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Hunter Valley Weeping Myall Woodland – is it really definable and defensible with and without Weeping Myall (*Acacia pendula*)?

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Abstract: Hunter Valley Weeping Myall Woodland is listed as a Critically Endangered Ecological Community (CEEC) under both the New South Wales *Threatened Species Conservation (TSC) Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. Uncertainty regarding the provenance of Weeping Myall (*Acacia pendula*) in the Hunter has led to questioning of the place of Hunter Valley Weeping Myall Woodland CEEC in State and Commonwealth legislation. A recent publication has endorsed its legislative listing, largely based on the co-association of Weeping Myall with a range of other semi-arid species in some parts of the Hunter Valley. We counter this argument and show that the semi-arid species present in low rainfall areas on Permian sediments of the Hunter Valley floor are in fact more widespread than previously documented. Through examination of distributional records, we demonstrate that these species display no fidelity to purported Hunter Valley Weeping Myall Woodland, but instead occur in a range of other vegetation communities across much of the central and upper Hunter Valley. Habitat suitability modelling undertaken for *Acacia pendula* shows there to be nearly 900 times the 200 ha of pre-European extent, or 20 times the area of occupancy previously estimated for this community.

We also revisit an earlier ordination analysis which showed a divergence in sample data potentially representative of Hunter Valley Weeping Myall Woodland. We add new samples and provide a revised classification of the purported community, which shows that sample plots from two forms of Hunter Valley Weeping Myall Woodland are floristically indistinguishable from comparative data in 20–25 year old mining rehabilitation forests of *Eucalyptus cladocalyx*, and native grasslands derived predominantly from landscapes of *Eucalyptus crebra* and *Eucalyptus moluccana*.

Relevant legislation requires any threatened community to be identifiable based on a particular species assemblage and its area of occupancy. We question whether Hunter Valley Weeping Myall Woodland is recognisable with and without the presence of *Acacia pendula*. We argue that the identification of Hunter Valley Weeping Myall Woodland is unachievable without the visual cue of *Acacia pendula*, and note that for some time regional botanists have used this species' presence as a *de facto* diagnostic tool to identify this community; in fact, there are no examples of the community having been identified as such in the absence of *Acacia pendula*. Finally, following from our ordination results, and the presence of key diagnostic species within more widespread grassy woodlands and derived native grasslands, we suggest that 200 years of anthropogenic disturbance across the Hunter Valley has sufficiently masked any distributional pattern of western semi-arid species that might have once occurred. We contend that there is little value in conserving a purported community that cannot be confidently delineated in numerical classifications, lacks a consistent and diagnostic suite of characteristic species, and for which there is uncertainty over the origins of its dominant, flagship species, *Acacia pendula*.

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Introduction

Hunter Valley Weeping Myall Woodland is listed as a Critically Endangered Ecological Community (CEEC) under both the NSW *Threatened Species Conservation Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. One of the key components of this community, Weeping Myall (*Acacia pendula*), is potentially alien to the Hunter Valley, and arguably the species has never naturally occurred there. In an earlier paper, we presented a case questioning the origins of *Acacia pendula* in the region, using historical literature, database records, voucher specimens and habitat assessments to suggest that this species was never a natural part of the Hunter flora (Bell & Driscoll 2014a). The publication of this view occurred at the time of a proposal to raise the status of Hunter Valley Weeping Myall Woodland to Critically Endangered under the *TSC Act 1995*, which highlighted a need to address inconsistencies in the perceived conservation value of this community.

In response to our concerns, Tozer and Chalmers (2015) recently argued that irrespective of the origins of *Acacia pendula*, the co-occurrence of other more western species within the Hunter Valley provides sufficient merit to maintain, and indeed elevate, legal protection for this ecological community. They accepted that there remains some uncertainty over the origins of *Acacia pendula* in the Hunter Valley, but reiterated that it is the assemblage of species, not *Acacia pendula* itself, which defines Hunter Valley Weeping Myall Woodland. Despite this sentiment, in regard to the ecological community they agree that “... competent, experienced botanists remain unconvinced the Hunter Valley Myall Woodland constitutes an assemblage of species distinct from others occurring in the upper Hunter Valley”.

Tozer and Chalmers (2015) made a number of generalisations which we believe require clarification. The views expressed by us were based on our experience in plant ecology spanning over 25 years in the Hunter Valley, and supported with extensive evidence from the literature (see Bell & Driscoll 2014a). Over the years, we have struggled to rationalise our field experiences and observations with the legislation on this issue, culminating in the views expressed in our 2014 paper. This current note addresses three important points raised by Tozer and Chalmers (2015) which are crucial in the debate over the conservation value of Hunter Valley Weeping Myall Woodland: 1) the general ecological basis for any threatened ecological community, and how that relates to Hunter Valley Weeping Myall Woodland; 2) the co-occurrence of other western species in the Hunter Valley, and the lack of support they provide to the existence of Hunter Valley Weeping Myall Woodland; and 3) the lack of numerical classification support for Hunter Valley Weeping Myall Woodland.

For the sake of progressing debate on this issue, this paper is concerned predominantly with furthering understanding on the existence or otherwise of Hunter Valley Weeping Myall Woodland, the community. Resolving the origin of *Acacia pendula* in the Hunter Valley is not addressed further, and our earlier opinion that the species is introduced remains

unchanged. In this regard, the principle question we now pose is this: Can Hunter Valley Weeping Myall Woodland be delineated in the field if *Acacia pendula* was removed from consideration? That is, on the assumption that *Acacia pendula* was absent in the pre-European Hunter Valley (as postulated in Bell & Driscoll 2014a), is the fidelity of the other co-occurring species included in the listing for this community strong enough to maintain a definable entity? If such an entity does exist, does it warrant formal protection in legislation, or have anthropogenic impacts been so great over the last 200 years that we are too late in our attempts to protect and conserve what at best could be described as a functionally extinct community?

The ecological basis for a threatened community

Ecological communities require logical and definable boundaries so that they can withstand legal scrutiny and can be managed effectively. In their review, Tozer and Chalmers (2015) rightly recognise that together with certain environmental factors, threatened species legislation typically defines a community as an “assemblage of species occupying a particular area”, although not all species included in a determination can be expected at all locations. They also highlight the potential confounding impacts on biogeographical landscape patterns that may arise following 200 years of anthropogenic disturbance, as has occurred in the Hunter Valley of New South Wales. The relative scarcity of systematic and quantitative survey data leads them to question the ecological basis for recognising Hunter Valley Weeping Myall Woodland as a distinct community. These are all valid points, since it is difficult for consistent and observable patterns in species distribution to be recognised from highly disturbed landscapes with few data.

To answer their question, Tozer and Chalmers (2015) discuss thirteen western taxa which have similar distribution patterns to the Hunter occurrence of *Acacia pendula*, alluding to the role this suite of species collectively plays as evidence for the movement of western species through the Goulburn Valley corridor. Seven of these in particular (*Calocephalus citreus*, *Acacia melvillei*, *Enteropogon acicularis*, *Eragrostis alveiformis*, *Enchylaena tomentosa*, *Lysiana exocarpi* subsp. *tenuis*, *Chenopodium glaucum*) are noted as displaying a more restricted distribution akin to that shown by *Acacia pendula*. Based on data from the Atlas of Living Australia, they suggest that the area encompassed by these species generally lies between Broke, Singleton, Muswellbrook and Sandy Hollow. Correlating the distributions of these species with annual rainfall, geology and topography, they observe that a natural truncation in occurrence is present just west of Sandy Hollow, where the Triassic Narrabeen sandstones converge along the Goulburn River Valley. At this locality, the Goulburn River valley exhibits a rain shadow effect, and reportedly forms part of the Goulburn Valley corridor which potentially facilitates the easterly movement of western species.

Using our own systematic plot data from the Hunter Valley collected over 20 years of sampling, we tested the assumption that these seven species show a restricted distribution within the Hunter, and that (by extension) they can be used in support of Hunter Valley Weeping Myall Woodland. From a review of our data, it was evident that the distribution of the seven species noted above show no fidelity to mapped occurrences of Hunter Valley Weeping Myall Woodland or *Acacia pendula*, and indeed occur in a range of vegetation communities on predominantly Permian-aged substrates

across a large portion of the central and upper Hunter Valley (Figure 1). In none of these communities (including Hunter Valley Weeping Myall Woodland) are they dominant, but they show a presence which is notable, not unusual. The suggestion that these species are indicative of a vegetation community characterised by *Acacia pendula* and co-occurring with a range of semi-arid species is unsupported by these data, and is perhaps an over-generalisation based on limited observations.

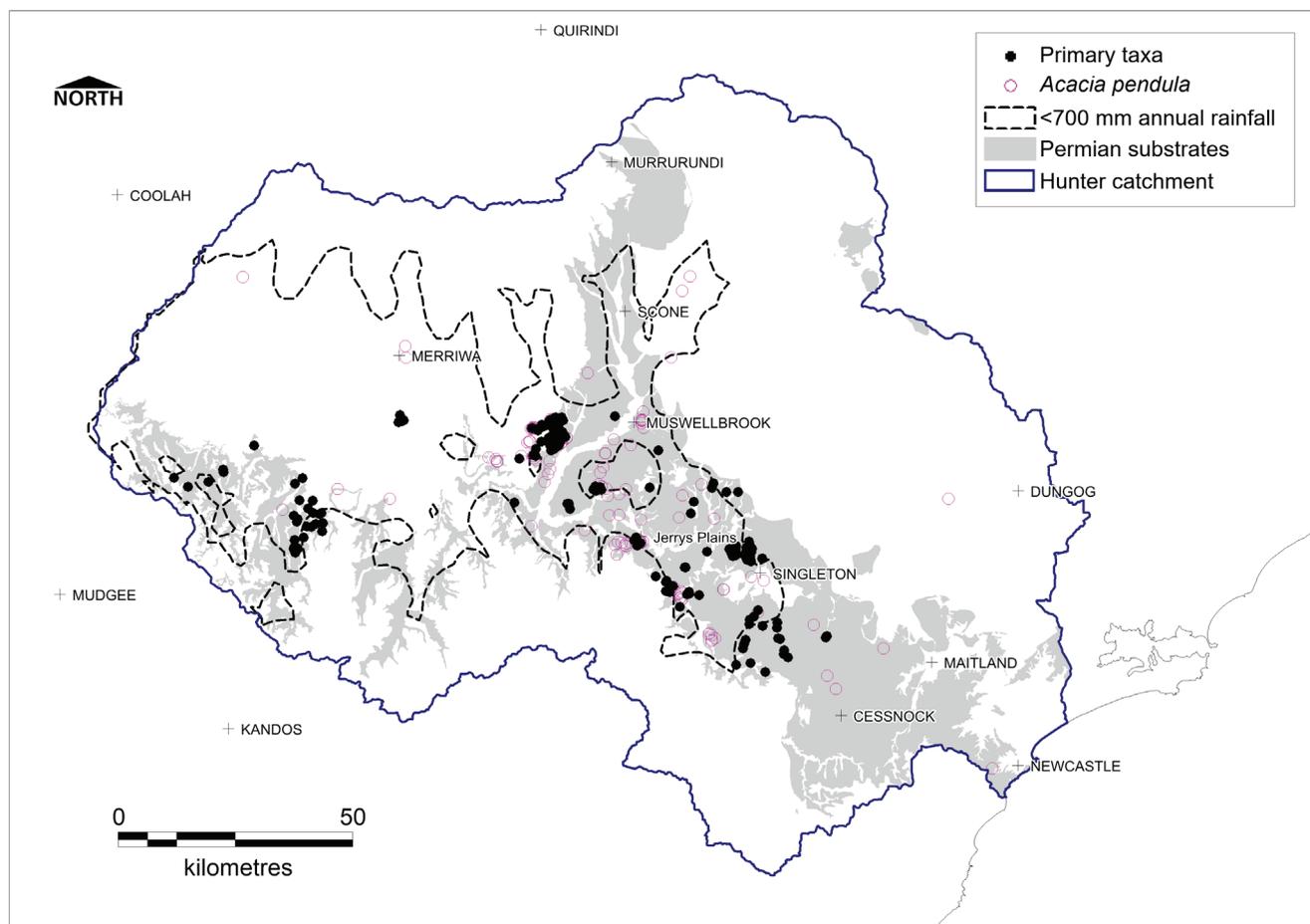


Figure 1. Regional distribution of primary key diagnostic taxa identified by Tozer & Chalmers (2015) for Hunter Valley Weeping Myall Woodland, shown with *Acacia pendula* records. Taxa included as primary taxa are *Acacia melvillei*, *Calocephalus citreus*, *Chenopodium glaucum*, *Enchylaena tomentosa*, *Enteropogon acicularis*, *Eragrostis alveiformis*, and *Lysiana exocarpi* subsp. *tenuis*. Data from personal database records.

As a further illustration of this point, Table 1 summarises the distribution of these seven taxa across differing vegetation types in the Hunter Valley, as extracted from our data. Rather than assign each vegetation type to broadly defined mapping units produced from the various classification projects over recent years, original field-recorded community descriptions are shown in the table. These community labels noted in the field provide a better indication of exactly where the target species occur in the landscape, and have not been compromised to accommodate a broader classification. Quite clearly, the combination of species nominated in Tozer and Chalmers (2015) as being indicative of Hunter Valley Weeping Myall Woodland also occur across a wide range of other vegetation types. Three species in particular

(*Calocephalus citreus*, *Enteropogon acicularis* and *Enchylaena tomentosa*) are common across many different vegetation types.

Derived Native Grasslands, those grasslands resulting from the partial or full removal of canopy and shrub layer and the retention of many native grasses and forbs, support five of the seven nominated species. The two remaining species are a large shrub (*Acacia melvillei*) and an aerial mistletoe (*Lysiana exocarpi*), neither of which are expected to occur within regularly grazed grassland landscapes (although the former does reappear in some grasslands where cattle have been removed). These data suggest that perhaps these seven species (and others) appear as characteristic and diagnostic

for Hunter Valley Weeping Myall Woodland because they were always present in grassland and grassy woodland areas in this part of the Hunter Valley. As invasion by *Acacia pendula* has progressed, most species have been shaded out, with these few remaining as the most notable. The paucity of systematic floristic data from derived grasslands across the entire Hunter Valley limits further examination of this theory. As a guide, however, a separate dataset of 262 grassland sample plots (0.01 ha in size; unpubl. data) from former Box-Ironbark woodlands of the central and upper

Hunter Valley shows, for example, that *Calocephalus citreus* has been recorded in 45 plots, *Enteropogon acicularis* in 22, *Eragrostis alveiformis* in 13, and *Enchylaena tomentosa* in 10. This demonstrates the presence of these species in derived grasslands across lands previously dominated by *Eucalyptus moluccana* and/or *Eucalyptus crebra*.

Table 1. Recorded occurrence of key Hunter Valley Weeping Myall Woodland taxa in systematic data from the Hunter Valley floor. Cc = *Calocephalus citreus*, Am = *Acacia melvillei*, Eac = *Enteropogon acicularis*, Eal = *Eragrostis alveiformis*, Et = *Enchylaena tomentosa*, Le = *Lysiana exocarpi* subsp. *tenuis*, and Cg = *Chenopodium glaucum*.

| Species | Cc | Am | Eac | Eal | Et | Le | Cg |
|---|----|----|-----|-----|----|----|----|
| Derived Native Grassland | ✓ | | ✓ | ✓ | ✓ | | ✓ |
| Dawson’s Box Forest | ✓ | ✓ | ✓ | | ✓ | | |
| Narrow-leaf Ironbark Grassy Forest | ✓ | | ✓ | | ✓ | ✓ | |
| Grey Box Grassy Woodland | ✓ | | ✓ | | ✓ | | |
| Spotted Gum – Narrow-leaf Ironbark Forest | ✓ | | ✓ | | ✓ | | |
| Spotted Gum – Red Ironbark Forest | ✓ | | ✓ | | ✓ | | |
| Western Grey Box Grassy Woodland* | ✓ | | ✓ | ✓ | | | |
| Grey Box – Paperbark Forest | | | ✓ | | ✓ | | |
| Swamp Oak Forest | | | ✓ | | ✓ | | |
| Forest Redgum Grassy Forest | | | ✓ | | ✓ | | |
| Bullock Thicket | | | ✓ | | ✓ | | |
| White Box Grassy Woodland | | | ✓ | | ✓ | | |
| Grey Box – Black Cypress Pine Forest | ✓ | | | | | | |
| Yellow Box Grassy Woodland | | | | ✓ | | | |
| Fuzzy Box Grassy Woodland | | | | | ✓ | | |
| Black Cypress Pine Forest | | | ✓ | | | | |
| Coast Myall Low Forest | | | | | ✓ | | |
| Rough-barked Apple Forest | | | | | | ✓ | |

* within the Hunter Valley but west of the Sandy Hollow truncation point noted by Tozer & Chalmers (2015).

Legal determinations for Hunter Valley Weeping Myall Woodland

In the original listing, Hunter Valley Weeping Myall Woodland comprised only eighteen plant taxa (NSW Scientific Committee 2006). All of these, including *Acacia pendula*, have been observed by us to be present across many habitats other than Hunter Valley Weeping Myall Woodland, and particularly within the surrounding State listed Central Hunter Grey Box – Ironbark Woodland, Central Hunter Ironbark – Spotted Gum – Grey Box Forest, and Hunter Valley Foothills Slaty Gum Woodland threatened ecological communities (TECs). There are no species on this list that occur only in areas supporting *Acacia pendula*, although this fact alone does not discount the presence of a community.

More recently, the Final Determination for listing Hunter Valley Weeping Myall Woodland as Critically Endangered (NSW Scientific Committee 2016) has expanded the list of characteristic species to approximately sixty taxa. In our view this expanded list does not aid but hinders identification

of this community, as it still includes a considerable number of taxa that are widespread and common across the Hunter Valley, and which are contiguous with the above-mentioned TECs. Using our dataset of systematic plot data, and in the absence of unequivocal numeric analytical support for this community, we examined the regional distribution of all taxa included in the revised description of Hunter Valley Weeping Myall Woodland.

Two of these taxa are eucalypts (*Eucalyptus crebra*, *Eucalyptus dawsonii*), both characteristic of three surrounding TECs, while seven are small trees (*Acacia homalophylla*–*Acacia melvillei* complex, *Acacia pendula*, *Acacia implexa*, *Acacia salicina*, *Allocasuarina luehmannii*, *Brachychiton populneus* subsp. *populneus*, *Callitris endlicheri*). The last five of these are particularly abundant and widespread across a range of habitats in the Hunter Valley, although *Acacia salicina* is most prominent between Jerrys Plains and Martindale, and extends into Ravensworth and the northern Hunter around Aberdeen and Scone. *Acacia homalophylla*–*Acacia melvillei* complex and *Acacia pendula* occur in several landscapes in

agricultural land across the mid and upper Hunter Valley, typically as individual trees or small clumps, with records increasing sharply in recent years as grazing pressure has been removed (Bell & Driscoll 2014a).

Six shrub species included in the determination are particularly wide ranging (*Dodonaea viscosa*, *Maireana microphylla*, *Myoporum montanum*, *Notelaea microcarpa* var. *microcarpa*, *Psydrax odorata* subsp. *buxifolia*, *Spartothamnella juncea*), while seven others are less common but are not confined to habitat supporting *Acacia pendula* (*Acacia gunnii*, *Geijera parviflora*, *Geijera salicifolia* var. *salicifolia*, *Rhagodia parabolica*, *Sarcostemma australe*, *Sclerolaena muricata*, *Senna artemisioides* subsp. *zygophylla*). Based on available data, *Geijera parviflora* and *Rhagodia parabolica* appear more abundant around Scone in the north of the Hunter, while *Geijera salicifolia* var. *salicifolia* is prominent along both the southern and northern rims of the Valley. *Sarcostemma australe* and *Sclerolaena muricata* are rare in the Hunter, with scattered records around and north of Denman and Wybong, but are again not confined to Hunter Valley Weeping Myall Woodland.

Ground layer vegetation includes sixteen grass taxa, sixteen forbs and herbs, one each of fern, graminoid and vine, and two mistletoes. As may be expected in grassy woodland landscapes, many of these are wind-dispersed and few occupy restricted distributions in the Hunter Valley. Exceptions include *Chenopodium glaucum*, *Lysiana exocarpi* subsp. *tenuis*, and *Ptilotus nobilis* subsp. *semilanatus*, all represented by few records in the Jerrys Plains to Wybong area (although the last two are more widespread based on Australia's Virtual Herbarium [AVH] data). The paucity of voucher specimens of *Chenopodium glaucum* from the Hunter (a single AVH collection from a storm water drain in urban Muswellbrook, possibly introduced) suggest that this normally coastal species is very rare or absent from the central and upper Hunter. Early records of this species from eastern Goulburn River National Park, Jerrys Plains and Wybong may have been, in the absence of fertile material, mistakenly referred to the superficially similar and more common *Atriplex semibaccata*. Similarly, the coastal mistletoe *Amyema congener* subsp. *congener* is also included in the community list for Hunter Valley Weeping Myall Woodland, but these early records from the Jerrys Plains area may be misidentified *Dendrophthoe vitellina*, a superficially similar but more prevalent mistletoe species in the area. Finally, two grass species are included in the determination list but their presence as diagnostic taxa is also questioned. We have no knowledge of *Monachather paradoxus* from the Hunter Valley, and herbarium collections indicate that it occurs well west of the region (west of Dubbo); it is not present in systematic data from known stands of Weeping Myall. While rare on the Hunter Valley floor, *Poa sieberiana* is common at higher elevations on basalt and other fine-sediment substrates, and it too is absent from plot data within Hunter Valley Weeping Myall Woodland.

When assessed collectively, the vast majority of taxa purported to be characteristic of Hunter Valley Weeping Myall Woodland are in fact common and widespread across the region in many differing habitats. Those that do display restricted distributions are not confined to definable areas or habitats, but appear to be opportunistic and a reaction to anthropogenic disturbances. As a consequence, it is difficult to identify a particular suite of taxa out of these sixty that could realistically characterise Hunter Valley Weeping Myall Woodland above all other surrounding vegetation. Acknowledging the fact that an ecological community is comprised of many different species occurring in differing abundances, and in a definable biophysical envelope, the high proportion of widespread species and few species showing clear fidelity suggests little demonstrable floristic evidence to support the existence of Hunter Valley Weeping Myall Woodland.

Western conduit for species movement in the Hunter Valley

Tozer and Chalmers (2015) discuss several times the theory first postulated by Beadle (1981) that there exists a conduit for the easterly movement of flora and fauna along the Goulburn River Valley and into the Hunter. They use this to suggest that the apparent disjunct occurrence of *Acacia pendula* and other semi-arid species in the Hunter Valley may be a function of discontinuities in edaphic and climatic factors, resulting in only scattered suitable habitat for these species. This line of reasoning does not concur with habitat modelling prepared by us for *Acacia pendula* over much of the central and upper Hunter Valley. Our habitat suitability model shows that almost the entire Hunter Valley floor (~175,000 ha) provides potential habitat for *Acacia pendula* (Figure 2), and by logical extension Hunter Valley Weeping Myall Woodland. This model was prepared using Maxent version 3.3.3k (www.cs.princeton.edu/~schapire/maxent/), a well-tested and widely used software package for creating environmental niche models, and was run at a 100 metre grid resolution across a 15,530 km² study area. By way of validation, the Area Under the Curve (AUC) of the Receiver Operating Characteristic (ROC) returned values of 0.942 for training data and 0.929 for test data for Sensitivity vs. 1-Specificity (i.e. true positives vs. false positives). An AUC value of 1 would be a perfect model and of 0.500 would be no better than random prediction.

Based on this model, there is no edaphic and climatic niche along the southern, central section of the Hunter floor where *Acacia pendula* would be restricted. Instead, existing records predict a considerably wider distribution, nearly 900 times the estimated 200 ha pre-European distribution, or 20 times the 84 km² estimated area of occupancy of Hunter Valley Weeping Myall Woodland (both estimates from NSW Scientific Committee 2016). It is likely that similar modelling of other semi-arid species present in the Hunter, such as the seven highlighted by Tozer and Chalmers (2015), would show a comparable distributional pattern.

Lack of definition through numerical classification

Despite the many numerical classifications of vegetation communities undertaken in the Hunter Valley, none have unequivocally delineated Hunter Valley Weeping Myall Woodland as a distinct community. At the time of Peake's (2006) vegetation classification of the Hunter Valley floor, he had no systematic plot data to analyse so resorted to a subjective description of the community based on limited field notes. Soon after, Umwelt (2006) documented two forms of Hunter Valley Weeping Myall Woodland at Jerrys Plains, but again this was subjectively defined. Bell (2007) performed a localised analysis of sample data collected at Jerrys Plains and Warkworth, and found a strong relationship between *Acacia*-dominated stands relative to other forest and woodland vegetation. Somerville (2009) did include Hunter Valley Weeping Myall Woodland in his classification, but only via an expert review process after finalising his numerical classification (see his Table 4.6). The subsequent classification by Sivertsen et al. (2011), leading onto the Greater Hunter Mapping Project, adopted Somerville's (2009) classification without question or further numerical interrogation.

Bell (2012) documented attempts to numerically define Hunter Valley Weeping Myall Woodland, but limited data and sampling opportunities brought into question the robustness of the results. Using ordination techniques, a divergence of samples in a regional dataset was demonstrated, suggesting that a distinct entity characterised by *Acacia pendula* may be present. However, conclusions drawn were only tentative given the low species diversity and abundances in some of the sites (18 taxa), and the high abundance rating applied to *Acacia pendula*. In their recent paper, Tozer and Chalmers (2015) interpreted the results of this ordination as sufficient justification for demarcation of Hunter Valley Weeping Myall Woodland, but we remain cautious on this issue for two reasons:

1. Limitations and context of available data - Numerical classification is only as good as the sample data that goes into it. Hence, if there are limited or questionable data, or even no data within a certain habitat or locality, it is easy to overlook the implications of this when interpreting an analysis. In situations such as Hunter Valley Weeping Myall Woodland, analysis is restricted to what data were available at the time, and the context in which they lie. In 2012, five sample plots were available. Two of these were within a single large and dense stand of *Acacia pendula*, which supported relatively few understorey species, all at low abundance. A third sample was located at a separate but similarly dense stand of *Acacia pendula*, again with a sparse and depauperate understorey. A fourth sample was located within a remnant patch of *Eucalyptus dawsonii* woodland, but with a mid-storey of *Acacia pendula* and various grasses and herbs. The fifth sample was located within derived native grassland in a *Eucalyptus moluccana* landscape, supporting a small group of *Acacia pendula* trees adjacent to a farm watering point. Clearly, a range of different conditions and contexts of Hunter Valley Weeping Myall Woodland

were present in this dataset, but all tied by the presence of *Acacia pendula*.

2. Datasets with limited observations – Some environments support few species, and in most cases such as this a single species tends to clearly dominate. Often, this dominance can lead to dense shading which impacts directly on co-occurring species. The formation of dense low forest *Acacia* stands with few other species in other environments is not an uncommon feature of the New South Wales landscape (Keith 2004; Hunter 2005). Even within the Hunter region there are sizeable stands of 'wattle scrubs' dominated by small tree species such as *Acacia binervia*, *Acacia doratoxylon*, *Acacia dangarensis*, and *Acacia bulgaensis*. For *Acacia pendula* stands in the Hunter, species diversity is less than half that recorded for surrounding forest and woodland vegetation (mean = 22.6, range 16-33, n = 5 vs 46.4, range 18-78, n = 141 from Peake 2006), largely a result of shading. When data from these environments are included in larger datasets where much more diverse environments are typical, seemingly legitimate sample clustering can be achieved in numerical analysis, but these should always be subject to closer scrutiny.

Tozer and Chalmers (2015) used the ordination presented in Bell (2012) to support their case for the existence of Hunter Valley Weeping Myall Woodland, but were likely unaware of the limitations and context of the underlying dataset. To help clarify the situation, we revisited this dataset with the addition of two new samples from purported Hunter Valley Weeping Myall Woodland (identified as such by Umwelt 2013), together with other more recently collected data from various landscapes on Permian sediments of the Hunter Valley, including several sample plots from derived native grasslands. We aimed to delve further into the relationships existing between samples collected within Hunter Valley Weeping Myall Woodland and the surrounding vegetation matrix in which it occurs. To examine the potential influence of low species counts on an analysis (noted in Bell 2012 as a possible reason for sample divergence), we also added four sample plots from an unquestionably foreign habitat that occurs in this part of the Hunter Valley: 20-25 year old mining rehabilitation of Sugar Gum (*Eucalyptus cladocalyx*) forest at Ravensworth (between Singleton and Muswellbrook). Sugar Gum is a South Australian species which was widely planted in the Hunter Valley from the 1970s, and has been used in the rehabilitation of several former mine sites in the region. All plots from the updated dataset are available in the NSW OEH VIS database (<http://www.environment.nsw.gov.au/research/Vegetationinformationsystem.htm>), and have been sampled by the one observer utilising identical methods (0.04 ha plots, sampling all vascular species, and application of standard 1-6 modified Braun-Blanquet cover abundance codes). Ordination analysis was undertaken in Primer 6 (Clarke & Gorley 2006), using non-metric multi-dimensional scaling, the Bray-Curtis similarity co-efficient and a minimum stress of 0.01.

The revised dataset comprised 402 sample plots from Permian sediments of the central and upper Hunter Valley,

extending west along the Goulburn River corridor to Bylong and Wollar (Figure 3), double the samples analysed by Bell (2012). The wide separation of the seven samples from Hunter Valley Weeping Myall Woodland in the ordination (Figure 4) illustrates the variation present in this community, and like the 2012 analysis shows two distinct groups of samples. Crucially, two important points can be highlighted from this analysis that have only become evident with the addition of data from anthropogenic Sugar Gum forest and derived native grasslands. Firstly, the ordination shows how similar some Weeping Myall sites are to the anthropogenic Sugar Gum community (Weeping Myall plots 1-3). These Weeping Myall plots are located at Jerrys Plains cemetery and at Warkworth (both accepted locations for the TEC, and specifically noted in determinations), and they share with *Eucalyptus cladocalyx* stands a very bare and species poor understorey (cf. Figure 5 & 6). In the ordination, these plots

fall well clear of the remaining collection of Permian-based forests and woodlands, yet due to their known anthropogenic status they would never be considered representative of an endemic or threatened vegetation community. With no prior knowledge of these data, this outlying group of seven plots (Weeping Myall & Sugar Gum collectively) could very easily be combined and presented as Hunter Valley Weeping Myall Woodland given the divergence it shows from other samples. Although an analysis of similarity would be beneficial to test the significance of such a union, the limited replicates available and the resultant lack of possible permutations restrict this.

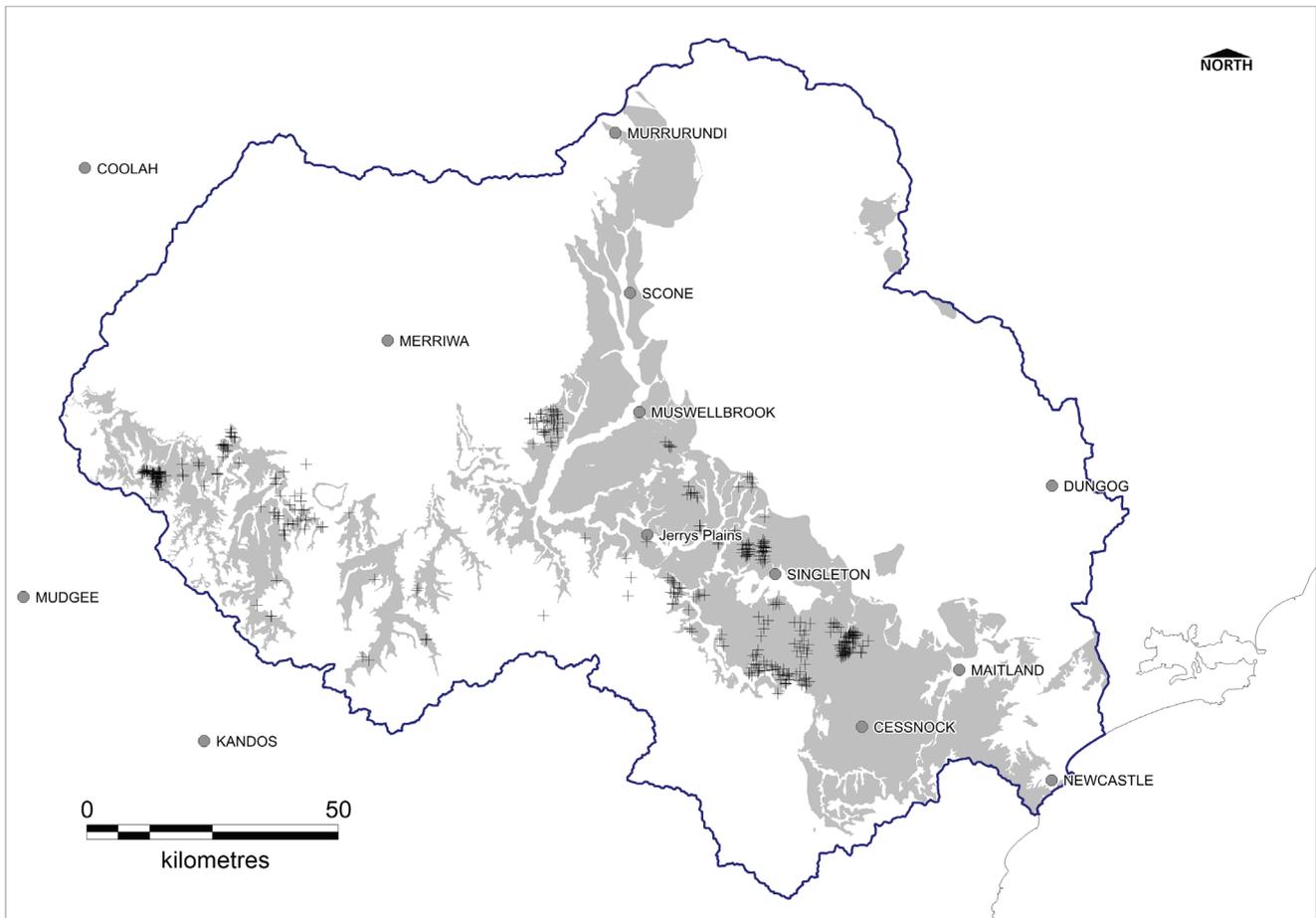


Figure 3. Distribution of 402 sample plots used in ordination analysis, from Permian sediments of the central to upper Hunter Valley, and west along the Goulburn River corridor.

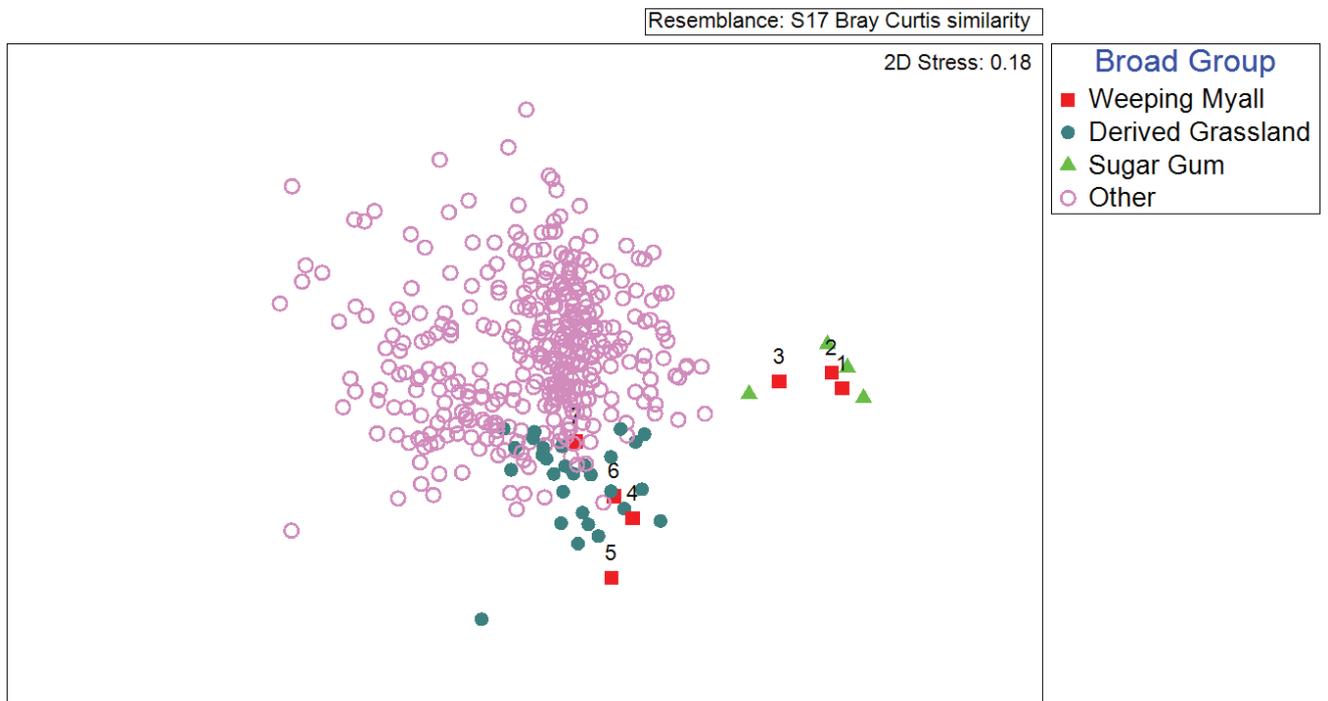


Figure 4. Non-metric multi-dimensional ordination of 402 sample plots from Permian sediments of the Hunter Valley. Plots sampled within Weeping Myall (1-7; 7 obscured), Derived Native Grassland and Sugar Gum are highlighted (*a priori* selected), the balance represent various forests and grassy woodlands on the Hunter Valley floor and footslopes between Cessnock, Muswellbrook and Wollar (approximating the 700 mm annual rainfall isohyet). Weeds removed for analysis; see Appendix 1 for repeat analyses varying key factors.



Figure 5. Hunter Valley Weeping Myall Woodland at Warkworth.



Figure 6. A stand of Sugar Gum (*Eucalyptus cladocalyx*) on mining rehabilitation near Ravensworth.

The ordination also clearly illustrates a strong gradation of Weeping Myall samples from grassy woodland to Derived Grassland (remaining four Weeping Myall plots, 4-7) from the Singleton, Wybong and Warkworth districts. The floristic composition of Weeping Myall plots 4-6 share many species with Derived Grassland, which themselves also merge with other grassy woodlands in the Hunter. Collectively, these three Weeping Myall sites (from the Wybong and Broke localities) are inseparable from the grasslands of the Hunter Valley floor. The final sample (7, also from Broke) is indistinguishable from other grassy woodlands in the Singleton and Broke localities. An analysis of similarity undertaken on these two groups (i.e. Derived Grassland & the grassy form of Weeping Myall), using the ANOSIM routine in Primer, showed there to be no significant difference between them ($R = 0.17$, $p = 0.119$).

The above analysis illustrates the value in a good knowledge of data, and the need to interpret perceived patterns with caution. Repeat analysis including all weed species, and with the masking of *Acacia pendula* returned near-identical results (Figures A1-A3, Appendix 1), suggesting that underlying trends are consistent irrespective of these key variables. Bell (2012) cautioned that the divergence shown in Weeping Myall samples was more likely to be a reflection of the depauperate understorey typical of dense *Acacia* populations, rather than a definable and meaningful group.

Tozer and Chalmers (2015) did not concur, but chose to interpret the divergence as representing a valid separation in the data. From the revised ordination produced here, either of the two Weeping Myall groups (Sugar Gum-Weeping Myall or Derived Grassland-Weeping Myall) could, in ignorance, be accepted as Hunter Valley Weeping Myall Woodland, but for the fact that the additional data has highlighted too many inconsistencies in its delineation. Both the Sugar Gum and Weeping Myall samples (samples 1-3 in the ordination) characteristically support a dense small tree layer, over a very poor understorey of similar species. It is not uncommon in numerical analyses for data with relatively few observations in each sample unit to form discrete groups in an ordination or cluster diagram, but it does not always indicate a sensible outcome. Differences may be apparent, but they may be the result of any of a number of unexpected past disturbances. Some authors (e.g. Benson & Ashby 1990) have employed the use of the Kulczynski similarity co-efficient rather than Bray-Curtis to examine disturbed landscapes, as it describes similarity based on shared species composition and not the absence of species. However, there is some evidence to suggest that this co-efficient behaves equally erratically to Bray-Curtis when samples are sparse (Clarke et al. 2006). Despite this, we have utilised this co-efficient in repeat analyses of our dataset, and overall trends remain the same as that presented above (see Figures A4-A6, Appendix 1).

How regional botanists identify Hunter Valley Weeping Myall Woodland

This lack of support for Hunter Valley Weeping Myall Woodland through numerical classifications has confounded attempts by workers in the field to identify this community. As noted earlier, current legislation dictates that a vegetation community be defined using floristic and abiotic characteristics. The *TSC Act 1995*, for example, defines a community as “*an assemblage of species occupying a particular area*”. Determinations and listing advices for threatened communities typically provide plant species that characterise a community, which when used in combination with abiotic features identify a particular habitat as that community. Ideally, these lists of species emanate from a numerical classification that can show unequivocal evidence for a community, particularly when placed into context with surrounding or floristically similar assemblages of species. This is yet to be demonstrated for Hunter Valley Weeping Myall Woodland, despite suggestions to the contrary by Tozer and Chalmers (2015).

For some years, regional botanists have highlighted the presence of Hunter Valley Weeping Myall Woodland in development application and other survey work only through the observed presence of *Acacia pendula*: it has become a flagship or *de facto* indicator species for the community. At the extreme, maps of this CEEC have been included in impact assessment reports purely by encircling regrowth stands of *Acacia*, with seemingly little investigation of co-occurring species or landscape position (e.g. Parsons Brinckerhoff 2012; Umwelt 2013). In other cases attempts have been made to rationalise field data with legal descriptions (e.g. FloraSearch 2014), but a conservative viewpoint has often been adopted. In the absence of more tangible guidelines, investigations such as these are good examples of how the presence of stands of *Acacia pendula* have been used as a surrogate for identifying Hunter Valley Weeping Myall Woodland. Indeed, there are no examples of habitat being mapped as Hunter Valley Weeping Myall Woodland in the absence of *Acacia pendula*. Such a situation is undesirable in threatened species planning, where competition for conservation dollars in an already congested field may impact on other more deserving species or communities.

Conclusions

In our earlier paper (Bell & Driscoll 2014a), we outlined several reasons in support of *Acacia pendula* never having been a natural component of the landscape in the Hunter Valley prior to European settlement. This included an extensive search of historical and contemporary literature, review of database and herbarium records, and an assessment of habitat both within and outside of the Hunter Valley. Our argument was acknowledged as persuasive by Tozer and Chalmers (2015), but they consequently suggested that uncertainty regarding the origins of this species did not necessarily preclude the existence of Hunter Valley Weeping

Myall Woodland, and the other semi-arid species apparently associated with it.

From the information presented here, Hunter Valley Weeping Myall Woodland, as a definable ecological community, is indefensible with and without the presence of *Acacia pendula*. Purported associations of this CEEC with a small number of western species, and their presence in the Hunter facilitated by a Goulburn Valley movement corridor, are difficult to support. Of the seven key species discussed by Tozer and Chalmers (2015), most have been shown here to be widespread in the Hunter, and are associated with a range of other ecosystems across the Hunter Valley floor between Cessnock, Muswellbrook and Sandy Hollow. These species are not restricted to, or most commonly found in, Hunter Valley Weeping Myall Woodland, but form a component of several other ecosystems across the landscape. Further, these species have been shown in recent surveys to also extend beyond the Sandy Hollow truncation suggested by Tozer and Chalmers (2015), and into the Bylong Valley and other catchments of the Goulburn River around Wollar; there is a consistent presence of many of these species extending east from western districts, which perhaps was not evident in previous collections or records. Across those lands *Acacia pendula*, or a community associated with it, does not form part of the current-day landscape, and there is little evidence to suggest it ever was.

There is indeed some merit in the theory that the dispersal of plant propagules from the west via this Goulburn Valley corridor has occurred in the past. However, this easterly movement of species should not be used in support of a threatened ecosystem that cannot be defined on the ground, and where there is still debate over whether its main and structurally domineering member naturally occurs in the Hunter. Despite the presence of these westerly species in the Hunter, and there are many, anthropogenic disturbances in the 200 years of European settlement have surely blurred the boundaries of any ecosystem that may have once had merit in protecting. Tozer and Chalmers (2015) themselves noted that “... *the long history of disturbance in the Hunter Valley, combined with a paucity of systematic, quantitative survey data, increases the risk that biogeographic patterns are confounded with anthropogenic artefacts*”. In short, there is no current-day evidence to suggest that these western species can be used as a surrogate for, or indication of, Hunter Valley Weeping Myall Woodland. More realistically, these species form a part of the dominant grassy woodlands of the Hunter Valley floor, habitats which are already represented in the State listed Central Hunter Grey Box – Ironbark Woodland, Central Hunter Ironbark – Spotted Gum – Grey Box Forest, Hunter Valley Foothills Slaty Gum Woodland, and grasslands derived from these, and the federally listed Central Hunter Valley Eucalypt Forest and Woodland.

If such a suite of western species indicative of Hunter Valley Weeping Myall Woodland cannot be identified by species association, can it be defined using numerical classification techniques? The revised ordination presented in this paper, based on over 400 sample sites across Permian sediments from the central and upper Hunter, shows conclusively

that it cannot. Samples representative of the two forms of Hunter Valley Weeping Myall Woodland are floristically no different from anthropogenic stands of *Eucalyptus cladocalyx* on old mining land, and native grasslands derived from *Eucalyptus crebra* and/or *Eucalyptus moluccana* landscapes. The divergence in data observed in the earlier ordination presented in Bell (2012) was evidently a function of data availability and context, which cannot be maintained when tested with additional data from these two habitats. Suggestions in that earlier work that shading by dense *Acacia* stands may be creating an unnatural grouping in the ordination, and that a cautious interpretation be made, have been justified here. There remains a lack of satisfactory and conclusive numerical support for the delineation of Hunter Valley Weeping Myall Woodland.

In our view, there is no justification for the listing of Hunter Valley Weeping Myall Woodland as a Critically Endangered Ecological Community at either State or Federal level. Further, with the uncertainty surrounding the origins of Hunter *Acacia pendula* plants, uncertainty which Tozer and Chalmers (2015) acknowledge, there is no justification for any endangered community or population listing related to this species. The distribution of multiple western species in relation to soil and climatic gradients in the Hunter occurs irrespective of, and in no relationship to, Hunter Valley Weeping Myall Woodland. Consequently, we disagree that the origin of *Acacia pendula* is irrelevant to the status of Hunter Valley Weeping Myall Woodland, as with or without this species there is no support for a community. We see little gain in legally protecting an entity at the highest possible threat category, both under Commonwealth and New South Wales legislation, when experienced and competent botanists cannot confidently locate it in the field without the visual cue of *Acacia pendula*, and when co-occurring species in those stands differ imperceptibly from the surrounding landscape.

Acknowledgements

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References

- Beadle NCW (1981) *The Vegetation of Australia*. Cambridge University Press, Cambridge.
- Bell, S.A.J. (2007) *Acacia pendula in the Hunter Valley: Update of investigations*. Unpublished Report to HLA Envirosciences Pty Ltd & Wambo Coal Mine. Eastcoast Flora Survey. June 2007.
- Bell, S. (2012) Consultancy advice regarding a review of the 2005 listing under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) of *Weeping Myall – Coobah – Scrub Wilga Woodland/Low Forest of the Hunter Valley*, for Department of Sustainability, Environment, Water, Population and Communities, Canberra.
- Bell, S. and Driscoll, C. (2014a) *Acacia pendula* (Weeping Myall) in the Hunter Valley of New South Wales: early explorers' journals, database records and habitat assessments raise doubts over naturally occurring populations. *Cunninghamia* 14: 179–200.
- Bell, S.A.J. & Driscoll, C. (2014b) *Assessment and mapping of vegetation in the Bylong Valley: Authorisations 287 & 342*. Unpublished Final Report to Hansen Bailey Pty Ltd. Eastcoast Flora Survey. December 2014.
- Benson, J.S. & Ashby, E.M. (2000) Vegetation of the Guyra 1: 100 000 map sheet New England Bioregion, New South Wales. *Cunninghamia* 6(3): 747-872.
- Clarke, K.R. & Gorley, R.N. (2006) *PRIMER v6: User Manual/Tutorial*. PRIMER-E: Plymouth.
- Clarke, K.R., Somerfield, P.J., & Chapman, M.G. (2006) On resemblance measures for ecological studies, including taxonomic dissimilarities and a zero-adjusted Bray-Curtis coefficient for denuded assemblages. *Journal of Experimental Marine Biology and Ecology* 330: 55-80.
- Ecovision (2008) *Ecological Impact Assessment – Stage 2 of the Moolarben Coal Project*. Unpublished Report to Moolarben Coal.
- FloraSearch (2005) *Wilpinjong Coal Project. Appendix HA: Flora Assessment*. Unpublished Report to Wilpinjong Coal.
- FloraSearch (2014) *North Wambo Underground – Longwall 10A Modification. Flora Assessment*. Prepared for Wambo Coal Pty Limited by FloraSearch, August 2014.
- Keith, D.A. (2004) *Ocean Shores to Desert Dunes: The Native Vegetation of New South Wales and the ACT*. Department of Environment and Conservation: Hurstville.
- Hunter, J.T. (2005) Floristics and distribution of Wattle Dry Sclerophyll Forests and Scrubs in north-eastern New South Wales. *Cunninghamia* 9(2): 317-323.
- Moolarben Biota (2006) *Moolarben Coal Project Flora, Fauna and Aquatic Ecology Assessment*. Unpublished Report to Moolarben Coal.
- NSW Scientific Committee (2006) *Final Determination to list Hunter Valley Weeping Myall Woodland of the Sydney Basin Bioregion as an endangered ecological community*. NSW Scientific Committee.
- NSW Scientific Committee (2016) *Final Determination to list Hunter Valley Weeping Myall Woodland of the Sydney Basin Bioregion as a critically endangered ecological community*. NSW Scientific Committee.
- Parsons Brinckerhoff (2012) *Doyles Creek underground mine and training school. Project overview*. NuCoal Resources Ltd, March 2012.
- Peake, T.C. (2006) *The Vegetation of the Central Hunter Valley, New South Wales. A report on the findings of the Hunter Remnant Vegetation Project*. Hunter–Central Rivers Catchment Management Authority, Paterson.
- Sivertsen, D., Roff, A., Somerville, M., Thonell, J., & Denholm, B. (2011) *Hunter Native Vegetation Mapping. Geodatabase Guide (Version 4.0)*. Internal Report for the Office of Environment and Heritage, Department of Premier and Cabinet, Sydney, Australia.
- Somerville, M. (2009) *Hunter, Central & Lower North Coast Vegetation Classification & Mapping Project. Volumes 1: Vegetation classification technical report*. Prepared by HCCREMS/ Hunter Councils Environment Division for Hunter-Central Rivers Catchment Management Authority, Tocal, NSW.
- Tozer, M., & Chalmers, A. (2015) Should Hunter Valley Weeping Myall Woodland in the Sydney Basin Bioregion be listed as a Threatened Ecological Community? *Cunninghamia* 15: 201-204.

Umwelt (Australia) Pty Limited (2006) *Status of the Endangered Ecological Community, Hunter Valley Weeping Myall Woodland*. Prepared by Umwelt (Australia) Pty Limited for the Department of Environment and Conservation (NSW).

Umwelt (Australia) Pty Limited (2013) *Ecological Impact Assessment: Bulga Optimisation Project*. Prepared by Umwelt (Australia) Pty Limited on behalf of Bulga Coal Management Pty Limited, April 2013.

Wells Environmental Services (2011) *Mt Penny Coal Project. Preliminary Environmental Assessment*. Unpublished Report, February 2011.

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Appendix 1 Repeat analyses varying weed presence, inclusion of *Acacia pendula* and *Acacia melvillei*, and similarity coefficient (Bray-Curtis vs Kulczynski).

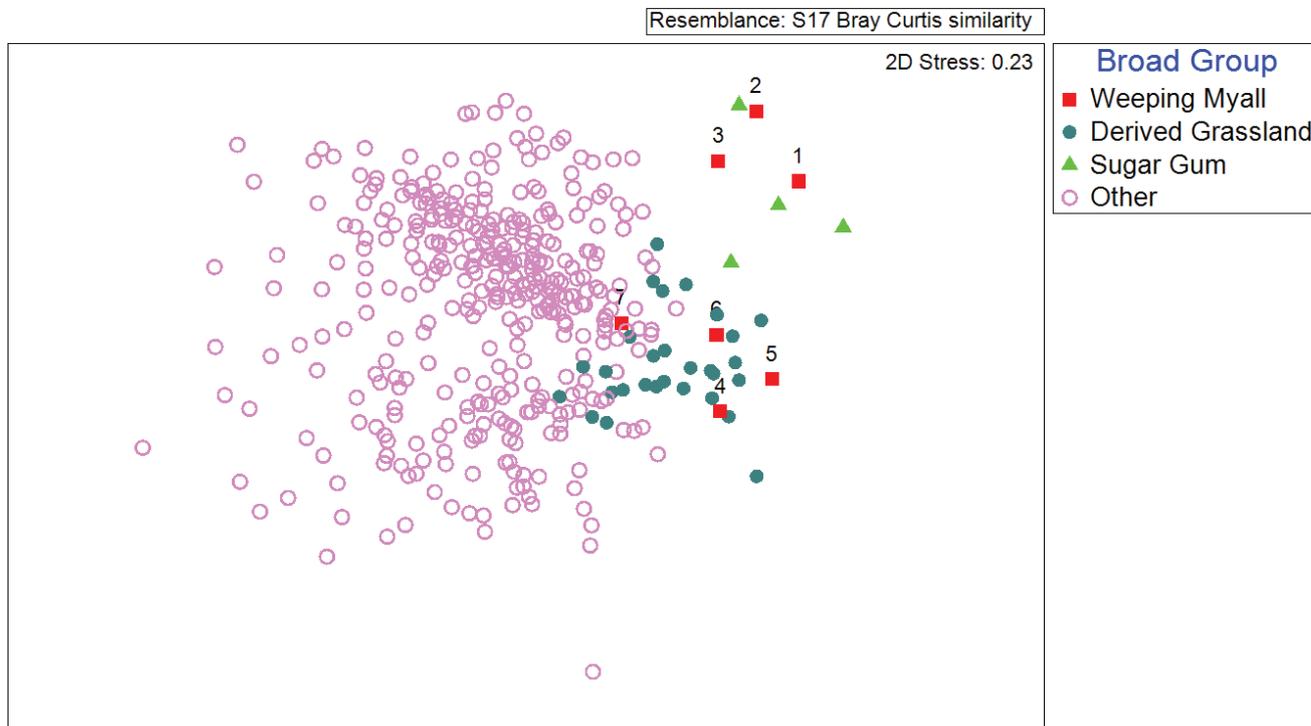


Figure A1. Non-metric multi-dimensional ordination of 402 sample plots from Permian sediments of the Hunter Valley. Plots sampled within Weeping Myall (1-7; 7 obscured), Derived Native Grassland and Sugar Gum are highlighted (*a priori* selected). **Bray-Curtis similarity index. Weeds included in analysis.**

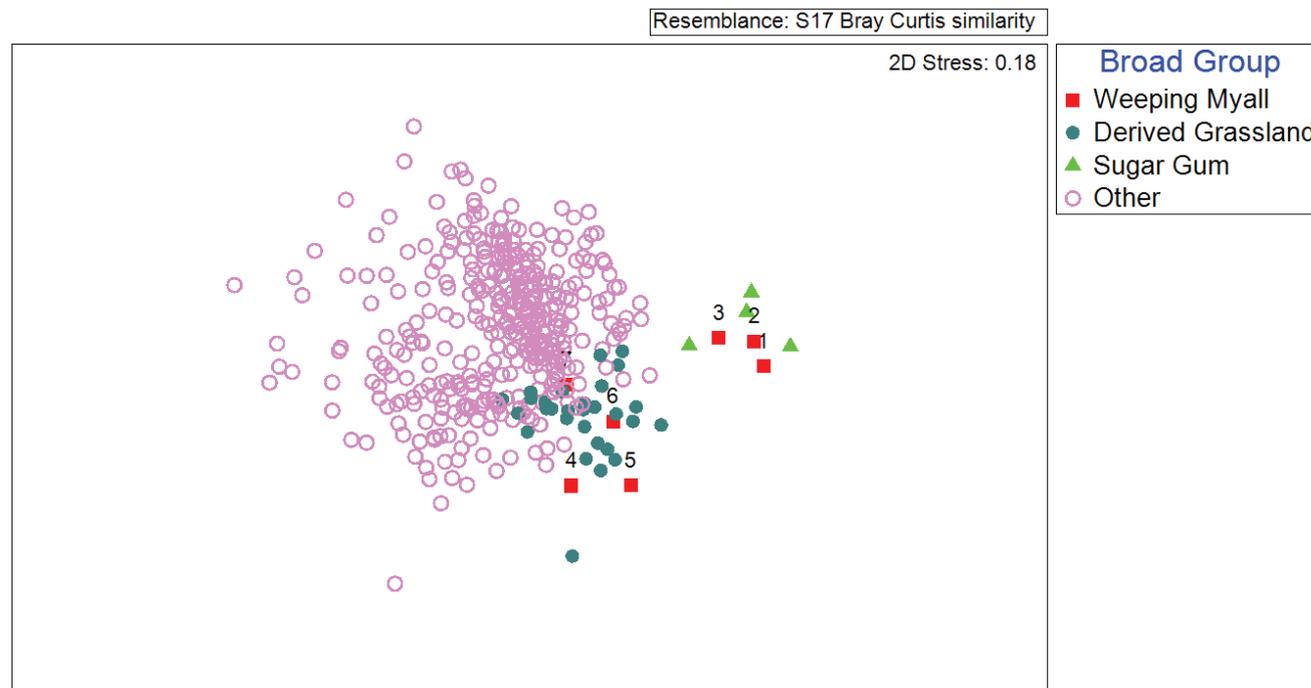


Figure A2. Non-metric multi-dimensional ordination of 402 sample plots from Permian sediments of the Hunter Valley. Plots sampled within Weeping Myall (1-7; 7 obscured), Derived Native Grassland and Sugar Gum are highlighted (*a priori* selected). **Bray-Curtis similarity index. Weeds, *Acacia pendula* and *Acacia melvillei* excluded from analysis.**

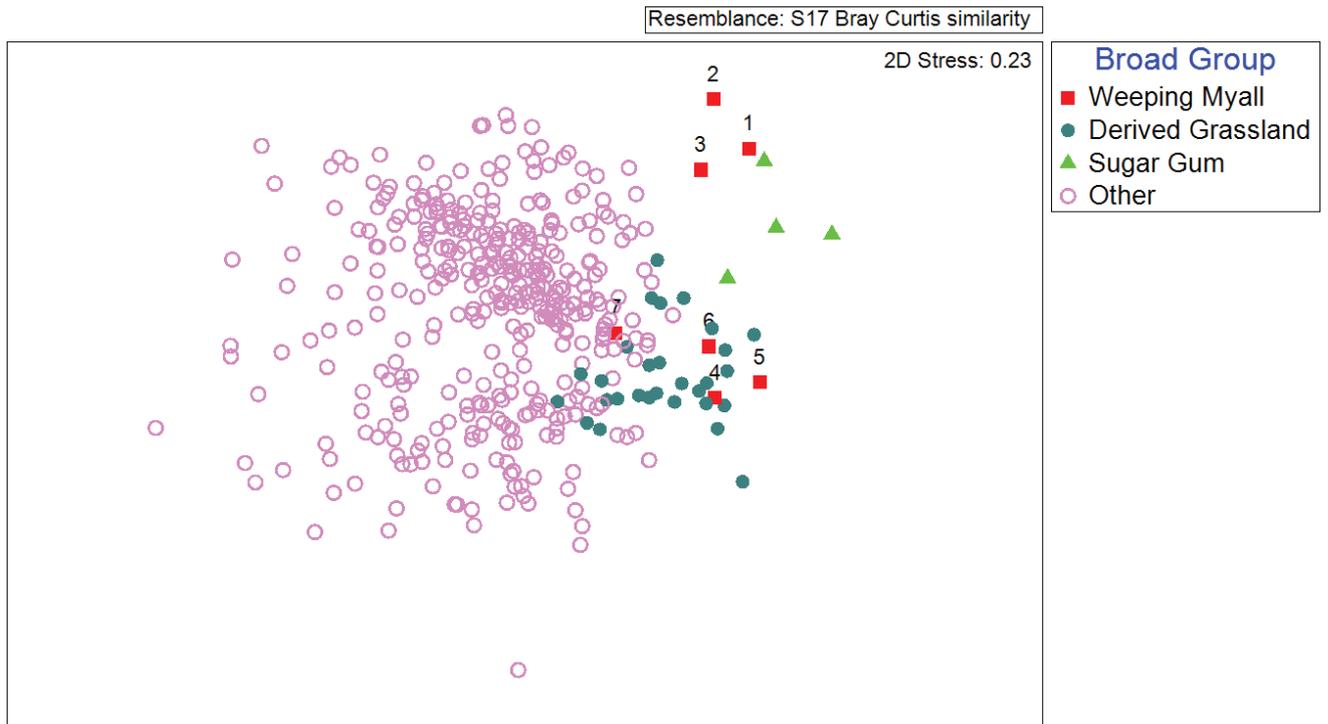


Figure A3. Non-metric multi-dimensional ordination of 402 sample plots from Permian sediments of the Hunter Valley. Plots sampled within Weeping Myall (1-7; 7 obscured), Derived Native Grassland and Sugar Gum are highlighted (*a priori* selected). **Bray-Curtis similarity index. Weeds included but *Acacia pendula* and *Acacia melvillei* excluded from analysis.**

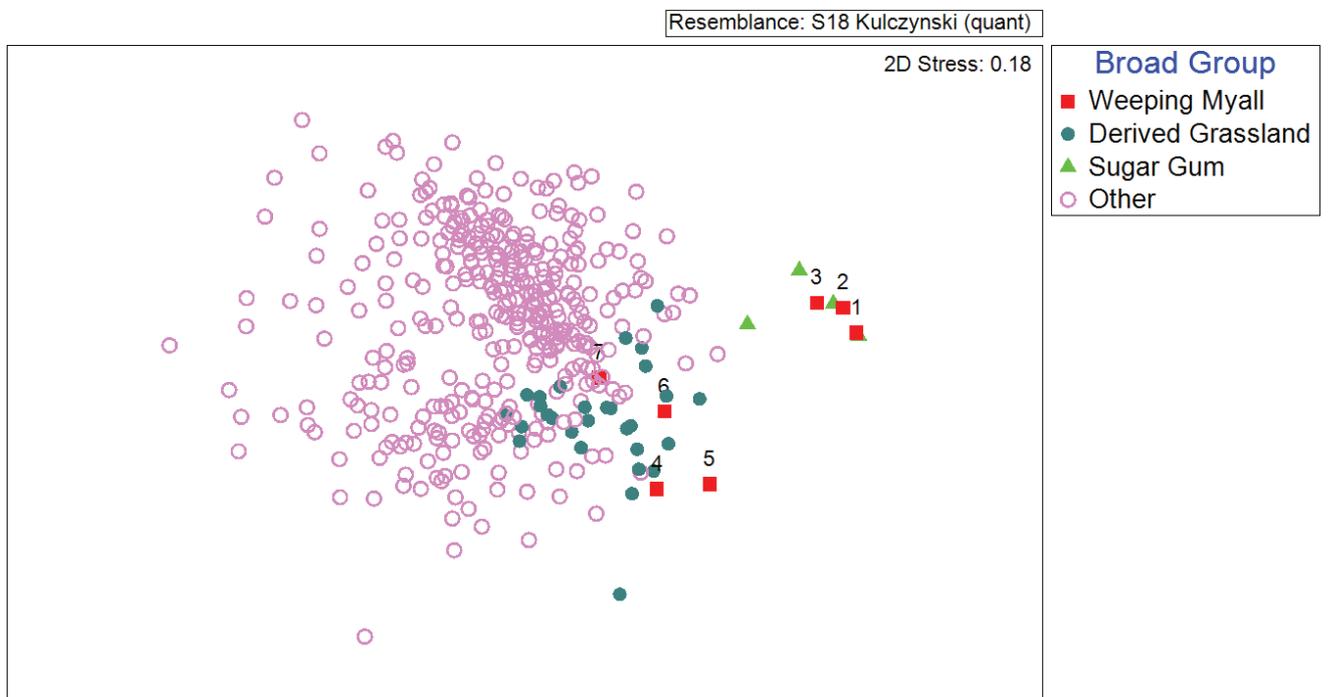


Figure A4. Non-metric multi-dimensional ordination of 402 sample plots from Permian sediments of the Hunter Valley. Plots sampled within Weeping Myall (1-7; 7 obscured), Derived Native Grassland and Sugar Gum are highlighted (*a priori* selected). **Kulczynski similarity index. Weeds excluded from analysis.**

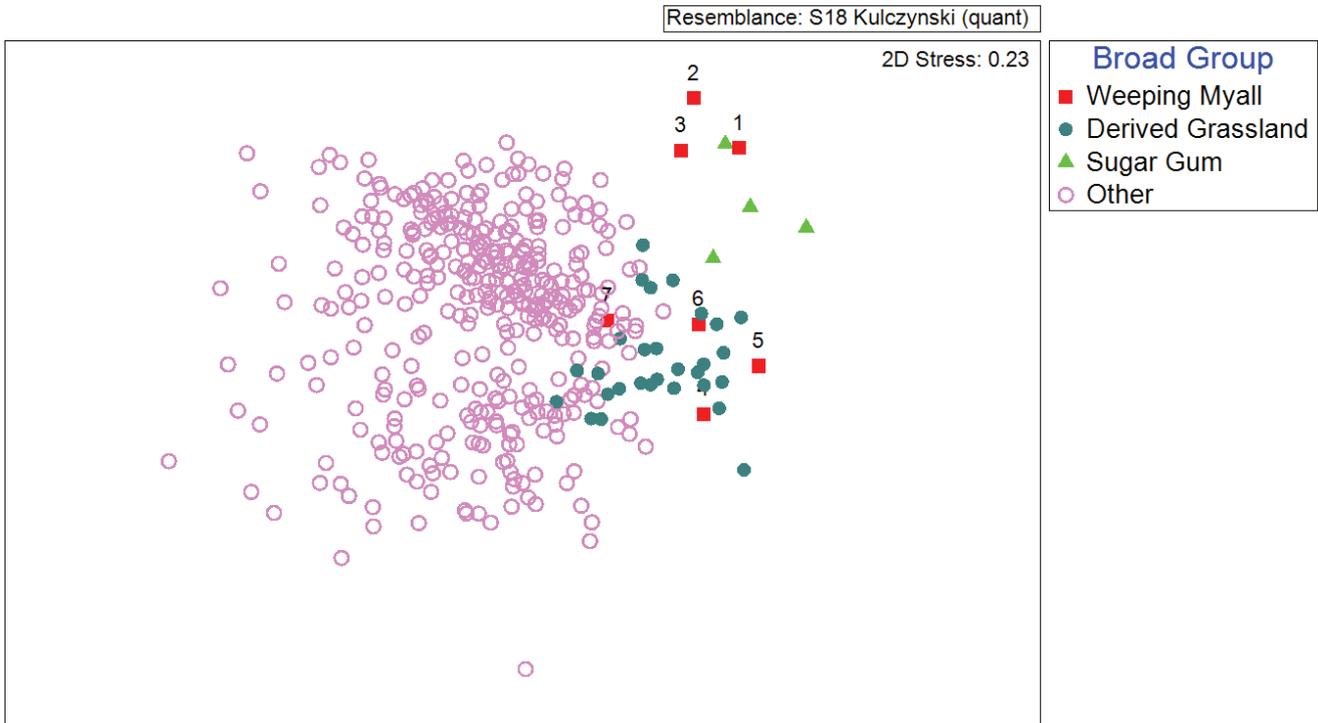


Figure A5. Non-metric multi-dimensional ordination of 402 sample plots from Permian sediments of the Hunter Valley. Plots sampled within Weeping Myall (1-7; 7 obscured), Derived Native Grassland and Sugar Gum are highlighted (*a priori* selected). **Kulczynski similarity index. Weeds included in analysis.**

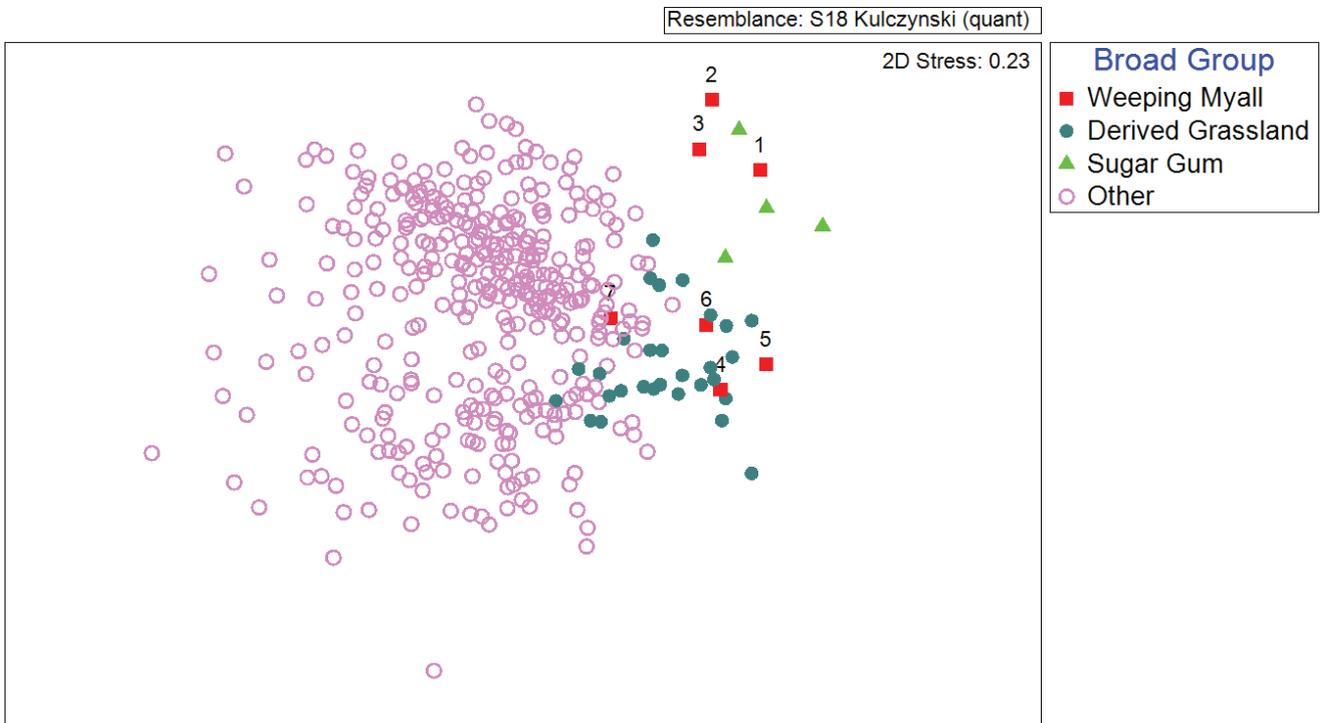


Figure A6. Non-metric multi-dimensional ordination of 402 sample plots from Permian sediments of the Hunter Valley. Plots sampled within Weeping Myall (1-7; 7 obscured), Derived Native Grassland and Sugar Gum are highlighted (*a priori* selected). **Kulczynski similarity index. Weeds, *Acacia pendula* and *Acacia melvillei* excluded from analysis.**