*	herb	0.60	1	0.13	1	uninformative
Leptochloa ciliolata	herb	0.58	1	0.09	1	uninformative
Dichondra species A	herb	0.46	1	0.30	1	uninformative
Panicum queenslandicum var. *queenslandicum*	herb	0.31	1	0.02	1	positive diagnostic
Chloris ventricosa	herb	0.28	1	0.04	1	positive diagnostic
Austrodanthonia bipartita	herb	0.22	1	0.03	3	positive diagnostic
Cymbopogon refractus	herb	0.21	1	0.04	1	positive diagnostic
Cheilanthes sieberi subsp. *sieberi*	fern	0.57	1	0.23	1	uninformative

There were 89 plots in Floristic Group 5. The mean species richness for a 0.04 ha plot in this group was 34 ± 1. The lowest richness was 17 taxa in plot TC113 and the highest 69 taxa in plot TC047.

Floristic Group 6

The dominant and most characteristic species of Floristic Group 6 is *Cadellia pentastylis* (Table 11; Figures 16 & 17), which occurs in all plots of the Group and at a median C/A of 4 (cover-abundance 20–50%). Other common tree species include *Notelaea microcarpa* var. *microcarpa*, *Elaeodendron australe* and *Geijera parviflora*. The most common shrubs are *Pimelea neo-anglica*, *Solanum parvifolium*, *Spartothamnella juncea* and *Beyeria viscosa*. Vines are not as frequent as in the other floristic groups, although the most common species are *Pandorea pandorana* and *Cayratia clematidea*. The most common herbs are *Austrostipa verticillata*/*A. ramosissima*, *Carex inversa*, *Poa labillardieri* var. *labillardieri* and *Wahlenbergia luteola*.

Table 11. Diagnostic species of Floristic Group 6.

Species	Growth form	Target frequency	Target CA	Residual frequency	Residual CA	Fidelity class
Cadellia pentastylis	tree	1.00	4	0.01	5	positive diagnostic
Notelaea microcarpa var. *microcarpa*	tree	0.88	2	0.95	3	frequent
Elaeodendron australe	tree	0.55	1	0.39	3	uninformative
Geijera parviflora	tree	0.55	1	0.63	3	uninformative
Alstonia constricta	tree	0.48	1	0.24	1.5	uninformative
Capparis mitchellii	tree	0.48	1	0.34	1	uninformative
Eremophila mitchellii	tree	0.27	2	0.05	1	positive diagnostic
Pimelea neo-anglica	shrub	0.67	2	0.39	1	positive diagnostic
Solanum parvifolium	shrub	0.64	2	0.49	1	positive diagnostic
Spartothamnella juncea	shrub	0.64	1	0.70	2	uninformative
Beyeria viscosa	shrub	0.61	3	0.38	2	positive diagnostic
Abutilon oxycarpum	shrub	0.48	3	0.48	1	positive diagnostic
Einadia hastata	shrub	0.39	2	0.20	1	positive diagnostic
Phyllanthus subcrenulatus	shrub	0.39	2	0.17	1	positive diagnostic
Cassinia laevis	shrub	0.30	1.5	0.03	1	positive diagnostic
Pandorea pandorana	vine	0.48	2	0.78	2	frequent
Cayratia clematidea	vine	0.39	1	0.18	2	uninformative
Austrostipa verticillata/A. ramosissima	herb	0.45	3	0.67	1	positive diagnostic
Carex inversa	herb	0.45	3	0.24	2	positive diagnostic
Poa labillardieri var. *labillardieri*	herb	0.36	3	0.01	3	positive diagnostic
Wahlenbergia luteola	herb	0.33	2	0.01	1	positive diagnostic
Eragrostis megalosperma	herb	0.24	3	0.02	1	positive diagnostic
Aristida caput-medusae	herb	0.12	4.5	0	0	positive diagnostic

Fig. 16. *Cadellia pentastylis* low microphyll vine forest (Floristic Group 6) on the lower slopes of a low, sandstone hill at "Tara" near Warialda. The canopy is dominated by *Cadellia pentastylis,* while the silver-leaved ironbark *Eucalyptus melanophloia* is an occasional co-dominant.

Fig. 17. Interior of *Cadellia pentastylis* low microphyll vine forest (Floristic Group 6) on the lower slopes of a low, sandstone hill at "Tara" near Warialda. The density of the canopy in this community is variable, from open canopy such as in this part of the stand, to closed canopy, as in Figure 16.

There were 33 plots in Floristic Group 6. The mean species richness for a 0.04 ha plot in this group was 23 ± 1. The lowest richness was 11 taxa in plot OOL31 and the highest 35 taxa in plot OOL16.

Structural classification

Floristic groups were readily and unambiguously assigned to Webb structural types based on leaf size classes, proportions of deciduous versus evergreen species and canopy height

(Table 12). Proportions of leaf retention and leaf size classes were similar whether based on proportion of tree species richness or proportion of the importance index. There were generally low proportions of deciduous rainforest trees, usually less than 10%, and sometimes as low as 2%, although 16% (by proportion of importance index) of Floristic Group 5 was categorized as deciduous, due to the abundance of *Ehretia membranifolia* in this community (Figure 15). Two floristic groups (1 and 4) had equal mixes of trees of notophyll and microphyll size classes, Floristic Group 2 comprised two-thirds notophyll leaf classes and one-third microphyll leaf classes, while groups 3, 5 and 6 comprised two-thirds to three-quarters microphyll classes and one-quarter to one-third notophyll classes. There were very low or no nanophyll classes in all groups. Mean height of the rainforest canopy was highest in Groups 2 and 6 and lowest in Group 5. The mean canopy heights of Groups 2 and 6 (>9m) were such that these groups were considered to be vine forest, while the lower heights of the remaining groups (<9m) categorized these as vine thicket.

Distribution

Floristic Group 1 predominantly occurs in the Nandewar (NAN) Bioregion, but also includes some sites in the Brigalow Belt South (BBS) Bioregion and the upper Hunter Valley, including three sites at Mt Dangar near Denman (Figure 18). Sites from Floristic Group 2 and 4 were all restricted to the Hunter Valley, with Floristic Group 4 confined to Brushy Hill, east of Scone. Floristic Groups 5 and 6 were found in the BBS and NAN, while Floristic Group 3 was restricted to Derra Derra Ridge, west of Bingara, in NAN.

Discussion

Floristic classification

The floristic groups of dry rainforest on the western slopes of NSW delineated in this project were broadly similar to those identified by other projects, and largely reflect the groupings predicted from the literature. There was a high degree of concurrence with studies that analysed quantitative plot data (e.g. McDonald 1996; DLWC 2002; DEC 2004a) and generally with those which relied on intuitive classification (e.g. Floyd 1990).

A community dominated by *Cadellia pentastylis* occurring on sedimentary substrates was delineated, as per McDonald (1996), DLWC (2002) and DEC (2004a). This consistency may well be because each of these studies, including the current one, used data from *Cadellia pentastylis* stands collected by Benson (1993). As found by DLWC (2002), not all sites with *Cadellia pentastylis* in the current study were clustered together. Two additional sites were sampled from *Cadellia pentastylis* stands for the current study, both in stands also sampled by Benson (1993). One of these, TC010, clustered with the sites sampled by Benson (1993) in Floristic Group 6, while the other, TC133, was placed in Floristic Group 5. DLWC (2002) described an Ooline Forest floristic group that contained 16 sites. They noted that *Cadellia pentastylis* had a non-target group frequency of 0.01, which in their study equated to 9 sites. The DLWC (2002) study incorporated 16 sites from Benson (1993), but 9 (36%) of their sites from *Cadellia pentastylis* stands (presumably those not sampled by Benson) did not cluster in their Ooline Forest floristic group. Some of these clustered in the SEVT and Dry

Table 12. Webb (1959; 1968; 1978) structural types of each floristic group and the structural variables (leaf retention, leaf size, canopy height) that contribute to this classification. SSENVT=simple semi-evergreen notophyll vine thicket; SSENVF=simple semi-evergreen notophyll vine forest; SEVT=semi-evergreen vine thicket, LMVF=low microphyll vine forest.

Structural features	Floristic group					
	1	2	3	4	5	6
Leaf retention (percentage of tree species /percentage importance index)						
Deciduous	8/2	7/5	11/2	8/3	5/16	7/2
Evergreen	92/98	93/95	89/98	92/97	95/84	93/98
Leaf size classes (percentage number of tree species/percentage importance index)						
Nanophyll	4/1	-	-	8/1	5/2	-
Microphyll	48/61	36/33	67/74	46/47	64/64	73/88
Notophyll	48/38	64/67	33/26	46/52	32/34	27/12
Canopy height (m) mean (standard error)	8.6 (0.5)	13.6 (1.6)	N/A	7.3 (0.5)	6.4 (0.3)	13.2 (1.0)
Webb structural type	SSENVT	SSENVF	SEVT	SSENVT	SEVT	LMVF

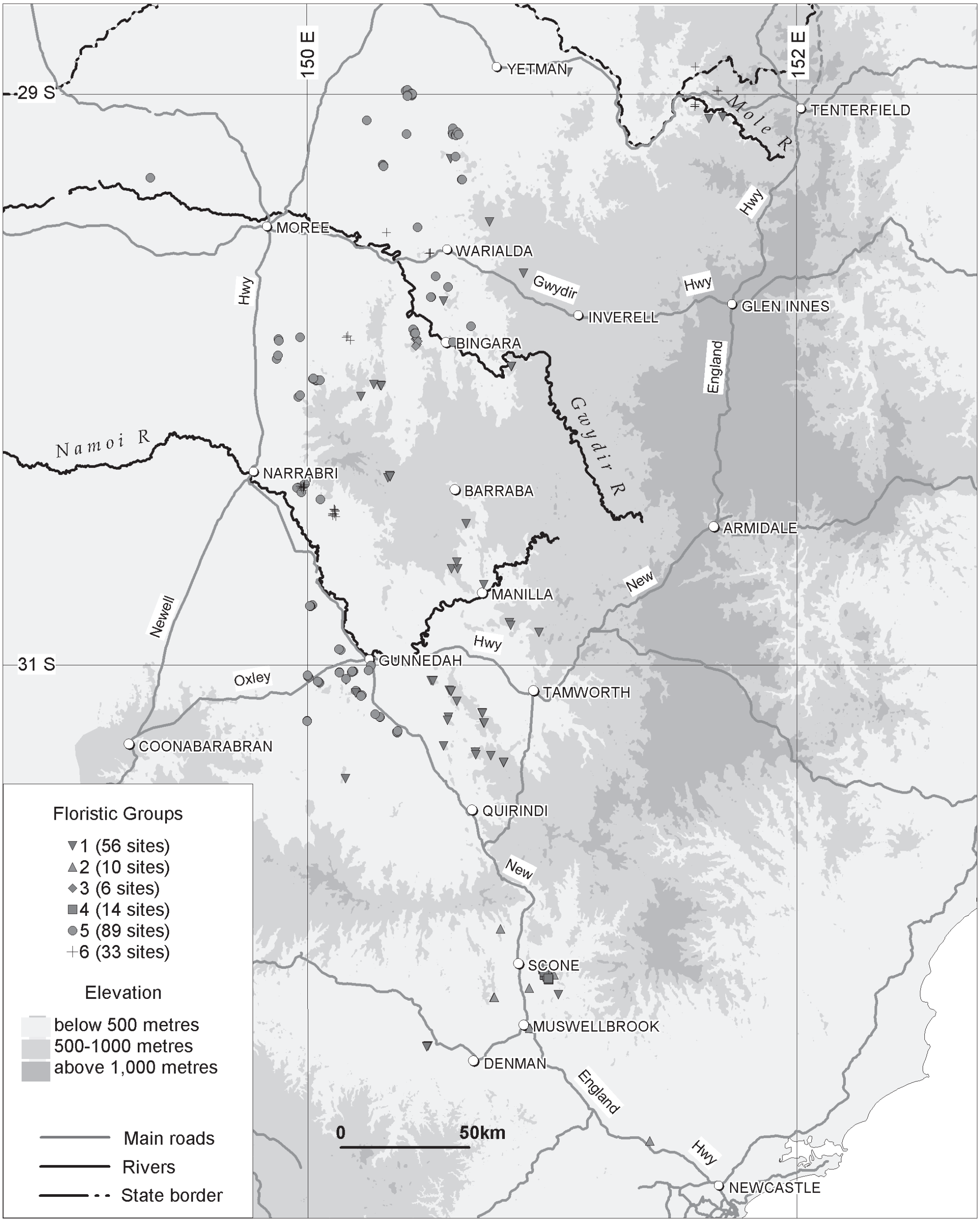

Fig. 18. Location of sites from each floristic group. Base Map data © 2004 Geosciences Australia.

Scrubs floristic group (DLWC 2002). Clearly, there is a need for further investigation of the relationships between plot data from *Cadellia pentastylis* stands collected by different operators.

Floristic Group 1 is similar to the Dry Rainforest floristic group of the Nandewar Ranges delineated by DLWC (2002) and to the Rusty Fig Dry Rainforest and *Alectryon*/Rusty Fig/Mock Olive Dry Rainforest groups identified by DEC (2004a). All these groups are dominated by *Notelaea microcarpa* var. *microcarpa* and *Ficus rubiginosa*, and also share *Alectryon subdentatus* and *Alphitonia excelsa*, and the emergent *Angophora floribunda*. Floristic Group 1 is quite variable in floristic composition and geographic extent and two subgroups broadly equate to each of the two DEC (2004a) groups in both geographic distribution and floristic composition.

An unexpected result was the delineation of two floristic groups of SEVT from the North Western Slopes of NSW. Floristic Group 3 contained only six sites, all sampled by Benson et al. (1996) at Derra Derra Ridge near Bingara, while Floristic Group 5 contained 89 sites sampled by the authors throughout the North Western Slopes, including four plots also sampled at Derra Derra Ridge. There is a high level of dissimilarity between these two groups (Figure 3; dissimilarity >1.3). This may be due to different operators. Collectively, Floristic Groups 5 and 3 equate to the SEVT and Dry Scrub groups of DLWC (2002), the SEVT of DEC (2004a) and the SEVT of McDonald (1996), sharing the same dominant species.

Floristic Group 4 equates to the Hunter Valley Vine Thicket community identified by Peake (2006), reflecting the use of the same data in both studies. Floristic Group 2 includes sites from both the Lower Hunter Dry Rainforest and Upper Hunter Depauperate Dry Rainforest groups of Peake (2006). The merging of these two groups, when analysed in the context of rainforest on the western slopes of NSW, demonstrates the greater similarity they have to each other than to other rainforest stands from the study area.

This project examined for the first time the broader scale relationships between different types of dry rainforest throughout the western slopes of NSW. It demonstrated that the main dichotomy in dry rainforest on the western slopes is between 1) *Ficus rubiginosa*–dominated communities (including those from the Nandewar Bioregion, the Hunter Valley, and to a lesser extent the Brigalow Belt South Bioregion), and 2) the *Elaeodendron australe–Geijera parviflora–Notelaea microcarpa* community of the upper Hunter Valley, the *Cadellia pentastylis* community, and the *Notelaea microcarpa–Geijera parviflora–Ehretia membranifolia* community of the North Western Slopes.

This broad scale dichotomy broadly reflects the distinction between the two vine thicket Suballiances of Floyd (1990); No. 31 *Alectryon forsythii–Alectryon subdentatus–Notelaea microcarpa* and No. 32 *Notelaea microcarpa–Ehretia membranifolia–Geijera parviflora*. All three of the diagnostic species from Suballiance No. 31 are present in Floristic Group 1, although one of the dominant species in this group is *Ficus rubiginosa*, which, while present in some of the stands of Suballiance No. 31 sampled by Floyd, is not a canopy dominant. Another difference is in the varieties of *Notelaea microcarpa*: *Notelaea microcarpa* var. *velutina* is found in Suballiance No. 31 in the Guy Fawkes–Macleay Gorges, while *Notelaea microcarpa* var. *microcarpa* is found on the North Western Slopes. Several of the characteristic species of Floristic Group 2, such as *Alectryon subcinereus*, *Backhousia myrtifolia*, *Geijera salicifolia* var. *salicifolia*, *Cissus antarctica*, *Aphanopetalum resinosum*, *Nyssanthes diffusa*, and *Pyrrosia rupestris*, are also found in Suballiance No. 31 (Floyd 1990).

Floristic Groups 3, 4, 5 and 6, which are all on the lower part of the first dichotomy in the dendrogram (Figure 3), collectively equate to suballiance No. 32 of Floyd (1990). This suballiance included stands of *Cadellia pentastylis* forest, vine thickets from the upper Hunter Valley and vine thickets from the North Western Slopes. A notable exception to this support for the intuitive classification of Floyd (1990) is the stand at Mt Dangar (floristic sites GNG056–058). Floyd placed the Mt Dangar stand in suballiance No. 32, whereas the quantitative analyses conducted in the current study clustered the Mt Dangar sites in Floristic Group 1. Based on the predominance of *Ficus rubiginosa* in these stands, the classification of Mt Dangar vine thicket in Floristic Group 1 seems the most logical result.

The floristic groups identified in this study are less readily matched with the floristic classification of Australian rainforests by Webb et al. (1984). The sites sampled in the present study, perhaps with exception of some sites from the Hunter Valley, are located within the C_2 ecofloristic province of Webb et al. (1984), which is characterized by stands of SEVT and a subtropical (mesotherm/megatherm), moderately seasonal, subhumid climate. Samples from near Gunnedah and from the upper Hunter Valley were used by Webb et al. (1984) to classify rainforest stands using numerical analysis of tree species presence/absence data. Despite the geographic and structural overlap, there is only limited affinity with the list of ten diagnostic species of the C_2 province. Of these ten species, which represent the most common tree species found in the province (Webb et al. 1984), only two, *Alstonia constricta* and *Cadellia pentastylis*, are found in the stands sampled on the western slopes of NSW. Floristic Group 6 is best matched to the C_2 province, having both these taxa as positive diagnostic species. Floristic Groups 1, 3 and 5 all have *Alstonia constricta*, but at low frequencies, while Groups 2 and 4 have neither species. Fensham (1995) also sampled stands in the C_2 province, and encountered all of the diagnostic species of Webb et al. (1984) except *Cadellia pentastylis*, but pointed out that, due to sparse sampling, the Webb et al. scheme did not represent the floristic variation in dry rainforest in inland North Queensland. Russell-Smith (1991) encountered difficulties in assigning his floristic groups to the Webb et al. typology. Webb et al. (1984) acknowledged the limitations in their scheme for outlying stands away from the "core" area of each province. Given that the core area for the C_2 province is at Biloela in central Queensland, some 500 km north of the northern most sites in the present study, and the sparse coverage of sites used by Webb et al. (1984) in the study area of the current project, this lack of concurrence with the Webb et al. typology is understandable.

Structural typology

Unlike studies elsewhere, there were no problems in assigning floristic groups of rainforest on the western slopes of NSW to the structural classes of rainforest defined by Webb (1978). Russell-Smith (1991) was not able to apply the Webb typology unambiguously to his 16 floristic groups. This may be because of the lesser diversity of leaf size classes in rainforests of the western slopes of NSW; there being only three size classes in western NSW (Table 5) compared to five in monsoon rainforest in northern Australia (Russell-Smith

Table 13. Equivalent and proposed nomenclature of dry rainforest assemblages on the western slopes of NSW

Source	Floristic group 1	2	3	4	5	6
Webb (1978)	SSENVT	SSENVF	SEVT	SSENVT	SEVT	LMVF
Floyd (1990a) Suballiance	No. 31	No. 31	No. 32	No. 32	No. 32	No. 32
DLWC (2002)	Dry Rainforest		SEVT		SEVT and Dry Scrubs	Ooline forest
DEC (2004a)	1) Alectryon/Rusty Fig/Mock Olive Dry Rainforest and 2) Rusty Fig Dry Rainforest		SEVT		SEVT	Ooline Open or Closed Forest
Keith (2004)	Dry Rainforest	Dry Rainforest	Western Vine Thicket	Western Vine Thicket	Western Vine Thicket	Western Vine Thicket
Peake (2006)		1) Upper Hunter Depauperate Dry Rainforest and 2) Hunter Valley Dry Rainforest		Hunter Valley Vine Thicket		
Proposed name	*Ficus rubiginosa–Notelaea microcarpa* notophyll vine thicket	*Ficus rubiginosa–Alectryon subcinereus–Notelaea microcarpa* notophyll vine forest	As for Group 5	*Elaeodendron australe–Notelaea microcarpa–Geijera parviflora* notophyll vine thicket	*Notelaea microcarpa–Geijera parviflora–Ehretia membranifolia* semi-evergreen vine thicket	*Cadellia pentastylis* low microphyll vine forest

1991). The lower diversity of leaf size classes means that there is less structural diversity; four structural types on the western slopes of NSW compared to ten types for monsoon rainforest (Russell-Smith 1991), and floristic groups could be readily assigned to one of the four structural types. These four structural types: semi-evergreen vine thicket (SEVT), low microphyll vine forest (LMVF), simple semi-evergreen notophyll vine thicket (SSENVT) and simple semi-evergreen notophyll vine forest (SSENVF), are structurally simple forms, lacking many of the specialized life forms and tall height of other rainforest structural types (Webb 1978). This may also contribute to the satisfactory equilibration of floristic groups with structural types. These outcomes contradict the contention of Russell-Smith (1991) that the problems in applying the Webb typology to monsoon rainforests in northern Australia were due to the inherent structural simplicity of those stands. Russell-Smith (1991) based this argument on the finding by Webb et al. (1976) that the scheme was more effective at classifying stands of greater structural complexity. The results of this study suggest that the scheme can also be effectively applied to very simple stands of rainforest.

The differing dissimilarity levels at which floristic groups were delineated may explain the different effectiveness between this study and that of Russell-Smith (1991) in applying the Webb typology. The current study described floristic groups at a very high level of dissimilarity (dissimilarity index>1.0; Figure 3), as the aim was to describe broad floristic groupings, rather than extensively explore differences at lower levels of dissimilarity. While no indication of levels of dissimilarity are given in the dendrogram presented by Russell-Smith (1991)—most likely due to the type of cluster analysis used (two-way indicator species analysis) which does not include such measures—16 floristic groups were described, which suggests that groups were delineated at lower dissimilarity levels than the current study. If Russell-Smith (1991) had described fewer floristic groups, i.e. delineated at higher dissimilarity levels, he may well have found greater concurrence between floristic groups and structural classes.

There was considerable robustness in the categorization of structural classes. Each floristic group of western slopes rainforest was assigned to the same structural type irrespective of whether proportions of numbers of species of different leaf size classes or proportion of the total importance index of different leaf size classes were used. This robustness has important implications for the nomenclature of these rainforest stands on the western slopes of NSW.

Nomenclature of rainforest assemblages

Current nomenclature (e.g. DLWC 2002; DEC 2004a) uses a mixture of both structural and floristic names. For instance, in most schemes, SEVT (equivalent to Floristic Groups 3 and 5 in this study) is consistently referred to by its structural type, whereas other types, e.g. Rusty Fig Dry Rainforest (*sensu* DEC 2004a) or Ooline (*Cadellia pentastylis*) forest (*sensu* DLWC 2002), largely ignore structural classifications and incorporate floristic information. The latter approach is based on the use of vernacular names which incorporate key components of the vegetation and habitat to help readers visualize floristic groups (Keith and Bedward 1999). However, such a scheme should be applied consistently, incorporating such information for all communities.

In an attempt to provide consistency in the nomenclature of rainforest communities on the western slopes of NSW, the following options, with their equivalents from other studies, are proposed (Table 13). The proposed community names include both floristic and structural information on the groups, thus providing a useful guide to the floristic composition, functional attributes (predominant leaf size class) and structure (height) of each group. It is recognized that this nomenclature may be of limited use in conveying visual images of the communities to lay audiences, for instance, Ooline Forest is a much more succinct and evocative description of Floristic Group 6 than *Cadellia pentastylis* low microphyll vine forest. However, the most widely used equivalent of Floristic Group 5, SEVT, is also difficult to explain to lay audiences. Given that it is not possible to derive simple names for each floristic group it was felt that the names should 1) be consistent in their derivation, and 2) convey useful botanical and ecological information. With a little patience and some explanation of the terms, these names could be used for lay audiences and they certainly should be logical, and, importantly, able to be applied consistently to other stands by ecologists and botanists.

Fensham (1995) mounted an argument for dispensing with the term “vine thicket” in favour of dry rainforest on the grounds that 1) people introduced to the former term for the first time envisaged thickets of exotic vines; and 2) that the minimum height for forest under the Specht (1970) structural scheme was 5 m, a height usually attained by the canopy in most stands Fensham sampled. His experiences match those of one of us (TJC) in referring to vine thicket for the first time to several lay people (and some horticulturalists). While Fensham’s (1995) view that dry rainforest would be an appropriate general term for the rainforests of the dry tropics and sub-tropics of eastern Australia is supported, the term vine thicket was found to be useful in describing structural features and highlighting the diversity of dry rainforest types on the western slopes of NSW, by helping to distinguish different communities.

Distribution in New South Wales

Elements of this study can be used to describe the limits to the distribution of inland NSW. Dry rainforest communities, with floristic similarities to those described from NSW, particularly SEVT, are found further north in inland Queensland (McDonald 1996). To the east, the high elevation plateau of the Great Dividing Range (Figure 18) provide a barrier to the occurrence of rainforest, most likely due to very low minimum temperatures (King 1980), with the nearest rainforest on the upper reaches of gorges 20 km to the south-east of Armidale (Suballiance No. 31; Floyd 1990).

There are some small stands of dry rainforest to the west of the study area, for instance on scree slopes of the Warrumbungle Mountains, 40 km west of Coonabarabran (Figure 18). These are dominated by *Ficus rubiginosa* and would likely be placed in Floristic Group 1. However, further north and to the west of the Warrumbungles there are no similar steep slopes with such topographic refugia. Also to the west of the study area, the mean annual rainfall steeply declines below 500–600 mm, which is the recognised arid climatic limit for rainforest in North Queensland (Fensham 1995) and the Northern Territory (Russell-Smith 1991). Despite the occurrence of basalt-derived loams further west, which may compensate for lower rainfall (Curran 2006), it appears that there is simply not enough rainfall, nor the topographic refugia, to support rainforest further west in NSW. The outlying site to the west of Moree (TC125; Figure 18), sampled because it was identified as SEVT by Cooper and McAllan (1999), was placed in Floristic Group 5, but was quite dissimilar to other sites in this group. While it had some species common to this group (e.g. *Ehretia membranifolia* and *Geijera parviflora*), there were also species more characteristic of western plains communities, not found in other sites. Consequently, it likely represents a different community, with some affinities to dry rainforest, but representing a transition to more arid vegetation, perhaps part of the “rainforest-derived genera woodlands and shrublands of the inland slopes and plain” vegetation formation of Benson (2006).

The reason for the southern limit is less clear, although the dry rainforests in the study area represent the most southerly stands west of the Great Dividing Range in NSW. With increasing latitude from the study area, rainfall shifts from a summer predominance to equal and then winter predominance. Within SEVT on the North Western Slopes there is a general decline in the richness of trees (TJC pers. obs.) with increasing latitude. While some species which are canopy dominants in SEVT, such as *Notelaea microcarpa* and *Geijera parviflora* do occur further south, few of the other dominants do. So there may not actually be a clear threshold beyond which rainforest does not occur; rather it may be a simple loss of canopy trees to be replaced by more open eucalypt woodlands further south. Adam (1992) noted that in northern Australia there were more rainforest taxa interspersed in surrounding vegetation than in south-east Australia, and implicated lower temperatures and less predicable rainfall in the latter region. This could explain the reduction of rainforest trees with increasing latitude and perhaps the lack of inland rainforest further south than the study area.

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