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## Hunter Valley Weeping Myall Woodland in the Sydney Basin Bioregion should remain listed as a Threatened Ecological Community until strong evidence emerges in support of delisting.

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Determinations for the listing of Ecological Communities made under the NSW *Threatened Species Conservation (TSC) Act (1995)* draw on the best information available at the time of listing. These data may either be qualitative or quantitative, and with or without analytical evaluation. Periodic reappraisal of the definition or status of a community may therefore be required as new data or analyses become available. In this respect, the contributions of Bell and Driscoll (2014, 2016) constitute a commendable commitment to the application of quantitative survey data to the question of how (or if) the Hunter Valley Weeping Myall Woodland should be defined.

In our response to their proposition that *Acacia pendula* was introduced to the Hunter Valley following European settlement (Tozer and Chalmers 2015), we argued that: i) the definition of a community should not be based on the presence of an individual species; and ii) irrespective of the status of *Acacia pendula*, there is evidence to support the definition of Hunter Valley Weeping Myall Woodland as an assemblage characterised by semi-arid species occupying hot and dry parts of the Hunter Valley. We believe that there are several weaknesses in the counter-arguments presented by Bell and Driscoll (2016). We outline these below before briefly elaborating on how the ordination of floristic data may be used to progress toward a more refined understanding of the composition and distribution of this Critically Endangered Community.

Bell and Driscoll (2016) contend that the assemblage of species listed in the Final Determination does not constitute a valid definition of Hunter Valley Weeping Myall Woodland because the species are widespread in a range of communities and thus show no fidelity to the community as listed. We concede that in the absence of a set of quantitative data sampled across the range and extent of the community, the nominated list of species is unlikely to be both optimal and comprehensive, and can be expected to evolve as suitable data become available. We point out, however, that the existence of such a sample is a prerequisite to the determination of fidelity, and thus the lack of fidelity alluded to by Bell and Driscoll (2016) is asserted rather than demonstrated.

More importantly, their argument suggests a misunderstanding of the community concept as currently applied to vegetation classification. The contemporary application is informed by a continuum model, under which species are understood to vary in abundance along environmental gradients with some degree of independence (Begon *et al.* 2006). As a consequence of this:

- communities are expected to exhibit variability in the assemblage of species present in different locations,
- boundaries between different communities are likely to be vague,
- there is likely to be much overlap in the species membership between different communities, and
- communities can rarely be identified conclusively based on their dominant species alone.

Bell and Driscoll's (2016) evidence for the distribution of semi-arid species across a range of vegetation communities in the central and upper Hunter Valley is therefore inconclusive. A species need not be either diagnostic of, or faithful to, a community in order to be a characteristic member, and it is widely understood that species listed in Determinations of Threatened Ecological Communities frequently occur in other communities as well. Our characterisation of the Hunter Weeping Myall Woodland implicitly incorporates the notion that semi-arid species are distributed on a gradient of moisture supply, and that they decrease in abundance from west to east due to factors such as physiological constraints and competition from other species. From this perspective, the key question is not how widely distributed individual species are, but how they co-occur in recognisable patterns along ecological gradients. We assume that the response optima of different species will vary along the hypothesised moisture gradient, and that species rarely occupy the full extent of their fundamental niches as a consequence of interactions with other species, disturbance regimes and other factors (Weins *et al.* 2009).

The logical progression from our characterisation of Hunter Valley Weeping Myall Woodland is the acquisition of data appropriate for a closer scrutiny of patterns of species turnover along climatic gradients in the central and upper Hunter Valley. Evidence in support of the continued listing of the community would comprise a more precise characterisation of the niche it occupies and the way in which the particular assemblage of species differs from others in the area. Alternatively, such evidence may not be found, in which case the argument for continued listing would be weakened and alternative vegetation classifications and possible listings could be considered.

From this perspective, the ordination analyses of Bell and Driscoll (2016) do little to advance arguments either for or against the recognition of Hunter Valley Weeping Myall Woodland, because they rely on the assumption that the sites in which *Acacia pendula* occurs constitute a sample of the putative assemblage. This stance is dependent on an extensional definition of the community and is inflexible to the proposition that the community forms part of a continuum in response to a moisture/temperature gradient. It is also inconsistent with their view that the populations of *Acacia pendula* in the Hunter Valley are not natural. Their assertion that "*community types identified 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*" suggests they favour an approach to community classification constrained by dominant species. We emphasise that dominant species are not a reliable basis for the classification and identification of community type under a continuum model.

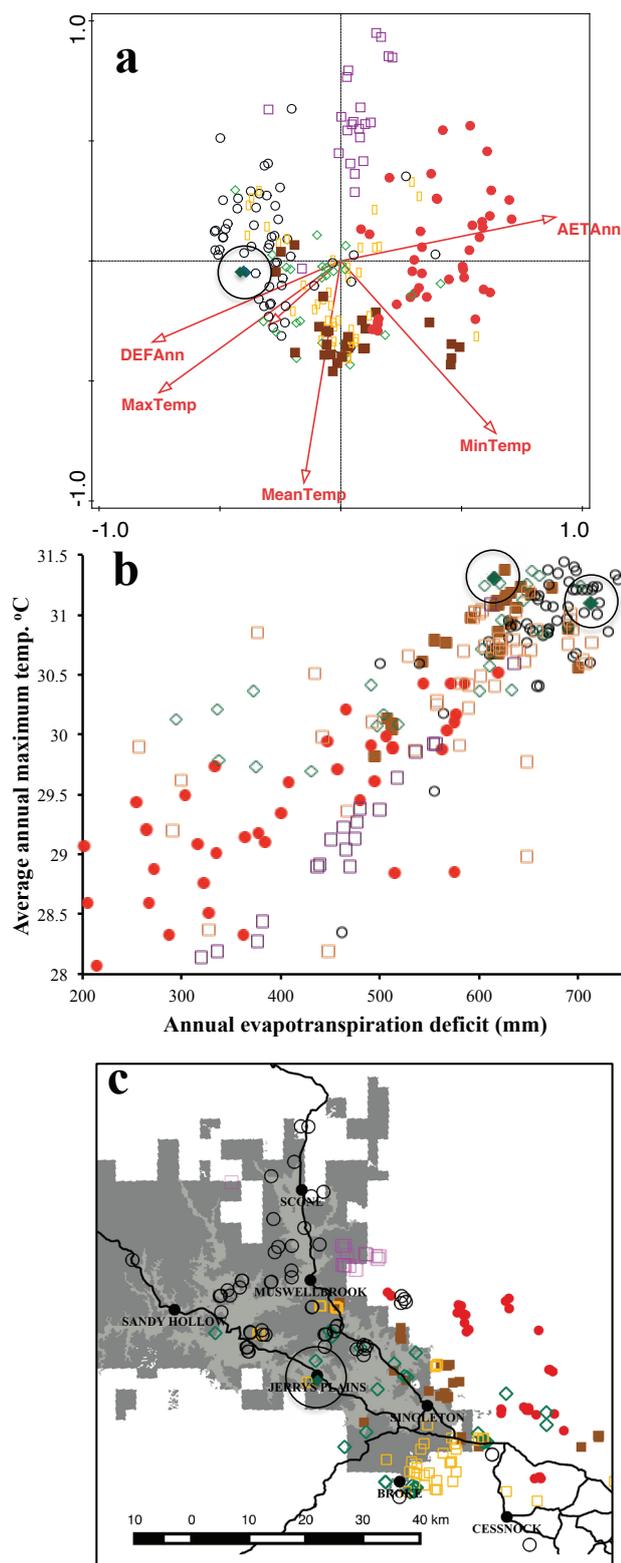
The limitations imposed when community membership is assumed *a priori* by reference to structure or dominant species are illustrated by Bell and Driscoll's (2016) interpretation of the overlap in species composition between four sites dominated by *Acacia pendula* and sites sampling

derived grassland (native vegetation from which the trees have been removed). They argue that Hunter Valley Weeping Myall Woodland is not a unique assemblage because there is no difference in average similarity among sites sampling *Acacia pendula* or derived grasslands. This assumes that sites sampling grasslands and those sampling *Acacia pendula* are not part of the same assemblage on the basis of the presence or absence of a single species. We argue that an alternative interpretation deserves scrutiny: that those sites (both eucalypt woodland and derived grassland) clustering closely with sites dominated by *Acacia pendula* have in common a suite of species by virtue of the physical characteristics shared by the locations in which they occur.

A resolution of this argument requires that the evidence for any anthropogenic effects be weighed against the potential influence of ecological drivers via a gradient analysis. For example, the ordination diagrams presented by Bell and Driscoll (2016) do not show a distinct cluster representing a combination of derived grassland and *Acacia pendula* sites. Rather, they show a continuum along which there is extensive overlap among the three categories of woodland and grassland. The extent to which this pattern constitutes evidence for the recognition of Hunter Valley Weeping Myall Woodland depends on the degree to which it correlates with plausible ecological drivers and is manifested in response gradients in individual species.

While we do not have access to the full data analysed by Bell and Driscoll (2016) we illustrate the first steps of such an approach in Figure 1. Figure 1a shows that the two sites sampling stands of *Acacia pendula* (those we had at our disposal) lie at one end of a compositional gradient that correlates with gradients in primary productivity, water deficit and extremes in summer temperature maxima. Compositionally, therefore, these sites plausibly represent the end point of a pattern in the distribution of species (and hence the composition of communities) between the coast and the hottest and driest parts of the valley. This environmental space is also sampled by a subset of sites representing other communities (as interpreted by Sivertsen *et al.* 2011) (Figure 1b). However, the full set of samples for these communities (MU085, MU086, MU173) is more broadly distributed in environmental space, including areas with lower summer maxima and lower water deficit (Figure 1b). All samples located in the relatively restricted areas of the Hunter valley that experience the most extreme drought conditions (Figure 1c) are candidates for reassessment as a sample of Hunter Weeping Myall Woodland.

We emphasise that this result is merely indicative of an ecological (as opposed to anthropogenic) pattern and does not constitute a comprehensive analysis of all the available survey data. It supports the concept of the Hunter Valley Weeping Myall Woodland as we have interpreted it, but reinforces the need to acquire more field data as a precursor to defining an appropriate sample set upon which to refine the classification.



**Figure 1:** a) Ordination of survey samples representing major vegetation communities occurring on Permian sediments in the central and upper Hunter Valley. Community classes are as defined by Sivertsen *et al.* (2011) and differentiated by symbols as described below. Sample data were analysed by canonical correspondence analysis assuming unimodal species response curves and projected in two dimensions using biplot scaling. Arrows indicate the direction of increase in environmental variables in the ordination space and their lengths are proportional to the magnitude of change. The large

black circles indicate the locations of two sites sampling vegetation dominated by *A. pendula*. AETAnn and DEFAnn represent total annual evapotranspiration and evapotranspiration deficit calculated by compiling a water balance model in a spatial framework using a Geographic Information System (Stephenson 1990, Dyer 2009). Temperature data are average annual maximum, minimum and mean supplied as raster layers by the Bureau of Meteorology (<http://www.bom.gov.au/climate/averages/climatology/gridded-data-info/gridded-climate-data.shtml>).

b) Location of the samples depicted in a) in environmental space as represented by the size of the annual evapotranspiration deficit and the average annual maximum temperature. Symbols are as described below.

c) Extent of area in the Hunter Valley in which the annual evapotranspiration deficit exceeds 600 mm (dark grey). The subset of this area over which the average maximum temperature exceeds 31.25°C is overlaid in light grey and is indicative of the envelope in which Hunter Weeping Myall Woodland potentially occurs.

(◆ - MU026 Weeping Myall/ Cooba/ Wilga shrubland of the Hunter Valley, ■ - MU083 Spotted Gum/ Narrow-leaved Ironbark / Red Ironbark shrub/ grass open forest of the central and lower Hunter, ● - MU084 Spotted Gum/ Narrow-leaved Ironbark shrub/ grass open forest of the central and lower Hunter Valley, ◇ - MU085 Narrow-leaved Ironbark/ Bull Oak/ Grey Box shrub/ grass open forest of the central and lower Hunter, □ - MU086 Narrow-leaved Ironbark/ Grey Box/ Spotted Gum shrub/ grass open forest of the central and lower Hunter, ◻ - MU088 White Box/ Narrow-leaved Ironbark/ Blakely's Red Gum shrubby open forest of the central and upper Hunter O - MU173 Narrow-leaved Ironbark/ Grey Box grassy woodland of the central and upper Hunter).

We concede that we may have confused the issue by stating that the current distribution of *Acacia pendula* is a better approximation of the distribution of the community than any other available proxy. By this we meant the extent of its present occurrence between the locations of Broke, Singleton, Muswellbrook and Sandy Hollow rather than the location of individual stands. Nevertheless, we did not, as Bell and Driscoll (2016) claim, draw any inference from the distribution of Weeping Myall sites in the ordination diagrams of Bell (2012). We simply reported these findings and Bell's interpretation that the most parsimonious explanation for the separation of Weeping Myall sites from others in the dataset was the depauperate understory of those sites. That being the case, the subsequent analyses of Bell and Driscoll (2016) lead only to the trivial conclusion that dense stands of *Acacia pendula* with a depauperate understory are most similar to other monospecific stands with depauperate understory. The key question of whether the hottest and driest parts of the Hunter Valley support an assemblage of species that differs significantly from other parts of the Hunter Valley remains unanswered.

Nominations for Threatened Ecological Communities derive from a range of sources and are supported by observations and data with different strengths and weaknesses. Inevitably, experienced ecologists will disagree on the merits of a particular nomination, and it is in this context that the Scientific Committee must weigh the uncertainty with respect to how a community can be defined against the risk of an adverse outcome should it fail to be listed. While the current Determination may not be the best possible characterisation

of Hunter Valley Weeping Myall Woodland, Bell and Driscoll's (2016) observation that 200 years of European settlement may well have blurred any putative assemblage of semi-arid species beyond recognition suggests that a Critically Endangered Listing is indeed warranted.

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