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Submission on *Warkworth Sands Woodland* EEC: Warkworth / Mt Thorley Continuation Project



July 2014

Submission to

NSW Department of Planning and Environment
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EXECUTIVE SUMMARY

A review of the proposed Warkworth Continuation Project (the “2014 Application”) has been undertaken, specifically in relation to the Warkworth Sands Woodland Endangered Ecological Community (WSW). In this regard, the 2014 Application, plans to:

- clear 72 hectares of WSW and 0.5 hectares of WSW Grassland, which will be offset by the provision of 75.5 hectares of WSW and the re-establishment of 159.5 hectares of WSW on former WSW Grassland;
- prepare an Integrated Management Plan for WSW;
- develop completion criteria for the re-establishment of WSW.

The key findings that I have found as part of this review are as follows,

Definition of Warkworth Sands Woodland – There is a long and convoluted history behind the current listing of WSW. It was originally nominated for listing on the NSW *TSC Act 1995* by the Hunter Rare Plants Group, of which I am a founding member. In our nomination of 2002, after 2 years of deliberations and research (in our own time), we included two separate species lists: one listing those species which were abundant and characteristic of WSW, and the second listing uncommon species which characterised ecotonal areas. The NSW Scientific Committee merged these two lists, and inadvertently removed the distinction between included ecotonal areas of WSW and excluded surrounding non-WSW clay vegetation (resulting in ongoing confusion by practitioners as to what constitutes WSW). Apart from this, our original nomination was adopted largely unchanged by the NSW Scientific Committee when listing WSW as an EEC.

Distribution & Extent of Warkworth Sands Woodland – Despite the NSWLEC acceptance of the 3,038 hectares of pre-European Settlement WSW calculated by Umwelt (2011), I have not changed my opinion that I believe it to be more in the vicinity of ~800 hectares. My calculation, as outlined in Bell (2012), is based on a review of finer scale soils mapping, including the Aeolian unit Czb, than was done by Umwelt (2011). In relation to the extent of WSW currently remaining, my estimate of ~400 hectares approaches the 465 hectares settled upon by the NSWLEC, which again accepted the calculations of Umwelt (2011). Both of these figures (area extant & area pre-European Settlement) have important implications on the assessment of significance and impacts on WSW, and more generally on the acceptance to remove portions of such a critically restricted vegetation community.

Significance of Warkworth Sands Woodland - WSW is a community of very high significance. It is listed only as Endangered in NSW on the *Threatened Species Conservation Act 1995*. However, application of listing criteria for State and Commonwealth legislation shows that the community should be considered as Critically Endangered on both the NSW *Threatened Species Conservation Act 1995* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Additionally, applying the threat criteria of the International Union for the Conservation of Nature (IUCN) also results in an assessment of Critically Endangered. For all intents and purposes, WSW is a **factually Critically Endangered** ecological community.

Variable Condition of Warkworth Sands Woodland – Previous land use history across the pre-European extent of WSW has resulted in a range of condition classes for the vegetation that does remain, as different areas respond to the easing of detrimental pressures. The proposal to remove the bulk of high quality areas of WSW and to compensate for that removal by the low-to-medium condition WSW in the NBA and SBA land-based offsets (despite the promises of successful restoration) is unacceptable. In the absence of any ‘old growth’ WSW, these high condition portions of WSW should be attributed greater conservation significance. Such areas have had a longer period of time in which to regenerate and mature following their last clearing event, and consequently are more likely to embody the full complement of characteristics that define the entity.

Extinction & the Precautionary Principle – WSW is a factually Critically Endangered ecological community of highly restricted distribution (465ha). For this reason alone the irreplaceability of this ecosystem warrants higher consideration in any proposal that threatens its continued existence. To date, there has been no demonstration of successful restoration of WSW, so claims that such activities will adequately offset the removal of 72ha (15%) of this community are unsupported.

UNE Research on Warkworth Sands Woodland Restoration– The 2010 Application for mining made much of the \$5.5 million paid to the University of New England (UNE) for research into the ecology of WSW. While statements to this effect are also included in the 2014 Application, nowhere are the results of this \$5.5 million research reported on, nor how they will be incorporated into restoration efforts. Apart from the mapping investigation by Kumar et. al. (2009), which yielded little new knowledge, no results of any of the WSW research have been mentioned. My own investigations have uncovered two published papers on microsatellite markers in *Banksia integrifolia* and *Hardenbergia violacea*, both sampled from WSW (Fatemi et. al. 2012, 2013), one paper on seed bank dynamics and the arrested development of WSW restoration in cleared sites (Gross & Vary 2014), and one research thesis on the role of ants in seed dispersal of selected WSW shrub species (Taylor 2010). The fact that none of these papers (nor any of their results if their publication dates post-date EA preparation) have been incorporated into plans to restore WSW is of some concern. Instead, it appears as though restoration efforts of WSW will be based on the restoration manual prepared by Niche Environmental (Thackway et. al. 2013). I have not been able to source a copy of this manual, so am unable to comment on the material contained therein. As a consequence, I consider that the role of the \$5.5 million towards WSW offsetting should be perhaps downplayed somewhat, since it appears that little of the research completed by UNE has been incorporated into WSW restoration plans.

Northern & Southern Biodiversity Areas – The 2014 Application continues to maintain that 19.5 hectares of WSW is present within the NBA, together with 156.6 hectares of WSW Grassland. Despite accepting a reduction in the overall extent of WSW currently extant to be 465 hectares (as directed by the NSWLEC), the 2014 Application does not accept the NSWLEC judgement that WSW has been over-mapped in the NBA (by about 50%). Evidently, this over-mapping has implications on the value of the NBA as an offset area, and also on the credits that may be retired under the Upper Hunter Strategic Assessments policy. For the SBA, the 56 hectares of WSW detailed in the 2014 Application is a reduction from the 85 hectares proposed in 2010, but this difference is due to some boundary changes within the SBA, and the resolution of 2003 offsetting issues.

Supplementary Offset Measure 1: Integrated Restoration Implementation Plan - In addition to the more typical land-based offsetting options, the 2014 Application proposes to prepare an Integrated

Restoration Implementation Plan (or Integrated Management Plan) for WSW as a supplementary offset measure. This is a good initiative, and aims to collaborate resources towards the recovery of WSW in the region, by the sharing of knowledge and experiences among the various land owners where WSW occurs. There is, however, little information as to how this will be undertaken, nor who will be responsible for its implementation.

Supplementary Offset Measure 2: Research into Completion Criteria for WSW – A second supplementary offset measure, research into completion criteria for WSW, has also been proposed in the 2014 Application. While on first reading this is a welcome initiative, the sort of criteria that is proposed to be researched (diversity & abundance of characteristic WSW species; appropriate % cover estimates of all strata; presence of key indicators species; habitat diversity; weed presence; etc) is already represented by a wealth of existing data which could be readily adapted for such use. In addition, it is unclear if this new research would be a duplication of information already present in the WSW Restoration Manual prepared by Thackway et. al. (2013), since that document reportedly contains: “... *a process for tracking the recovery of WSW sites towards a reference state...*” For both of the reasons outlined here, I suspect that this supplementary measure, in its current form, to be a minor compilation task of existing data, and should not be presented as an offset measure of any significance.

In conclusion, I remain concerned that the removal of 72 hectares of mostly high quality WSW will expedite the ultimate demise of this factually Critically Endangered community. Offset measures proposed have been over-stated in value, and restoration efforts planned offer no certainty that WSW can yet be re-established successfully on former grazing lands. In addition, the uncertainty regarding the stability from wind erosion of transferred sand material in which to restore WSW requires some clarification.



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25 July 2014

Table of Contents

EXECUTIVE SUMMARY	ii
1. Introduction.....	6
1.1 Background	6
1.2 Aims & Objectives.....	6
1.3 Review Documents	7
1.4 Qualifications and Experience	7
2. Warkworth Sands Woodland	9
2.1 Nomination of Warkworth Sands Woodland	9
2.2 Distribution of Warkworth Sands Woodland	10
2.3 Significance of Warkworth Sands Woodland	12
2.4 Variable Condition of Warkworth Sands Woodland	13
3. Proposed Warkworth Continuation Project	14
3.1 Key Difference between 2010 and 2014 Proposals.....	15
3.2 Risk of Extinction & the Precautionary Principle	15
3.3 University of New England Research.....	16
3.4 Biodiversity Offsetting	18
3.4.1 Northern Biodiversity Area	19
3.4.2 Southern Biodiversity Area	22
3.4.3 Supplementary Measure 1: Integrated Restoration Implementation Plan	22
3.4.4 Supplementary Measure 2: Research into Completion Criteria	22
3.4.5 Re-establishment of WSW	23
3.4 Other Endangered Ecological Communities	24
4. Concluding Comments.....	25
5. References	27
Appendix 1 – Resume: Dr Stephen Bell	30
Appendix 2 – Comparison of WSW FD & Original Nomination.....	36

1. Introduction

1.1 Background

1. In April 2010, Coal & Allied submitted an Environmental Assessment for the Proposed Warkworth Extension, near Singleton in the Hunter Valley. In February 2012 this proposal was approved by the NSW Planning Assessment Commission (PAC), and in March 2012 EDO NSW commenced merit appeal proceedings in the Land and Environment Court on behalf of the Bulga-Milbrodale Progress Association (BMPA). BMPA sought refusal of the mine extension on the basis that the proposed mining of the biodiversity offset was contrary to the public interest and ecologically sustainable development, and that the expansion would result in detrimental economic and social impacts on the Bulga community, and was also contrary to the principles of ecologically sustainable development.
2. In April 2013, the Land and Environment Court upheld the appeal and refused the project application. The Court concluded that the project would have significant and unacceptable impacts on biological diversity, including on endangered ecological communities, noise impacts, and social impacts. The Court considered that the proposed conditions of approval were inadequate and would not allow the project to achieve satisfactory levels of impact on the environment, including the residents and community of Bulga. The Court found that these matters outweighed the substantial economic benefits and positive social impacts of the project on the region, and that the extension project should not proceed. Existing mine operations at Warkworth mine are still authorised under the existing consent until 2021. However, as a result of the Land and Environment Court proceedings the extension project will not go ahead, and the biodiversity offset will not be mined. This decision was upheld in the NSW Court of Appeal in April 2014.
3. Rio Tinto has now submitted a new application for the Warkworth and Mt Thorley projects. I have been asked, on behalf of the Bulga-Milbrodale Progress Association, to conduct a review of the revised application, with particular emphasis on the Warkworth Sands Woodland endangered ecological community (EEC).

1.2 Aims & Objectives

4. The principal aim of my review is to address the potential impacts of the revised application on the endangered Warkworth Sands Woodland EEC. I have addressed the following two objectives:
 - a. Review the documents listed below (Section 1.3);
 - b. Prepare a written expert report that addresses the issues identified below, and ensure that the work is prepared in accordance with Division 2 of Part 31 of the *Uniform Civil Procedure Rules 2005*:
 - In your opinion, was the assessment undertaken by the proponents adequate?
 - In your opinion and within your area of expertise what, if any, are the environmental impacts that would arise from the project?
 - Provide any further observations or opinions which you consider to be relevant.

1.3 Review Documents

5. Relevant parts of the following documents have been reviewed for this submission:
- Warkworth Continuation Project EIS – Main Report *Executive Summary* available at:
<https://majorprojects.affinitylive.com/public/b3dd99643e51ebf5ddc55fe1f29a7d42/10.%20Warkworth%20Continuation%20Project%20EIS%20-%20Executive%20Summary.pdf>
 - *Main Report Part 1* available at:
[https://majorprojects.affinitylive.com/public/7dce71e2246a7be8b66c71e6b2117057/11.%20Warkworth%20Continuation%20Project%20EIS%20-%20Main%20Report%20\(1\).pdf](https://majorprojects.affinitylive.com/public/7dce71e2246a7be8b66c71e6b2117057/11.%20Warkworth%20Continuation%20Project%20EIS%20-%20Main%20Report%20(1).pdf)
 - *Main Report Part 2* available at:
[https://majorprojects.affinitylive.com/public/19a148777067a9ff9435c9693af02dae/12.%20Warkworth%20Continuation%20Project%20EIS%20-%20Main%20Report%20\(2\).pdf](https://majorprojects.affinitylive.com/public/19a148777067a9ff9435c9693af02dae/12.%20Warkworth%20Continuation%20Project%20EIS%20-%20Main%20Report%20(2).pdf)
 - *Warkworth Continuation Project EIS – Appendix H Ecology*. Available at:
<https://majorprojects.affinitylive.com/public/c9aef70075f989369c94300b6fc32122/17.%20Warkworth%20Continuation%20Project%20EIS%20-%20Appendix%20H%20Ecology.pdf>
 - *Warkworth Continuation Project EIS – Appendix I Soil Study*. Available at:
<https://majorprojects.affinitylive.com/public/f304bef4f09c81bb80ae505b7cec8091/18.%20Warkworth%20Continuation%20Project%20EIS%20-%20Appendix%20I%20Soil.pdf>
6. Other published and unpublished reports and papers that form part of my review have been cited in the normal way, with publication details contained in Section 5.

1.4 Qualifications and Experience

7. I am a vegetation scientist and senior partner at *Eastcoast Flora Survey*, a specialist vegetation consultancy operating out of Newcastle, New South Wales. Eastcoast Flora Survey was founded in 1996, and specialises in the assessment, classification and mapping of native vegetation. Prior to this, I have been employed on short-term projects with the NSW National Parks and Wildlife Service, the University of New South Wales, the University of Newcastle and other environmental consultancies principally in the vegetation and ecology fields. In 1990, I graduated from the University of Newcastle with a Bachelor of Science (Honours) degree. In 2013, I received my PhD for a thesis investigating the definition and mapping of rare plant communities, with particular reference to threatened ecological communities. Currently, I am a Conjoint Fellow within the Plant Sciences Group, School of Environmental and Life Sciences, at the University of Newcastle.
8. I have nearly 25 years' experience in the assessment of vegetation within the Hunter and Central Coast regions. This experience has included a large number of survey, classification and mapping projects under contract to the NSW National Parks and Wildlife Service (NPWS), investigating and classifying the native vegetation of over thirty conservation reserves. I have also assisted the NPWS with major regional projects, such as the Lower north-east Comprehensive Regional Assessments (1998-99), Lower Hunter & Central Coast Regional Environmental Management Strategy (1999-

- 2000), Warragamba Special Area (2001-2002), Priority 5 Management Area (2002), Barrington Foothills (2003), and several projects (2005-present) as lead botanist sampling the Greater Sydney conservation reserve system (Blue Mountains, Wollemi, Yengo NPs & environs). During 2011, I was contracted to contribute directly to the NSW Vegetation Classification and Assessment Database, on behalf of the Royal Botanic Gardens (Sydney), by assessing and describing a number of endemic Hunter Region communities.
9. On behalf of the relevant local councils, I have completed the survey, classification and mapping of native vegetation in the Wyong local government area (2002), Gosford local government area (2004, 2009), Pittwater local government area (2010-2011), Lake Macquarie local government area (in progress), and assisted in the Blue Mountains local government area mapping project (2000-2001). From 1999-2000, I was an instrumental member of the team preparing the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS), which resulted in a regional classification of native vegetation and the production of a vegetation model showing the distribution of 53 vegetation communities throughout the Lower Hunter and Central Coast. For this same region, I have also co-authored the flora and fauna survey guidelines for Hunter Councils Inc.
 10. During 2001-2003, I was the Ecological Society of Australia representative on the Hunter Regional Vegetation Committee, as well as a member of the DIPNR Expert Panel for Regionally Significant Vegetation (2003) and the subsequent CMA Expert Panel (2005). I am also a founding member of the Hunter Rare Plants Group (2000), a sub-committee of the Hunter Region Botanic Gardens, which assesses the conservation significance of native plant species and vegetation communities. I have published many peer-reviewed scientific papers on various aspects of native vegetation within the Hunter and Central Coast regions. Professionally, I am a member of the Ecological Society of Australia (ESA), the International Association for Vegetation Science (IAVS), and the Australian Network for Plant Conservation Inc. (ANPC).
 11. In relation to EECs, I have conducted several numerical data analyses into the presence or otherwise of listed EECs on private and public lands, including River Flat Eucalypt Forest on Coastal Floodplains, Kurri Sands Swamp Woodland, Umina Sands Coastal Woodland, Littoral Rainforest, Lower Hunter Spotted Gum – Ironbark Forest, White Box – Yellow Box – Blakely’s Redgum Grassy Woodland, Pittwater Spotted Gum Forest, Hunter Lowlands Redgum Forest, Kincumber Scribbly Gum Forest, and Warkworth Sands Woodland. All of these investigations have involved multivariate analysis of systematic plot data in support of conclusions reached. My 2012 scientific paper on the characteristics, extended distribution and definition of Pittwater Spotted Gum Forest EEC was agreed to by the NSW Scientific Committee, and resulted in a revision to the formal description of this endangered ecological community. On behalf of the NSW Office of Environment & Heritage, I am currently undertaking a field and analysis-based review of the Tablelands Snow Gum, Black Sallee, Candlebark, and Ribbon Gum Grassy Woodland EEC from the Southern Tablelands of NSW.
 12. While I am well qualified to comment on issues involving plant species identification, distribution and abundance, and the composition and distribution of ecological communities, aspects of life cycle processes of individual plants, such as plant physiology and impacts of topsoil removal or deposition of fill, are outside of my area of expertise. Similarly, while I often make general observations on the quality and nature of the soil in which plants and vegetation communities occur, I am not a qualified soil scientist. My opinions on the influence of soil on plant distribution and the generation of explanations on community distribution are heavily reliant on the available published and unpublished works of soil scientists, to which I refer whenever necessary.
 13. My full Curriculum Vitae are appended as Appendix 1.

14. I have been provided with a copy of the Expert Witness Code of Conduct, being Schedule 7 to the *Uniform Civil Procedure Rules 2005 (NSW)*. I have read the Code and agree to be bound by it.

2. Warkworth Sands Woodland

15. The definition and extent of the endangered Warkworth Sands Woodland (WSW) has been in dispute amongst ecologists involved in previous impact assessments on the proposed site. This has largely resulted from the confusion over exactly what it is that the WSW determination is meant to be protecting. A brief history of the nomination process of this community is critical to understand where this confusion originates, and is presented in Section 2.1.
16. My views on the composition and distribution of WSW have been previously expressed both in evidence to the Land and Environment Court (Bell 2012), and during the process of that hearing (NSWLEC 48, 2013). It is noted that in his judgement of that case, Justice Preston agreed with my interpretation of WSW, and with the lack of certainty in the proposal to restore grassland areas to WSW, and with my interpretation of the value of proposed offsets. Further, in the subsequent NSW Court of Appeal hearing (NSWCA 105, 2014), Justices Bathurst, Beasley and Tobias upheld the views of Justice Preston, and found no errors in his interpretation of the law.

2.1 Nomination of Warkworth Sands Woodland

17. It is important as a first step to briefly return to the initial nomination of WSW to gain an understanding of the reasons this vegetation community was ultimately listed as endangered in New South Wales. During the mid-1990s to mid-2000s, I was one of five local ecologists who met regularly in our own time to assess the significance of plant species and vegetation communities within the Hunter Region. Collectively, the five of us had an impressive amount of experience in ecological issues, and particularly so in the vegetation of the region. Apart from myself, members of this group were **Terry Tame** (former Director of Botanical Collections at the Hunter Region Botanic Gardens & Honorary Research Associate at the NSW National Herbarium), **Travis Peake** (former Hunter Catchment Management Trust / HCRCMA Regional Botanist, & author of the Hunter Remnant Vegetation Study), **Dr Tim Curran** (former ecologist with the Australian Koala Foundation, currently Senior Lecturer in Ecology, Lincoln University, New Zealand), and **John Simpson** (former ecologist for Forests NSW and a range of private firms and consultancies, currently Strategic Planner with the Hunter Water Corporation). Our group was formally a sub-committee of the Hunter Region Botanic Gardens, and regularly communicated with the NSW Scientific Committee on a range of issues relating to the Hunter Valley flora.
18. In 2000, we began researching the vegetation now known as WSW to assess its composition and significance, ultimately leading to a nomination submitted by us in 2002. In preparing the nomination, we undertook considerable investigations into the habitat and composition of the community, and also compared the area with other known sand deposits in the Sydney Basin region. Without ready access to the land due to private property access constraints, we were limited in our capacity to collect new data at that time. Consequently, the species list contained in our nomination originated from that compiled by Terry Tame during the early 1980s for his monograph "*Vegetation of the Hunter Valley*" (Tame 1984). After submitting our nomination, we received feedback from the NSW Scientific Committee on the high quality of our research and documentation.
19. Importantly, and as shown in Appendix 2, it is clear that the NSW Scientific Committee strongly supported our original nomination. Much of the text contained in the Final Determination for WSW

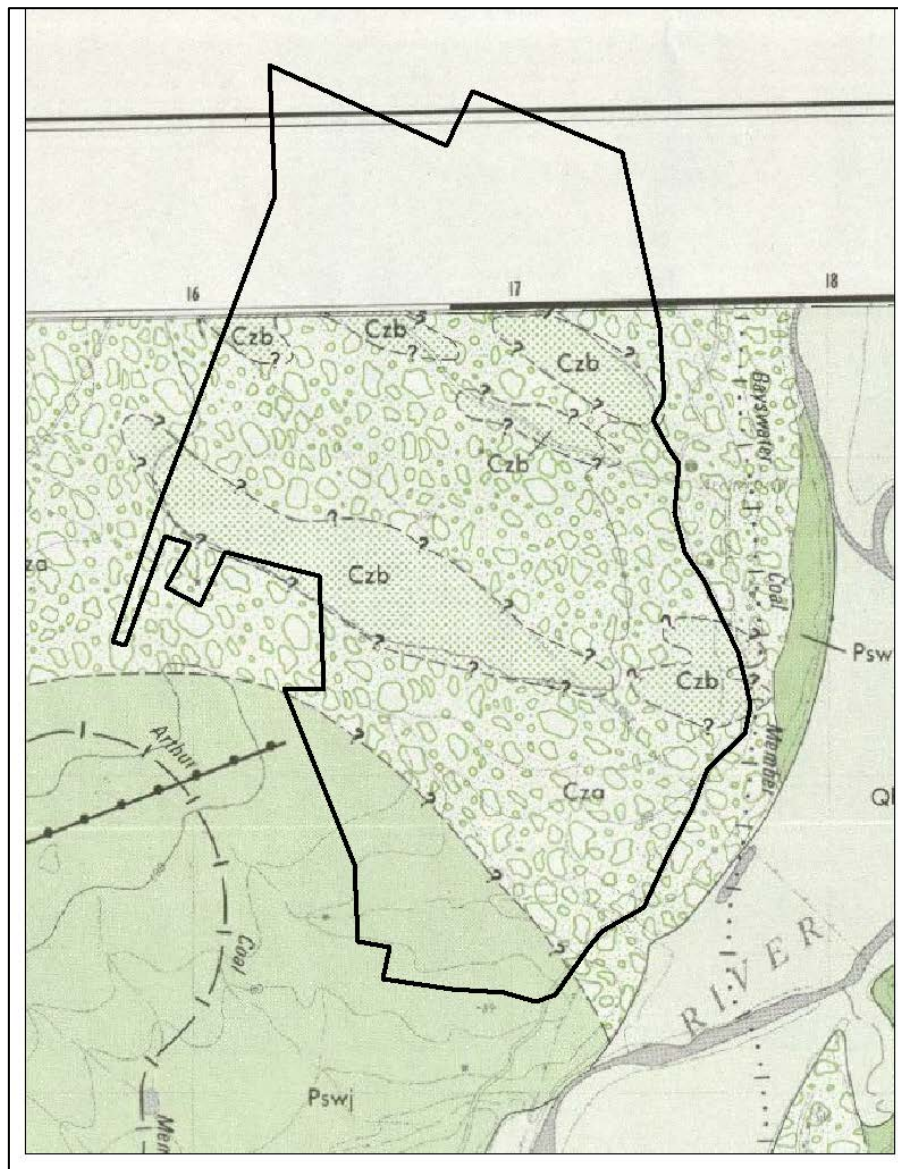
was lifted directly out of our nomination, including all of the plant species that we proposed as comprising the WSW. In keeping with the procedures of listing for all TECs, however, our original two lists of species were amalgamated to form one. This simple action effectively removed the discrimination between 'core' WSW areas and those 'marginal' areas where a veneer of shallow sandy material overlays Permian-based clays. Never-the-less, it was clear that the intent of the Final Determination for WSW was overwhelmingly identical to the intent of our original nomination.

20. Paragraph 8 of the Final Determination explicitly excludes surrounding areas of clay-based vegetation, unless it supports a dominant abundance of WSW species. Our intent in the original nomination for the definition of 'WSW species' was those species included in our list of 'Abundant and/or characteristic' species, not those in our list of "less common taxa". This is clear in the inclusion of the words "*common and characteristic species listed above*" included in our nomination (see Appendix 2, Paragraph 8), a phrase not carried over into the Final Determination. By merging the two species lists, the NSW Scientific Committee had inadvertently removed the distinction between *included* ecotonal areas of WSW and *excluded* surrounding non-WSW clay vegetation.

2.2 Distribution of Warkworth Sands Woodland

21. Acceptance of the extant distribution of WSW has never been agreed upon by ecologists. In part, this is largely related to the differences of opinion expressed on exactly what defines the legal entity. In my State of Evidence to the NSWLEC (Bell 2012), I discussed this issue in considerable detail (including the use of numerical data analysis) and concluded that I considered there to be currently ~400 hectares of WSW remaining. The following two paragraphs are based largely on Bell (2012), and summarise my current understanding on this issue:
22. Umwelt (2011) documented the geographical extent of Warkworth Sands Woodland EEC, where it was estimated that only 15.3% remained of its presumed 3,038 ha pre-settlement distribution. I consider that all prior pre-settlement distribution estimates of this community have been over-estimates, based on my examination of the mapped extent of Aeolian sand deposits known from the mid Hunter Valley. Although detailed geological mapping for the mid Hunter Valley is restricted to the Muswellbrook, Singleton, Jerrys Plains and Doyles Creek 1:25,000 map sheets, I suggest that only ~800 ha of Aeolian sand habitat suitable for Warkworth Sands Woodland EEC exists, and of that ~400 ha presently supports the community. This equates to an estimated loss since European settlement of around 50%, considerably more than all previous estimates. With all due respect to the NSW Scientific Committee, I consider that the *extant* area estimate of 800 ha in the Final Determination for this community (NSW Scientific Committee 2011) is in fact more likely to represent the original *pre-settlement* figure, and consequently the WSW EEC is more highly restricted than previously thought.
23. My current estimate for the extant distribution of Warkworth Sands Woodland EEC is somewhere in the vicinity of 400 ha. I am not able to present a more definitive figure as I have not examined all parcels of land that have been previously mapped as supporting the EEC. Those that I have inspected, sampled and analysed have either supported what I refer to as Core WSW EEC, Marginal WSW EEC or Non WSW EEC (see Section 3.2.2 of Bell 2012), but I have not been able to formalise these results into map format across the whole distributional range. Umwelt (2011) detailed how they considered the 800 ha extant estimate of NSW Scientific Committee (2011) to be too high, and suggested that the true figure was more likely to be in the order of 465 ha. As explained in Bell (2012), I further refined this extant figure down to ~400 ha by assessing the mapped extent of Aeolian sands.

24. In his judgement from NSWLEC 48 (2013), Justice Preston followed the reasoning of Umwelt (2011), and considered that approximately **465 hectares** of WSW remains extant, from an original 3,038 hectares prior to European Settlement. This figure of 3,038 hectares was arrived at by Umwelt (2011) through an assessment of the Warkworth Land System mapping of Story et. al. (1963), less two occurrences near Kurri Kurri which were considered not to be WSW. As I outlined in my Statement of Evidence (Bell 2012), I do not agree with this estimate of 3,038 hectares and believe that a more accurate figure for the pre-European Settlement extent is ~800 hectares. As noted earlier, this is based on a GIS review of the finer scaled soils mapping of Summerhayes (1983), McIlveen (1984), Sniffin & Summerhayes (1987) and Sniffin et al. (1988), all of which map the distribution of Aeolian sand deposits (Czb), a necessary pre-requisite of WSW.
25. Importantly, this finer soils mapping distinguishes the Aeolian sand (Czb) from riverine alluvial sand (Cza), and by way of example the figure below showing the NBA has been extracted from my Statement of Evidence (Bell 2012) to illustrate the pattern of sand deposition:



Extract of geology mapping for the Singleton 1:25000 map sheet, showing the Northern Biodiversity Offset and component geology (from McIlveen 1984). Cza = Tertiary relict alluvial terraces; Czb = Quaternary Aeolian dunes; Pswj = Permian coal measures (Jerrys Plains subgroup).

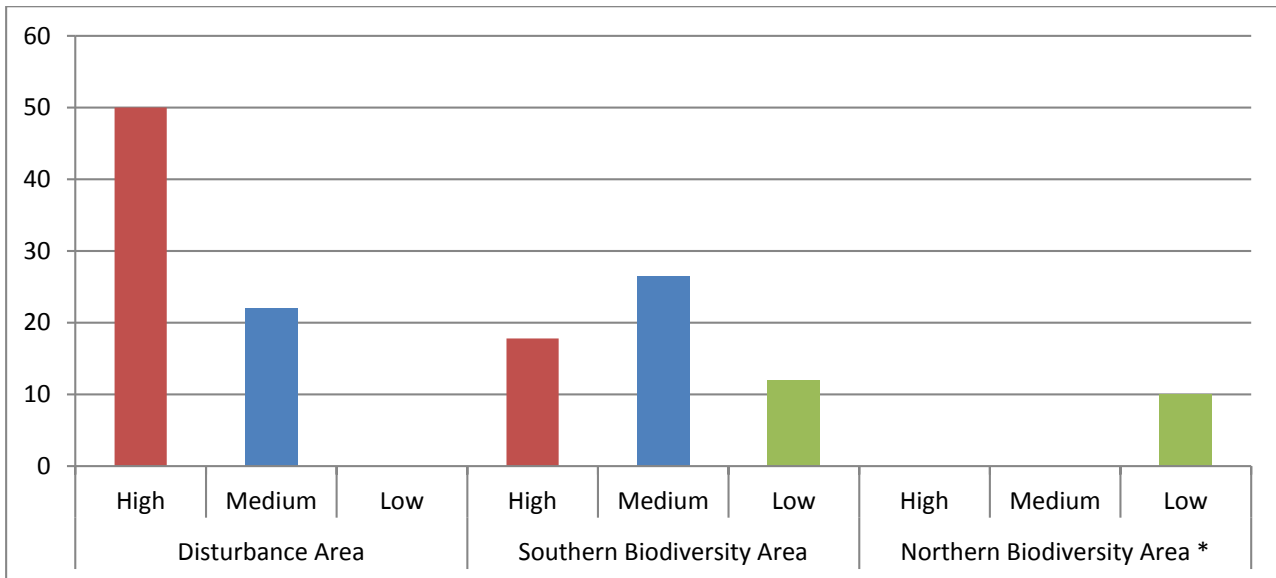
26. In total, 689 hectares of this Aeolian sand (Czb) were mapped on the available map sheets, covering all but four of the Warkworth Land System map polygons of Story et. al. (1963). By extrapolation of landform patterns within these outstanding four polygons, I estimated a maximum pre-European distribution of WSW to be **~800 hectares**. This estimate is 74% less than the figure calculated by Umwelt (2011), which was accepted by the NSWLEC.
27. During the NSWLEC hearings, evidence was presented from Dr Pam Hazelton on the results of her investigations into the nature of the sandy soils across the proposed development area and offset areas (Hazelton 2012). Her assessment of the sand within the NBA was that Aeolian sand was present across the majority of the NBA. As I am not a soil scientist I cannot refute her findings; however, I do note the observation of Justice Preston that *"The belief that any vegetation community that occurs on aeolian sands must necessarily be WSW EEC is incorrect. Occurrence of aeolian sands substrate is a necessary condition but it is not sufficient for a vegetation community to be classified as WSW EEC; the vegetation community must also satisfy the floristic and other criteria in the Scientific Committee's Final Determination listing WSW as an EEC"* (NSWLEC 48, 2013, paragraph 224). By this reasoning, I consider that my estimate of WSW extent, using both the Aeolian sands mapping and my own observations of dominant plant species, provided a more accurate depiction than previous estimates.

2.3 Significance of Warkworth Sands Woodland

28. The significance of the WSW is directly related to a proper understanding of exactly what the WSW is, and this too has resulted in some confusion among ecologists. All agree that it is a community of some significance, reflected in its listing as an Endangered Ecological Community on the NSW *TSC Act 1995*. It is not listed at a higher threat category (Critically Endangered), as at the time of listing this was not an option under the Act. WSW is also not listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), but this is simply due to the lack of a nomination to do so.
29. As outlined in my Statement of Evidence (Bell 2012), WSW would clearly qualify as Critically Endangered for both the NSW and Commonwealth legislation, and also Internationally. Applying the Commonwealth listing criteria for this community reveals that it would qualify as Critically Endangered through Criterion 2 (small geographical distribution – less than 1,000 ha - coupled with demonstrable threat). Based on other figures, Umwelt (2011) also considered that Warkworth Sands Woodland would qualify as Critically Endangered on the *EPBC Act*, and suggested too that it would also qualify as Critically Endangered on the NSW *TSC Act*. The International Union for the Conservation of Nature (IUCN) has also begun to categorise levels of threat to ecosystems throughout the world (Rodríguez et al. 2007, 2011). Using this system, WSW EEC qualifies as Critically Endangered under Criterion D (very small current distribution – less than 500 ha – and under serious plausible threat).
30. Irrespective of differing opinions on the extent of pre-European extent of WSW, it is clear that the WSW remaining should be regarded as Critically Endangered in any development that may impinge on its persistence or quality. For all intents and purposes, WSW is a **factually Critically Endangered** ecological community (NSWLEC 48, 2013, paragraph 136), and any escalation in existing threats to its persistence should be very carefully assessed.

2.4 Variable Condition of Warkworth Sands Woodland

31. In Section 4.3 of the Ecology (Appendix H) report, a brief overview of the history of clearing across the Warkworth area is outlined, and previous documentation related to prior applications have expanded upon this (eg: Cumberland Ecology 2010). As with many parts of the Hunter Valley, there has been extensive clearing of landscapes for agricultural enterprises over ~200 years of European Settlement, followed by passive regeneration in some areas.
32. Notwithstanding this, areas which now support WSW include a range of condition or quality classes that reflects the history and type of disturbances. At the time of its listing as an EEC in 2003, WSW had already been extensively cleared and regenerated (see Figure 4.3 in Appendix H, Ecology report). Despite this, the NSW Scientific Committee determined that the community still warranted listing as a Threatened Ecological Community due to its restricted distribution and ongoing threats: they made no distinction between 'good' and 'poor' examples of the community, but recognised the influence that past land management has on species composition and structure.
33. During assessments of WSW undertaken for the current and previous mine applications, there has been some emphasis placed on the quality of the WSW that is present in certain areas, particularly in regard to those stands to be removed and those included in offset areas. For example, working on behalf of the mine Bower (2004) categorised stands of WSW into three classes (high, medium, low), based on species diversity, weed presence, age of regeneration and general health. In the absence of any 'old growth' WSW (given the history of clearing noted above), it is these high quality examples of the community that should carry higher importance than low quality examples. Such areas have had a longer period of time in which to regenerate and mature following their last clearing event, and consequently are more likely to embody the full complement of characteristics that define the entity.
34. The mapping of WSW quality classes, shown as Figure 3 in Bower (2004), provides a good indication of the locations of the better stands of WSW. In my Statement of Evidence (Bell 2012), I highlighted how the bulk of the high quality WSW occurs in areas planned for removal, while the proposed offset areas support only medium to low stands. I understand that the proposed disturbance footprint has changed little for the 2014 Application, and so my conclusions from 2012 remain valid. However, I have updated my Figure 3.19 from that report (shown below) to highlight the disparity between areas of WSW that will be cleared for mining, and areas proposed for conservation. I have used the quality classification of Bower (2004) to determine the proportions of high-medium-low condition WSW within both the Disturbance boundary and the proposed offset areas. For the SBA, the brief report prepared by Cumberland Ecology (2011) on the former grazing property 'Springwood' has been used to classify those areas not assessed by Bower (2004). I note that Cumberland Ecology (2011) state, "*Most notable is the condition of the grassland and regenerating woodland areas on Warkworth Sand which is highly weed invaded in the understorey*". Although it appears that the WSW Grassland areas should be classified as low condition, I have taken the 'middle-ground' and included all of the Springwood property WSW as medium in the figure below.



Graphical depictions of condition classes of WSW EEC for the Disturbance Area and proposed Offsets [SBA & NBA], based on condition mapping of Bower (2004) and my own assessment of the NBA (*).

35. Justice Preston agreed with me in my assessment of this disparity in condition classes of WSW (NSWLEC 48, 2013, paragraphs 131-132), and in the inappropriateness of offsetting high quality WSW with low quality WSW, and particularly WSW Grassland that is intended to be restored to WSW. Justice Preston went on to say (in paragraph 249): *"I find that the real risk and uncertainty of, and the considerable timeframe required for, restoration of WSW EEC on the Warkworth Sands grassland in the Northern and Southern Biodiversity Areas reduces the conservation benefits of those areas of Warkworth Sands grassland as offsets for the extant WSW that would be cleared in the disturbance area"*.
36. A review of the 2014 Application does little to change my opinion that the removal of high quality WSW, as close to 'old growth' WSW as is currently available, should not be compensated for by the conservation of low quality WSW stands and the promises of successful restoration of WSW Grassland. The last remaining stands of WSW, which the NSWLEC has stipulated to be in the vicinity of only 460 hectares, should not be removed until successful restoration of WSW can be demonstrated beyond any reasonable doubt.

3. Proposed Warkworth Continuation Project

37. In relation to the Warkworth Sands Woodland EEC, the proposed Warkworth Continuation Project, outlined in the 2014 Application, plans to:
 - clear 72 hectares of WSW and 0.5 hectares of WSW Grassland, which will be offset by the provision of 75.5 hectares of WSW and the re-establishment of 159.5 hectares of WSW on former WSW Grassland;
 - prepare an Integrated Management Plan for WSW;
 - develop completion criteria for the re-establishment of WSW.
38. I will address each of these offset measures in Section 3.4 of this submission.

3.1 Key Difference between 2010 and 2014 Proposals

39. In order to focus on what I see as the main issues, I have reviewed for key differences in the ecological assessment between the 2010 and 2014 Applications. These include:

- no assessment of the Precautionary Principle in the 2014 Application
- no discussion on the risk of extinction in the 2014 Application
- no Biodiversity Management Plan with the 2014 Application
- three new vegetation communities in the 2014 Application
- closure of Wallaby Scrub Road rather than its relocation in the 2014 Application
- recognized extent of WSW reduced from 1,133ha to 465ha, following the NSWLEC judgment
- WSW assessed as Groundwater Dependent in the 2014 Application
- a reduction in the amount of vegetation to be cleared from 2010 (765ha) to 2014 (611ha)
- a reduction in the amount of WSW to be cleared from 2010 (104ha) to 2014 (72ha)
- the removal of potential habitat of *Macrozamia flexuosa* in the 2014 Application
- a reduction in the amount of vegetation to be removed from fauna corridors from 2010 (765ha) to 2014 (456ha)
- a reduction in Biodiversity Management Areas to NBA and SBA only in the 2014 Application
- no discussion of the Putty Road Conservation Area in the 2014 Application, despite its inclusion on Figure 7.1 and others (Appendix H)
- a small decrease in the extent of forest & woodland in the SBA from 2010 (661ha) to 2014 (559ha)
- a small increase in the extent of forest & woodland in the NBA from 2010 (123ha) to 2014 (124ha)
- a reduction in the amount of EEC vegetation in the SBA from 2010 (635ha) to 2014 (497ha)
- a small increase in the amount of EEC vegetation in the NBA from 2010 (123ha) to 2014 (124ha)
- an increase in the total area of the SBA from 2010 (718ha) to 2014 (788ha)
- a reduction in the total area of the NBA from 2010 (342ha) to 2014 (306ha)
- inclusion of an Integrated Management Plan and development of completion criteria for WSW in the 2014 Application
- a reduction in the amount of WSW to be conserved in the SBA from 2010 (85ha) to 2014 (56ha)
- no change in the amount of WSW to be conserved in the NBA from 2010 to 2014 (both 20ha)
- limited discussion of the 5 year \$5.5 million research program undertaken by the University of New England on WSW restoration, and no detail on the results of that study in the 2014 Application

40. I will briefly discuss the most relevant of these in the following Sections.

3.2 Risk of Extinction & the Precautionary Principle

41. In his NSWLEC judgment, Justice Preston stated that the loss of WSW from areas proposed to be mined would be permanent and irreplaceable (NSWLEC 48, 2013, paragraphs 134-135). Coupled with the highly restricted distribution of this community (465 hectares), there is a very real risk of extinction. In cases such as this, implementation of offsetting initiatives should be very carefully assessed and the risks for failure evaluated: the irreplaceability of some elements of biodiversity should be recognized and acknowledged (Bekessy et. al. 2010; Fallding 2014; Norris 2014). In my Statement of Evidence (Bell 2012, Section 3.5), I detailed further the scientific literature on the promises and pitfalls of offsetting, which is yet to reach a phase that instills confidence in land use planning and dispute resolution.

42. Offsetting the removal of established WSW with promises of restoration of this same community on current grassland areas does not acknowledge the precautionary principle. Further discussion on the restoration of WSW is found in Section 3.4.5 of this submission, however it is evident that the 2014 Application continues to maintain the assumption that such restoration can be successfully achieved. This is despite the research program undertaken by UNE on this topic, the results achieved to date of which the 2014 Application barely discusses (see Section 3.3 following). It has not yet been established that successful restoration of WSW is achievable, particularly on cleared sites that have been used for grazing over many decades. For this reason, the precautionary principle would dictate that successful restoration of WSW is not yet possible, and that further clearing of intact WSW should be treated with extreme caution.

3.3 University of New England Research

43. Research Outcomes from UNE: In the 2010 proposal, much was made of the contribution to the proposed restoration of WSW in offsets and rehabilitated areas by research conducted through the University of New England (UNE). The proponent provided funding to UNE for this 5-year research project, to be undertaken under the leadership of Professor Caroline Gross. Several projects have been instigated by UNE, but to my knowledge few have been reported on to date. The 2014 application notes that \$5.5 million has been provided to the UNE for ecological research into WSW since 2003, but only limited results have yet been published. A check of the UNE web page of Professor Gross shows an unpublished document entitled “*A Blueprint for the Restoration of Warkworth Sands*” (Gross 2007), which presumably is, as its name suggests, a ‘blueprint’ and not the results of her scientific research projects. Other papers for which she is a co-author include those outlined in the following paragraphs (only one of which is noted in the 2014 Application):
44. Kumar et. al. (2009) produced an unpublished document detailing the results of a mapping project to determine the distribution of WSW within the Warkworth project area. They used Quickbird satellite imagery to map distribution, but concluded that “*data cannot be used to collate the amount of area attributable to a [WSW] community*” and that “*we are not making recommendations here on the rules for what determines a WSW community*”. Concluding, they state, “*we have produced a reliable digital signal for vegetation associated with WSW and not a definitive summation of WSW area*”. Evidently, the use of satellite imagery interpretation does not add further to our understanding of distribution and composition of WSW.
45. Taylor (2010) undertook an Honours thesis, under the supervision of Professor Gross, on the role of ants as seed dispersers in WSW. I have not been able to locate a copy of this work, although Gross and Vary (2014) do cite some results. In particular, they report that seed removal was higher in cleared sites than in intact sites, and that the larger *Acacia falcata* seed was preferred over *Pimelea linifolia*. Understanding the fate of seed in restoration projects can be critical in their success, and this study touched on only a handful of species known from WSW.
46. Fatemi et. al. (2012, 2013) published brief papers on the results of genetic studies of *Hardenbergia violaceae* and *Banksia integrifolia* (key species in WSW), presumably undertaken as part of WSW research, to examine genetic variation and population structure. Knowledge on the microsatellite markers uncovered will be of use in restoration projects where plant provenance is of importance. However, such research contributes only marginally to the restoration of WSW, particularly for *Banksia integrifolia*, which occurs in an environment well disjunct from other stands (and where plant provenance is not an issue). Both of these papers used samples from the WSW area together with samples from other locations in NSW, and were part of broader studies.

47. Most recently, Gross and Vary (2014) published some valuable seed bank results from experimental work undertaken within WSW. In this paper, the disparity between above-ground and below-ground (seed bank) species diversity was explored to investigate why some plant species do not return to habitats after large scale disturbances (such as clearing). They proposed that large-seeded species experienced higher predation rates from fauna than small-seeded species, which effectively skews the recovery of WSW on cleared sites and creates a disparity between the restored community and intact WSW. This implies that the restored community may resemble the target community, but it will be difficult to successfully establish that target community. Addressing such seed bank dynamics is but one aspect of successful WSW restoration, and clearly further studies such as these are required.
48. UNE Research & the 2014 Application: Despite the amount of information that I have been able to locate online, there is little mention of any of these UNE research projects in the 2014 Application. The point is made in Section 7.2.4 of the Ecology (Appendix H) report that \$5.5 million was given to UNE for research on WSW, but nothing is stated about the results obtained from that research, nor of the benefits of that research to restoration of WSW, nor how it will be used. Neither the two papers of Fatemi et. al. (2012, 2013) nor the work of Taylor (2010) cited by me above, for example, are mentioned in the Ecology report, so presumably were not seen as an important outcome of the UNE research. Similarly, the mapping project of Kumar et. al. (2009) has been cited only as part of the literature review phase of the Ecology report, but has contributed nothing to knowledge on WSW restoration. Only the paper by Gross and Vary (2014) offers some tangible, science-based research which can be used to inform future restoration activities, albeit tied to the need for continuing research. Most likely, this paper was not included in the Ecology (Appendix H) report due to its recent publication date (June 2014); however, given that it does contain useful insights into the practicalities of WSW restoration, it is surprising that the raw results of this research were not made available and cited in support of the Application.
49. Clearly, the outcomes of the UNE research were that, in fact, more research is required before we can be confident of successfully restoring WSW. Relying on passive restoration alone will not return a disturbed WSW site to an analog condition (Gross & Vary 2014 reported depauperate species diversity, skewed towards introduced species), and restoring a degraded site using only above-ground species as a guide will skew the recovery (*"it is critical to [describe the below-ground diversity] where there is an expectation to match Green Offsets with analog habitats"*: Gross & Vary 2014). These authors continue that *"from a restoration perspective, the practice of broad-scale direct seedling may prove to be unsuccessful for reinstating large and heavy seeded species because they are at risk of not entering the seed bank – and seed bank entry could be crucial for species with specific dormancy-breaking requirements"*. Regarding longevity of the soil seed bank, they state *"We are yet to resolve levels of seed persistency in the soil seed banks of the Warkworth Sands Woodlands as our initial trials reported here were undertaken on soil recently harvested from the field and germination trials were only conducted for 75 contiguous weeks"*. As I outlined in my Statement of Evidence (Bell 2012), the promises of ecosystem restoration are rarely met in practice, and there is still much research (like that reported on in Gross and Vary 2014) still to be done for WSW.
50. Interestingly, instead of basing restoration efforts on the UNE research outcomes, reference is made in the Ecology (Appendix H) report to the restoration manual prepared by a separate consultancy firm, Niche Environmental (Thackway et. al. 2013). I have not had access to this restoration manual to examine its contents, nor to determine whether or not it is directly based on the research outcomes of the UNE project. Given that the UNE appeared to focus on 'pure' science topics such

as gene flow, pollination biology, faunal interactions and food webs, it is uncertain how much of this will be incorporated into the restoration manual. It is hoped that the raw data and preliminary results of Gross and Vary (2014) on the need to redress the imbalance in above-ground and below-ground species diversity (although unpublished at the time of the Thackway et. al. 2013 document), has been included.

51. Ultimately, the \$5.5 million spent on WSW research has not yet been incorporated into the proposed restoration of WSW, and consequently this component of the offset package for the mine continuation should be considerably downplayed. The precautionary principle should remain in place for this aspect of the package, as quite clearly there remain many research questions unresolved.

3.4 Biodiversity Offsetting

52. In the 2010 Application, an offset package incorporating seven separate parcels of land in addition to the restoration of WSW and other EECs was proposed. The 2014 Application has reduced this down to two, presumably in response to the judgment in the NSWLEC which found many of the proposed offsets to be inappropriate (NSWLEC 48, 2013, paragraph 202-207). In total, this has resulted in a reduction of land-based offsetting from 5,037 hectares in 2010, to 1,094 hectares in 2014. This approximates to 1/5th of that originally proposed.
53. Given the uniqueness and highly restricted distribution of the WSW (see Section 2 above), and acknowledging the judgment on this issue from the NSWLEC, it is perfectly understandable that no amount of land-based offsetting can be expected to satisfactorily compensate for the removal of portions of WSW. Like-for-like offsetting is highly unattainable in this case: removal of a factually Critically Endangered ecological community.
54. To compensate for this reduction in suitable land-based offsets, the 2014 Application offers instead what it calls a *"range of supplementary measures"*, but which in reality amounts to just two: preparation of an Integrated Restoration Implementation Plan, and research into acceptable completion criteria for the re-establishment of WSW. These two issues are discussed further by me in Sections 3.4.3 and 3.4.4 respectively, and do not appear to offer much in the way of additional compensation. A third supplementary measure concerns the restoration of WSW, but this was always a component of the package put forward in 2010, and one considered by Justice Preston to be over-stated in value.
55. In addition, the 2014 Application proposes to use the retirement of credits under the Upper Hunter Strategic Assessment (UHSA) as a further offset measure. Although I am familiar with the UHSA coordinated by OEH, and have been involved in workshops concerning this planning initiative, I am not an accredited assessor under the scheme. For these reasons I cannot make comment on how the retirement of credits under the UHSA scheme will compensate for the removal of WSW. I do consider, however, that these credits will require recalculation given the over-mapping of WSW that has occurred in the NBA.
56. The Ecology (Appendix H) report details these biodiversity offsetting proposals from the 2014 Application. It structures the offsets as comprising three Components: **Component 1** – Offsetting the impacts to WSW & WSW Grassland; **Component 2** – Offsetting the impacts to non-WSW & WSW Grassland; and **Component 3** – Offsetting the impacts to non-WSW & WSW Grassland related to the 2003 Extension. For the purposes of this review, I will be concentrating on Component 1 and issues related to impacts on the WSW.

57. The 2014 Application proposes to offset impacts on WSW through the conservation of the remaining WSW vegetation within two Biodiversity Offset Areas: the Northern Biodiversity Area and the Southern Biodiversity Area. In addition, two supplementary measures have also been proposed, including an Integrated Restoration Implementation Plan, and research into completion criteria for the re-establishment of WSW. As noted above, a third measure (restoration of WSW on grassland areas) was always a component of proposed offsetting. I will address each of these separately.

3.4.1 Northern Biodiversity Area

58. The 2014 Application continues to present the Northern Biodiversity Offset (NBA) land as a viable offset for the loss of WSW for mining. This same offset area was included in the 2010 Application, and was discussed at length in my Statement of Evidence (Bell 2012, Section 3.2). At that time, I was particularly concerned with the amount of WSW that had been mapped within the NBA, some of which I believed to be inaccurately portrayed. The differences of opinions between myself and the other ecologists involved centred on the plant species that were present, and how these related to those listed in the Final Determination.
59. As I have detailed in Section 2.1 above, the original nomination for WSW included two lists of plant species: one showing plant species that characterised the community, and another of uncommon species that could occasionally be present. Because the NSW Scientific Committee merged these two species lists for the Final Determination, the distinction between 'core' WSW and 'marginal' (ecotonal) WSW was lost. However, our statement from the original nomination concerning surrounding communities was mostly maintained (see Appendix 2, this report), in that *"These areas [surrounding clay-based Permian sediments] are not considered to be part of this community, except in ecotones where there is a dominant abundance of the species of the Warkworth Sands Woodland"* (Paragraph 8, Final Determination).
60. This statement in Paragraph 8 of the Final Determination excludes areas from the WSW if they are dominated by non-WSW species (the second list of uncommon species in our original nomination). Certain parts of the NBA are dominated in the canopy by Ironbark (*Eucalyptus crebra*), with a range of grass species on the ground. I argued previously that such areas support characteristics that align more with other vegetation types than they do with WSW. In his judgment, Justice Preston agreed with my position on this, stating *"Further, I accept Mr Bell's evidence, including his floristic analysis, that much of the vegetation that Dr Robertson now classifies as WSW, does not meet the floristic and other criteria in the Scientific Committee's Final Determination for WSW EEC and in fact comprises other vegetation communities"* (NSWLEC 48, 2013, paragraph 225).
61. By way of example, the two figures below show one area of the NBA where I sampled vegetation in 2012 (and purported to be WSW), and a second from another location west of Singleton where a very similar regenerating Ironbark forest grows. Neither of these locations support floristic compositions or characters that are indicative of WSW: both support regenerating stands of *Eucalyptus crebra*, bare patches on the ground, and a low cropped and interrupted cover of grass species. None of the characteristic species mentioned in Paragraph 4 of the Final Determination (*Angophora floribunda*, *Banksia integrifolia*, *Acacia filicifolia*, *Pteridium esculentum*, *Imperata cylindrical*, *Brachyloma daphnoides*, and *Melaleuca thymifolia*) are evident in either photograph.



62. Given the discrepancies noted above and highlighted in my Statement of Evidence (Bell 2012), to which Justice Preston also agreed, it is surprising that the 2014 Application maintains that 19.5 hectares of WSW is still present in the NBA. I will elaborate further on this.
63. In the 2010 Application, Cumberland Ecology mapped 210 hectares of current and former WSW (incorporating extant WSW and what they termed WSW Grassland, or WSG) for the NBA. In my

review of that area I considered there to be 96 hectares of current (10.2ha) and former (86.3ha) WSW (Bell 2012). For the 2014 Application, the NBA is stated to support 176 hectares of WSW (19.5 hectares WSW + 156.5 hectares WSG), which is a little under double my 2012 estimate. Although I have not completed any further survey or assessment of the NBA since 2012, I still consider the 2014 estimate of 176 hectares to be an over-estimate.

64. In support of this it is important to refer back to Paragraph 8 of the Final Determination, where it distinguishes WSW from surrounding vegetation. When preparing my Statement of Evidence in 2012, I sampled vegetation (my sample plots Q01 & Q02) within stands of vegetation mapped by Cumberland Ecology as WSW. That vegetation was dominated in the canopy variously by *Eucalyptus crebra* and *Eucalyptus tereticornis*, and on the ground by *Digitaria diffusa*, *Microlaena stipoides*, *Aristida ramosa* and *Cynodon dactylon*. Of these, only *Aristida ramosa* and *Eucalyptus crebra* are included in the Final Determination for WSW, but these species were included in the 'uncommon' species list in the original nomination (see Appendix 2, this report). The remaining species are not listed at all.
65. As noted above, Justice Preston agreed with my interpretation that areas such as these are more likely to represent a vegetation community other than WSW (NSWLEC 48, 2013, paragraphs 97 & 225), and yet in the 2014 Application these same areas remain mapped as WSW. The 2014 Application accepts that the overall extant distribution of WSW is ~465 hectares as stipulated by Justice Preston (a reduction from the ~746 hectares put forward by Dr Robertson during the LEC hearing); however, for the NBA the current estimate of 19.5 hectares of WSW remains unchanged. To put this another way, the 2014 Application has accepted the LEC decision that only 465 hectares of WSW remains extant, yet they have not accepted the LEC decision that over-mapping of WSW has occurred within the NBA (19.5 hectares in both 2010 & 2014 Applications).
66. This is particularly an issue for those areas of WSW Grasslands within the NBA, which are intended to be restored back to WSW. In the 2010 Application, WSW Grassland was mapped across 190.8 hectares of the NBA, while in the 2014 Application it has been mapped across 156.5 hectares, a reduction of 34.3 hectares. There is no explanation in the Ecology (Appendix H) report as to why the WSW Grasslands have been reduced in area, so I can only assume that the "*Warkworth Sands Woodland Re-establishment Area (2003 Consent)*" shown in Figure 7.3 is the reason for this, which appears to approximate 35 hectares in area. As I understand it, this 2003 WSW Re-establishment Area was the subject of a previous approval and cannot be included as part of a new offset package. Accepting that this is the reason for the change in WSW Grassland extent from 2010 to 2014, it is evident to me that the 2014 Application has retained its over-mapping of the extent of WSW Grassland, and hence has over-mapped the extent of restorable WSW EEC. The 156.5 hectares of WSW Grassland shown in the 2014 Application is a 45% increase on the 86.3 hectares mapped by me in Bell (2012). Based on the arguments I presented at that time, I do not consider that 156.5 hectares of WSW once occurred within the NBA in areas currently mapped as WSW Grassland.
67. In summary, the 2014 Application for the NBA has neglected to reduce the extent of current WSW back from 19.5 to 10.2 hectares (effectively halving the conserved amount) in keeping with the findings of the NSWLEC. By extension, the 2014 Application has also neglected to reduce the amount of WSW Grasslands that may be suitable for restoration of WSW: its estimate of 156.6 hectares represents a 45% increase on what I believe was originally WSW (86.3 ha).

3.4.2 Southern Biodiversity Area

68. The Southern Biodiversity Area (SBA) is stated in the 2014 Application to be 788 hectares in size, which is an increase of 70 hectares from the SBA discussed in the 2010 Application. On comparison of the SBA from the two Applications, it appears that the increase is due mainly to the addition of the former 'Springwood' property near the north, and a separate parcel of land adjacent to Bulga. The former Putty Road Conservation Area has also been excised from the SBA.
69. With this change in boundaries of the SBA, there is evidently also a change in the extent of EECs that are conserved within it. In relation to WSW, the area conserved has reduced from 85 hectares (2010) to 56 hectares (2014), a difference of 29 hectares. I assume that this difference is due to the excising from the SBA of the WSW conservation areas which were part of the 2003 consent conditions, and could not be used again for offsetting purposes. In addition, 2.5 hectares of WSW Grassland are contained within the SBA.
70. As in 2012, and without further field investigations, I have no reason to question the mapping of WSW within the SBA, and hence am satisfied that the stated amount of 58.5 hectares of current and former WSW (56 ha of WSW + 2.5 ha of WSW Grassland) will be conserved there as part of this Application.

3.4.3 Supplementary Measure 1: Integrated Restoration Implementation Plan

71. The Executive Summary of the Ecology (Appendix H) report refers to the *Integrated Restoration Implementation Plan* (or *Integrated Management Plan* elsewhere in the document) that will be prepared as a supplementary offset measure for WSW. This is a good initiative, and aims to collaborate resources towards the recovery of WSW in the region, by the sharing of knowledge and experiences among the various land owners where WSW occurs. There is, however, little information as to how this will be undertaken, nor who will be responsible for its implementation. Ideally, such a management plan should be prepared and overseen by an independent body with no ties to any of the relevant stakeholders. A person or body of recognised expertise in ecosystem restoration should take a lead role in this initiative.
72. The 2014 Application includes in its documentation a report on the rehabilitation performance and completion criteria for the mine (Appendix Q). The performance measures and indicators in this document have been designed to "*provide the ability to track the development of sustainable ecosystems through a series of conceptual stages*". It is intriguing that the Integrated Restoration Implementation Plan proposed as a supplementary offset measure is not mentioned in Appendix Q, although admittedly the Plan would involve liaison with a number of other land holders, and hence would be logistically difficult to document here. I understand too that Appendix Q is centred on the rehabilitation of mined land, and that no WSW will be restored and managed in those areas.

3.4.4 Supplementary Measure 2: Research into Completion Criteria

73. A second supplementary measure involving further research has also been proposed. On first reading, this is a good initiative that should ensure restored landscapes approach or exceed expected milestones for the establishment of WSW. Section 7.2.4 of the Ecology (Appendix H) report provides a list of seven criteria that may be used to show that successful re-establishment has occurred, all of which are basic ecological features of vegetation communities (diversity & abundance of characteristic WSW species; appropriate % cover estimates of all strata; presence of

key indicators species; habitat diversity; weed presence; etc). However, there is no indication as to what form this “research into completion criteria” will take.

74. Section 3 of the Ecology (Appendix H) report correctly states that the project area and surrounds has been extensively surveyed since the 1990’s (and see Appendix A in that report). In relation to WSW, there have been many survey programs undertaken where quantitative data have been collected across the range of this community (eg: Orchid Research 2003; Bower 2004; Bell 2007; Cumberland Ecology 2010; Bell 2012; Clements 2012; Umwelt 2013; Gross & Vary 2014; and others). Consequently, I do question why new research into these basic community criteria (such as the 7 listed in Section 7.2.4) is being proposed as a supplementary offset measure, when clearly there already exists a wealth of information that could be readily used to formulate suitable completion criteria for WSW. Proposing research to develop completion criteria, presumably through the collection of new data, appears to me to be an impressively sounding but unnecessary supplementary measure: a simple compilation exercise using existing data would quickly develop a suite of suitable completion criteria.
75. I am also curious as to whether or not the WSW Restoration Manual that has already been prepared by Thackway et. al. (2013) (which I have not been able to source for review purposes) contains sufficient information on completion criteria for WSW, since it reportedly contains: “... *a process for tracking the recovery of WSW sites towards a reference state.*” I would expect that a restoration manual would already include data on such things as species diversity and abundance, acceptable cover estimates of key strata layers etc if it is claimed to be capable of tracking recovery to a reference state. Is the proposed supplementary measure of researching completion criteria duplicating work that has already been done?

3.4.5 Re-establishment of WSW

76. Section 7.2.1 in the Ecology (Appendix H) report claims that 159.5 hectares of WSW Grassland in the NBA and SBA will be used to re-establish WSW “*and develop high quality examples of WSW in the long term*”. As detailed in my Statement of Evidence (Bell 2012), and as supported by Justice Preston and the NSW Court of Appeal, there is a high risk of failure in achieving high quality restoration of natural ecosystems because the science lags well behind the policy. Gross and Vary (2014), the researchers appointed by the proponent to undertake research into WSW, state in their recent paper that “*it is not surprising but very alarming that fewer than 30–50% of restoration projects bring about a reassembly of the original habitat (Suding 2011) and instead novel communities may form that have different properties compared with the original community (Hobbs et al. 2009)*”. The very research that they were contracted to do within WSW has raised new questions about seed bank dynamics, and it is likely that similar scenarios will become evident from other avenues of WSW restoration research.
77. As in 2012, I remain concerned that there is little evidence in support of claims that restoration of WSW is achievable. Section 7.2.4 of the Ecology (Appendix H) report states that “*However, re-establishment will not rely upon the natural regeneration potential of this vegetation alone and will draw on the results of extensive research to ensure that the WSG is returned to a fully functioning form of the WSW community*”. As noted in Section 3.3 above, there is no discussion of the results of this “extensive research” included in the 2014 Application, and hence it is difficult to be confident of success. Justice Preston recognised the poor results of restoration efforts during the NSWLEC hearing in 2012, stating that “*The research program being undertaken by UNE in the Northern Biodiversity Area has not progressed sufficiently to have actually re-established WSW EEC or to have clearly demonstrated that restoration of WSW EEC would be completely successful*” (NSWLEC 48,

2013, paragraph 241). I do not consider that additional research completed since that statement was made has changed the situation.

78. Consequently, the uncertainty of successful restoration of the factually Critically Endangered WSW should be clearly acknowledged in any offsets package, and I do not consider that this has been done for the 2014 Application. The promise of restoring 159.5 hectares of WSW in grassland areas, when there is no precedent for success, should raise extreme caution.
79. An additional but related concern is the proposal to strip the sand from the disturbance area, where WSW currently occurs, and to transport that material to offset areas where it will be spread out to assist restoration. In reference to the soil type supporting WSW, I note that on page 13 of the Soil (Appendix I) report, it is firstly stated that *"this soil is not suitable for stripping and reuse as topdressing in mine rehabilitation works due to its single grain sandy structure"*. It goes on to say that *"Due to its single grain texture, preventing wind erosion during storage is recommended"*. A similar statement is provided in Table 14.4 (Topdressing biodiversity areas) of the Main EIS report (page 248): *"...preventing wind erosion during stripping, haulage and re-spreading is required"*. Given that this sandy material would be spread out across former grazing lands to assist restoration of WSW in the NBA, what preventions will be in place to prevent removal of this sand by wind erosion, prior to establishment of sufficient vegetative cover (which may take 3-5 years)? It is after all Aeolian (wind-blown) sand, which if left unprotected by vegetation cover will likely be re-distributed throughout the Central Hunter by prevailing winds. Much of the NBA currently comprises bare open grassy rises and slopes adjacent to the Hunter River, within a largely cleared agricultural landscape, and shows little protection from such potentially sand-lifting winds.

3.4 Other Endangered Ecological Communities

80. The 2014 Application adds three new vegetation types to the description of vegetation diversity within the project area, which were otherwise not present in the 2010 Application:
- *Regenerating Central Hunter Grey Box – Ironbark Woodland* - indicative of former grassland areas that have been left to regenerate, and now supports vegetation in a juvenile phase of development;
 - *Regenerating Hunter Valley River Oak Forest* – indicative of regenerating River Oak along active stream channels;
 - *Central Hunter Grey Box – Ironbark Derived Grassland* – indicative of areas where grazing activities have cleared most shrub and canopy species, leaving grasslands dominated by native species.
81. In discussing these new communities, the 2014 Application rightly includes Regenerating Central Hunter Grey Box – Ironbark Woodland as *Central Hunter Grey Box – Ironbark Woodland EEC*, as such areas now display characteristics closer to that EEC than to a derived grassland. Neither of the other two new communities are equated to EECs, although arguably the CHGBIW Derived Grassland could equally be considered Regenerating Central Hunter Grey Box – Ironbark Woodland (and hence EEC) at a younger stage of development. There is little advice from the NSW Scientific Committee or OEH on this issue, and the problems of assigning significance of grasslands derived from EECs in the Hunter Valley has been previously raised with them.
82. For the SBA, there has been a reduction in the total amount of all EEC vegetation conserved within it, from 635 hectares in 2010 to 497 hectares in 2014, a difference of 138 hectares. This difference is largely explained by the excising from the effective SBA those areas that were already required for conservation under the 2003 consent, in addition to some other minor boundary changes. This

is despite the closure rather than relocation of Wallaby Scrub Road, which will prevent the clearing of ~30 hectares of vegetation.

4. Concluding Comments

83. The Warkworth Sands Woodland is a highly restricted vegetation community which is factually **Critically Endangered** following State, Commonwealth and International guidelines. Based on GIS calculations of the pre-requisite Aeolian soil type, it has undergone a reduction in range in the vicinity of 50% since European Settlement. Under the current Application, it is proposed to remove 72 hectares of WSW (excluding 36ha that already has approval for removal), or ~15-18% of all WSW remaining. Much of the highest quality WSW will be removed, and will be offset predominantly with medium to low quality WSW elsewhere. It is also proposed that grassland areas formerly thought to support WSW will be successfully restored to WSW as part of this offset package.
84. The offset package presented in the 2014 Application ("Component 1") proposes to compensate for the loss of 72 hectares of high quality WSW with:
- **75.5 hectares of WSW** [but I consider this to be over-mapped in the NBA, and a figure of 66.2 ha is more realistic; see Section 3.4.1]
 - **restoration of 159.5 hectares of WSW Grassland** [but I consider this to be over-mapped in the NBA, and a figure of 88.8 ha is more realistic; see Section 3.4.1]
 - **preparation of an Integrated Management Plan for WSW** [no indication of how this will be done]
 - **development of Completion Criteria for WSW** [unnecessary, and can be compiled from the wealth of existing data on WSW. May also duplicate information already contained in the WSW Restoration Manual; see Section 3.4.4]
 - **retirement of credits under the UHSA** [but these would require recalculation given the change in extent of conserved WSW listed above]
85. The promises of successful restoration of WSW remain an issue of concern, and one that was agreed upon by Justice Preston in his judgement of the former NSWLEC case (NSWLEC 48, 2013, paragraph 241-242). Despite the inclusion of statements extolling the virtues of the \$5.5 million spent by the University of New England (UNE) on WSW restoration research, the 2014 Applications offers no evidence that the results of this research has or will be implemented into the proposed restoration. On the contrary, I found it necessary to conduct my own online investigations to uncover published and unpublished papers stemming from the UNE research. Papers on seed dispersal by ants (Taylor 2010), microsatellite markers (Fatemi et. al. 2012, 2013), and seed bank dynamics (Gross & Vary 2014) were not mentioned anywhere in the Application, and it can only be assumed that the results of these studies were not considered conducive to the 'successful' restoration efforts as claimed in the Application. I suspect that the need for ongoing and further research on WSW restoration raised by the UNE researchers was the reason the \$5.5 million research program was downplayed in the Application.
86. In its defence, the 2014 Application did propose that the WSW restoration efforts would follow the procedures outlined in the Restoration Manual prepared by Thackway et. al. (2013). This is of interest as, for instead of relying on the results of the 5-year \$5.5 million UNE research project, the proponent intends to implement the findings of a separately contracted manual, perhaps put together to compliment the UNE research outcomes. The lead author of this work, Adjunct Associate Professor Richard Thackway, is a well-respected research scientist with a long publication

history related to natural resource management and the assessment of vegetation condition. However, I have not been able to source a copy of the Thackway et. al. (2013) document, so am unable to comment further on its guidance for the restoration of WSW. I have located a manual for describing restoration activities in Australia, with Professor Thackway as a co-author (Atyeo & Thackway 2009a) and a paper outlining a national structure for monitoring revegetation activities (Atyeo & Thackway 2009b), which may form the basis of the Thackway et. al. (2013) report. I do note, however, that I can find no evidence of previous experience with WSW or other endangered ecosystems on Associate Professor Thackways Google Scholar profile, and I suspect that the Thackway et. al. (2013) document deals more with generalisations of ecosystem restoration than it does with WSW-specific restoration.

87. In the brief supplied to me for this review, I was asked the following three questions, the answers to which I will briefly summarise here:

- **In your opinion, was the assessment undertaken by the proponents adequate?** – In keeping with the 2010 Application, I consider that this revised assessment has continued to over-map the extent of WSW and WSW Grassland within the Northern Biodiversity Area, and downplayed the significance that removal of ~70 hectares of this factually Critically Endangered community will effect. In addition, I consider that the results of the 5-year \$5.5 million research program undertaken by the UNE on the restoration of WSW, formerly promoted as ‘flagship’ research, has been downplayed in favour of a newly compiled Restoration Manual prepared by a leading research scientist with no experience in WSW ecology. I maintain that more certainty in the restoration of WSW is required prior to the granting of approval to remove ~70 hectares of high (50ha) and medium (22ha) quality WSW.
- **In your opinion and within your area of expertise what, if any, are the environmental impacts that would arise from the project?** – Key impacts that may be expected should this proposal proceed would include the loss of ~70 hectares of largely high quality WSW, representing a 15-18% reduction in the current extant distribution of this community. Given the uncertainties of success for the proposed restoration of WSW, the range of conditions and fragment sizes, removal of ~70 hectares of WSW would send this community further toward the extreme end of the irreplaceability spectrum (Bekessy et. al. 2010; Umwelt 2011).
- **Provide any further observations or opinions which you consider to be relevant** – other relevant observations have been briefly discussed elsewhere in this report, as required.

5. References

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- Umwelt (2013) *Bulga Optimisation Project: Ecological Impact Assessment*. Unpublished Report to Bulga Coal Management Pty Ltd. April 2013.

Appendix 1 – Resume: Dr Stephen Bell

CONTACT DETAILS



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PRÉCIS

Stephen has been involved in native vegetation survey, classification and mapping in the Greater Sydney and Hunter Regions since 1990. During this time, he has undertaken comprehensive surveys for the National Parks and Wildlife Service in over 30 conservation reserves, and has been contracted to the NSW Office of Environment & Heritage as Senior Botanist and Team Leader for several large scale regional projects within the Sydney Basin bioregion. Under contract to local Councils, Stephen has co-ordinated and completed LGA-wide vegetation classification and mapping projects for Wyong, Gosford, Cessnock, Pittwater and Lake Macquarie LGAs, and has assisted in similar mapping projects for Blue Mountains LGA. Stephen has also completed several studies on Endangered Ecological Communities and threatened plant species, and published the results of some of these in the scientific literature.

On behalf of the Ecological Society of Australia, Stephen was the ecological expert on the Hunter Regional Vegetation Committee (2003), and is a past member of the Hunter Threatened Flora Recovery Team, and a founding member of the Hunter Rare Plants Committee (a sub-committee of the Hunter Region Botanic Gardens). He is also often called upon by Government for advice regarding the significance of vegetation communities and plant species within the northern Sydney Basin bioregion, and has sat on numerous expert panels in this regard. Stephen has been called upon as an Expert Witness for several cases heard in the NSW Land and Environment Court, where his knowledge on the vegetation of the Sydney Basin bioregion has been used to argue contentious land-use decisions.

Stephen has published several scientific papers on various aspects of the vegetation of the Sydney Basin, including classifications of vegetation within conservation reserves, threatened and rare plant species, and the description of new plant species. Stephen has completed nearly 4000 standard full floristic sampling plots within the Sydney Basin, which are stored and used in classification analyses for many projects. Other skills include extensive multivariate data analysis experience, and GIS mapping. Stephen's PhD thesis, completed on a part-time basis through the University of Newcastle, presented improvements in the recognition, identification and classification of restricted and significant vegetation communities, such as Threatened Ecological Communities (TECs).

In October 1996, Stephen established *Eastcoast Flora Survey*, a specialist botanical consultancy providing high quality services to government and the private sector.

ACADEMIC QUALIFICATIONS

Doctor of Philosophy (PhD), 2013	<i>Defining and mapping rare vegetation communities: Improving techniques to assist land-use planning and conservation</i> (University of Newcastle)
Bachelor of Science (Honours), 1991	<i>Effects of the weed Scotch Broom on bird communities in open forests on Barrington Tops</i> (University of Newcastle)
Bachelor of Science, 1989	<i>Majors in Geography and Biology</i> (University of Newcastle)

EMPLOYMENT HISTORY

University of Newcastle, Plant Sciences Group	Conjoint Fellow	June 2014 - Present
<i>Eastcoast Flora Survey</i>	Consultant Botanist (Principal)	Oct. 1996 - Present
Ecotone Ecological Consultants Pty Ltd	Manager - Flora Studies	Jan. 1996 - Oct. 1996
Private Ecological Consultant	Sole trader	Jan. 1991 - Dec. 1995
NSW National Parks and Wildlife Service	Project Officer	Sept. 1993 - Jan. 1994
University of Newcastle, Geography Dept.	Field Tutor (Scientific)	July 1993 - Aug. 1993
NSW National Parks and Wildlife Service	Project Officer	Jan. 1993 - June 1993
University of NSW, School of Biol. Sciences	Research Assistant (Bird ecology)	Sept. 1992 - Jan. 1993
NSW National Parks and Wildlife Service	Technical Officer (Scientific)	Jan. 1992 - June 1992
RZ Mines (Newcastle)	Environmental Research Officer	Oct. 1990 - Dec. 1991
Wayne Perry & Associates P/L	Environmental Officer (Casual)	June 1990 - Oct. 1990

RESEARCH INTERESTS

- Vegetation classification and mapping, at local and regional scales
 - Definition and mapping of rare and threatened vegetation communities
 - Restoration of threatened grassy woodlands from derived grasslands
 - Improving data sampling methods for monitoring and classification
 - Re-constructing vegetation distribution using information from historical botanical explorers
 - Population ecology and habitat of rare and threatened plants
 - Taxonomy and significance of Hunter Region plants
-

MINISTERIAL APPOINTMENTS

- *Ecological Society of Australia* representative on the Hunter Regional Vegetation Committee (2001-2003)
-

SIGNIFICANT CONSULTANCIES

- Vegetation survey, classification and mapping of the *Singleton Army Training Area*, a project for the Department of Defence (2011-12).
- Attribution of endemic Hunter Region vegetation communities into the *NSW Vegetation Classification & Assessment* (NSW VCA Database), a project for the Hunter-Central Rivers Catchment Management Authority & the Royal Botanic Gardens and Domain Trust (2011).
- Consultant Lead Botanist for *Revised Classification and Mapping of Wollemi National Park*, a project for Department of Environment and Climate Change (2008-2013).
- Consultant Lead Botanist for *Native Vegetation of the Putty Valley*, a project for Department of

Environment and Climate Change & Hawkesbury-Nepean Catchment Management Authority (2007-2008).

- Consultant Lead Botanist for *Native Vegetation of the Northern Hawkesbury LGA*, a project for Department of Environment and Climate Change & Hawkesbury-Nepean Catchment Management Authority (2007-2008).
- Consultant Lead Botanist for *Native Vegetation of Yengo and Parr Reserves and Surrounds*, a project for Department of Environment & Climate Change (2006-2007).
- *Review of Central Coast Vegetation Communities* for Department of Environment and Climate Change bioregional conservation assessments (2007).
- Member of Steering Committee (and co-supervisor of Newcastle University Honours student) for the CCCEN NSW Wetland Action Grants-funded project on “*Biodiversity assessment and conservation of hanging swamps on the Central Coast Plateau, NSW*” (2004).
- Founding member of *Hunter Region Botanic Gardens'* Hunter Region Rare Plants Committee (2000-present).
- Consultant botanist for *Vegetation survey and analysis of Warragamba Special Area and Lake Burragorang catchment (incorporating Blue Mountains, Kanangra-Boyd & Nattai National Parks, and Yerranderie, Burragorang & Nattai SRA's)* for National Parks and Wildlife Service and the Sydney Catchment Authority (2001-2002).
- Consultant Botanist/ Vegetation Mapping Consultant (Hunter Region) for *NPWS CRA Lower North East (south of the Hunter)*. 1998-1999.
- Consultant Botanist/ Vegetation Mapping Consultant for *Lower Hunter & Central Coast Regional Environmental Management Strategy* for National Parks and Wildlife Service CRA Unit & Department of Urban Affairs & Planning. 1998-1999.

MEMBERSHIP OF EXPERT PANELS

- Commonwealth Department of the Environments *Hunter Valley Woodlands Expert Technical Workshop* (2014)
- Hunter Councils *Biodiversity Modelling & Prioritisation: Hunter, Central and Lower North Coast Region of New South Wales* Technical Review Workshop (2014)
- NSW Office of Environment & Heritage *Hunter Valley Grasslands* Expert Panel & Workshop (2013)
- Lake Macquarie City Council *Grevillea parviflora* Expert Panel & Workshop (2013)
- NSW Office of Environment & Heritage *Priority Action Statements for Threatened Species* Expert Panel (2012)
- NSW Office of Environment & Heritage *Review of Benchmarks for Greater Hunter Vegetation Classification* Expert Panel (2012)
- Hunter-Central Rivers CMA's *Hunter Vegetation and the NSWVCA* Expert Panel (2009)
- Port Stephens Shire Council *Conservation Assessment Database* Expert Panel (2009)
- Lake Macquarie City Council *Tetratheca juncea* Expert Panel & Workshop (2009)
- NSW Department of Environment & Climate Change *Climate Change & Biodiversity Impacts* Expert Panel (2008)
- Hunter-Central Rivers CMA's *Vegetation Classification* Expert Panel (2008)
- Ecological Expert for the HotSpots Fire Project, *Hawkesbury Pilot Program* (2007)
- *Hunter Valley Threatened Flora Recovery Team* Technical Advisor (2006-7)
- *Kurri Sands Swamp Woodland EEC Recovery Team* Member (2005)

- Hunter-Central Rivers Catchment Management Authority *Regionally Significant Vegetation* Expert Panel (2005)
 - NSW Department of Infrastructure, Planning & Natural Resources *High Conservation Value Vegetation* Expert Panel advising the Hunter Regional Vegetation Committee (2003)
 - *Environment Australia's* Expert Panel for the Lower North-east CRA division (1998)
-

CONFERENCE & WORKSHOP PRESENTATIONS

- Plant Identification for Flora of the Hunter Valley, 7th - 8th April 2014, Kurri Kurri, Australian Network for Plant Conservation: "*Introduction to the flora of the Hunter Valley - history, diversity and ecology*".
 - HOTSPOTS Fire Project: Awabakal and Worimi Fire Forum, 27th July 2011, Williamstown, Never Never Resources: "*Vegetation of the Worimi Conservation Lands*".
 - HOTSPOTS Fire Project: Wanaruah Fire Forum, 17th – 19th August 2010, Sandy Hollow, Upper Hunter Valley, Nature Conservation Council: "*Vegetation of Wanaruah Lands, Sandy Hollow*".
 - Coastal Groundwater Dependent Ecosystems Workshop, 3rd – 4th September 2009, South West Rocks, NSW (Geoscience Australia): "*Surveying, classifying and mapping vegetation on the Tomago Sandbeds*".
 - Vegetation Management and Biodiversity Conservation in the Hunter Region, May 2000, Singleton, NSW (Hunter Environment Lobby Inc.): "*An evaluation of vegetation survey and threatened plant species listings in the Hunter Region*"
-

AWARDS & GRANTS

- NSW Environmental Trust (2006/RR/0003) *Improved Methods of Predicting Threatened Species Preferred Habitat* (\$20,000, with Claire de Lacey & Steve Chamberlain)
 - UDIA NSW Award for Excellence (Professional Consultancy) for the *Thornton-Killingworth Sub-regional Conservation & Development Strategy* (2003)
 - Lake Macquarie City Council Environmental Research Grant (2000/2001-3) *Demography and conservation status of selected Acacia bynoeana populations* (\$5000)
 - Lake Macquarie City Council Environmental Research Grant (99/00-2) *Distribution and status of Macrozamia flexuosa (Zamiaceae) in Lake Macquarie LGA* (\$4400)
-

PROFESSIONAL MEMBERSHIPS

- Ecological Society of Australia (ESA)
 - Australian Network for Plant Conservation Inc. (ANPC)
 - International Association for Vegetation Science (IAVS). Paper reviewer for *Journal of Vegetation Science*
 - Australasian Native Orchid Society Inc. (ANOS)
-

PUBLICATIONS (PEER REVIEWED)

Bell, S.A.J. & Driscoll, C. (in review) Weeping Myall (*Acacia pendula*) in the Hunter Valley of New South Wales: early explorer's journals, database records and habitat assessments raise doubts over naturally occurring populations. *Cunninghamia*

- Bell, S.A.J. (in review) Experiences in translocation of threatened terrestrial orchids in the upper Hunter Valley of New South Wales: *Diuris tricolor* and *Prasophyllum* sp. Wybong. *Ecological Management & Restoration*
- DeLacey, C., Bell, S., Chamberlain, S., & Bossard, K. (in review) Prediction of and realised habitat for a cryptic plant species: the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls. *Cunninghamia*
- Bell, S.A.J. & Nicolle, D. (2012) *Eucalyptus expressa* (Myrtaceae): a new and distinctive species from the sandstone ranges north-west of Sydney, New South Wales. *Telopea* 14: 69-76.
- Bell, S.A.J. & Stables, M. (2012) Floristic variability, distribution and an extension of range for the endangered Pittwater Spotted Gum Forest, Central Coast, New South Wales. *Cunninghamia* 12(2): 143-152.
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- Bell, S., Branwhite, B., & Driscoll, C. (2005) *Thelymitra 'adorata'* (Orchidaceae): population size and habitat of a highly restricted terrestrial orchid from the Central Coast of New South Wales. *The Orchadian* 15(1): 6-10.
- Bell, S.A.J. (2004) Distribution and habitat of the vulnerable tree species, *Angophora inopina* (Myrtaceae), on the Central Coast of New South Wales. *Cunninghamia* 8(4): 477-484.
- Bell, S.A.J. (2004). Vegetation of Werakata National Park, Hunter Valley, New South Wales. *Cunninghamia* 8(3): 331-347.
- Bell, S.A.J. & Copeland, L.M. (2004) *Commersonia rosea* (Malvaceae s.l.: Lasiopetaleae): a new, rare fire-ephemeral species from the upper Hunter Valley, New South Wales. *Telopea* 10(2): 581-587.
- Bell, S.A.J. (2002) Habitat of the endangered *Hibbertia procumbens* (Labill.) DC (Dilleniaceae) from the Central Coast of New South Wales. *Victorian Naturalist* 119(2): 69-74.
- Bell, S.A.J. (2001) Notes on population size and habitat of the vulnerable *Cryptostylis hunteriana* Nicholls (Orchidaceae) from the Central Coast of New South Wales. *Cunninghamia* 7(2): 195-204.
- Bell, S.A.J. (2001). Notes on the distribution and conservation status of some restricted plant species from sandstone environments of the upper Hunter Valley, New South Wales. *Cunninghamia* 7(1): 77-88.
- Bell, S. (2000) An evaluation of vegetation survey and threatened plant species listings in the Hunter Region. Pp. 19-34 IN *Vegetation Management and Biodiversity Conservation in the Hunter Region - Where to from here?* Ed. by M.Fallding. Proceedings of the Public Workshop. Hunter Environment Lobby. Singleton, 12 May 2000.

PUBLICATIONS (OTHERS)

- Bell, S. & Elliott, M. (2013) Preliminary results suggest fire is required to maintain *Acacia dangarensis*, a threatened single-population endemic from the Hunter Valley of NSW. *Australasian Plant Conservation* 22(1): 9-10.

- de Lacey, C, Bell, S, Chamberlain, S. & Bossard, K. (2013) Finding the leafless tongue orchid '*Cryptostylis hunteriana*' Nicholls. *Nature New South Wales* Vol. 57 (1) Autumn 2013: 24-25. [online]
- de Lacey, C., Bell, S., & Chamberlain, S. (2012) Habitat of the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls throughout its known Australian distribution. *Australasian Plant Conservation* 20(4): 23-25.
- de Lacey, C., Bell, S., Chamberlain, S., & Bossard, K. (2012) Habitat of the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls throughout its known Australian distribution. *The Orchadian* 17(4): 162-174.
- Bell, S.A.J. (2010) Defining and mapping an endangered ecological community within Lake Macquarie Local Government Area, New South Wales. *Australasian Plant Conservation* 18(3): 18-19.
- Bell, S., Peake, T. & Driscoll, C. (2007) Dealing with taxonomic uncertainty in Weeping Myall *Acacia pendula* from the Hunter catchment, New South Wales. *Australasian Plant Conservation*. 16(1): 14-15.
- Bell, S. & Driscoll, C. (2005) New records of the endangered *Hibbertia procumbens* from the Central Coast of NSW. *Australasian Plant Conservation* 13(4): 24-25.
- Bell, S.A.J., Parsons, J., & Meldrum, R. (2005) Towards the protection and management of hanging swamps on the Somersby Plateau, Central Coast, New South Wales. *Australasian Plant Conservation* 13(3): 10-11.
- Bell, S. (2003) Another new and highly restricted mallee from the Hunter Valley, *Eucalyptus castrensis*. *Hunter Flora* 11: 2.
- Peake, T., Bell, S., Tame, T., Simpson, J., & Curran, T. (2003) *The Hunter Rare Plants Database: Identification and listing of regionally significant flora for the Hunter Region, New South Wales*. Poster Presentation at the Ecological Society of Australia Annual Conference 2003, Armidale NSW.
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NSW LAND & ENVIRONMENT COURT (EXPERT WITNESS)

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Appendix 2 – Comparison of WSW FD & Original Nomination

Relevant paragraphs from the Final Determination for WSW (left) and the original nomination (including page number where relevant) from the Hunter Rare Plants Committee (right). Matching text is highlighted.

Final Determination	Nomination
<p>2. Warkworth Sands Woodland is characterised by the following assemblage of species.</p> <p><i>Acacia falcata</i> <i>Ajuga australis</i> <i>Allocasuarina luehmannii</i> <i>Angophora floribunda</i> <i>Aristida ramosa</i> <i>Aristida warburgii</i> <i>Brachyloma daphnoides</i> <i>Callitris endlicheri</i> <i>Cheilanthes sieberi</i></p> <p><i>Desmodium varians</i> <i>Dichondra species A</i></p> <p><i>Echinopogon intermedius</i> <i>Entolasia stricta</i> <i>Eucalyptus blakelyi/tereticornis</i> <i>intergrades</i> <i>Exocarpos cupressiformis</i> <i>Hardenbergia violacea</i> <i>Hovea linearis</i> <i>Imperata cylindrica</i> <i>Jacksonia scoparia</i> <i>Lomandra leucocephala</i> <i>Melaleuca decora</i> <i>Persoonia linearis</i> <i>Pomax umbellata</i> <i>Solanum prinophyllum</i></p>	<p>“In defining Warkworth Sands Woodland the following common species have been listed after survey and reconnaissance of the community:</p> <p><u>Abundant and/ characteristic taxa:</u></p> <p><i>Acacia filicifolia</i> <i>Allocasuarina littoralis</i> <i>Amyema pendulum</i> subsp. pendulum <i>Angophora floribunda</i> <i>Aristida calycina</i> var. calycina <i>Aristida vagans</i> <i>Banksia integrifolia</i> subsp. integrifolia <i>Brachyloma daphnoides</i> subsp. daphnoides <i>Breynia oblongifolia</i> <i>Callitris endlicheri</i> <i>Dianella revoluta</i> <i>Entolasia stricta</i> <i>Eucalyptus blakelyi/tereticornis</i> <i>Exocarpos cupressiformis</i> <i>Exocarpos strictus</i> <i>Hardenbergia violacea</i> <i>Hibbertia linearis</i> <i>Imperata cylindrica</i> var. major <i>Jacksonia scoparia</i> <i>Leucopogon muticus</i> <i>Lomandra glauca</i> <i>Lomandra leucocephala</i> subsp. leucocephala <i>Melaleuca thymifolia</i> <i>Persoonia linearis</i> <i>Pimelea linifolia</i> subsp. linifolia <i>Pomax umbellata</i> <i>Pteridium esculentum</i></p> <p><u>Less common taxa:</u></p> <p><i>Acacia falcata</i> <i>Ajuga australis</i> <i>Allocasuarina luehmannii</i> <i>Aristida ramosa</i> var. speciosa <i>Aristida warburgii</i> <i>Calotis cuneifolia</i> <i>Cheilanthes sieberi</i> subsp. sieberi <i>Chrysocephalum apiculatum</i> <i>Desmodium varians</i></p>

	<p><i>Dichondra</i> species A <i>Echinopogon caespitosus</i> var. <i>caespitosus</i> <i>Echinopogon intermedius</i> <i>Einadia trigonos</i> <i>Eucalyptus crebra</i> <i>Eucalyptus glaucina</i> <i>Hovea linearis</i> <i>Hypoxis hygrometrica</i> var. <i>hygrometrica</i> <i>Indigofera australis</i> <i>Melaleuca decora</i> <i>Solanum prinophyllum</i> <i>Vittadina sulcata</i>"</p>
<p>4. Warkworth Sands Woodland is generally of woodland to low woodland structure with trees of <i>Angophora floribunda</i> and <i>Banksia integrifolia</i>, and shrubs and ground species including <i>Acacia filicifolia</i>, <i>Pteridium esculentum</i>, <i>Imperata cylindrica</i>, <i>Brachyloma daphnoides</i> and <i>Melaleuca thymifolia</i>.</p>	<p>"Woodland occurring on Aeolian sands of Pleistocene age. Dominant species include: <i>Angophora floribunda</i>, <i>Banksia integrifolia</i>, <i>Acacia filicifolia</i>, <i>Pteridium esculentum</i>, <i>Imperata cylindrica</i> var. <i>cylindrica</i>, <i>Brachyloma daphnoides</i> subsp. <i>daphnoides</i>, <i>Melaleuca thymifolia</i>" (p1)</p>
<p>5. Small drainage lines within the community may support a higher abundance of certain species (such as <i>Melaleuca thymifolia</i>) and less of others (such as <i>Banksia integrifolia</i>). Such areas are included as part of this community. In addition, adjacent areas, where woodland occurs on a shallow A horizon of sand, are included within this community.</p>	<p>"Whilst the species listed above are frequently found in WSW, many also occur in other communities. Small drainage lines within the community may support a higher abundance of certain species (such as <i>Melaleuca thymifolia</i>) and less of others (such as <i>Banksia integrifolia</i>). Such areas are included as part of the community. In addition, adjacent areas where woodland occurs on a shallow A horizon of sand are included within this community." (p5)</p>
<p>7. Warkworth Sands Woodland occupies sand dunes generally 1-6 m high, resting on a river terrace. The main dune deposit is aligned NW-SE. The sand deposit is thought to be of Pleistocene age (Story <i>et al.</i> 1963).</p>	<p>WSW occurs near to the northern boundary of the Sydney Basin Bioregion, in a small area near Warkworth, about 15 kilometres east-south-east of Singleton in the mid Hunter Valley. It occupies linear sand dunes that are 1-6 m high, resting on a high river terrace (Story <i>et al.</i> 1963). The main dune deposit is aligned NW-SE; Story <i>et al.</i> (1963) note that it is generally stable but is subject to blow-outs. Galloway (1963) suggested that the sand dunes formed some 18,000 to 15,000 years ago from the sandy alluvium of Wollombi Brook." (p5)</p>
<p>8. Woodlands occurring adjacent to the sand dunes on Permian clays share many species with Warkworth Sands Woodland but also have a higher abundance of Permian substrate species, such as <i>Corymbia maculata</i>, <i>Eucalyptus moluccana</i>, <i>Allocasuarina luehmannii</i> and <i>Eucalyptus crebra</i>. These areas are not considered to be part of this community, except in ecotones where there is a dominant abundance of the species of the Warkworth Sands Woodland. This is generally where a thin sandy veneer overlies the Permian substrate.</p>	<p>"Woodlands occurring adjacent to the sand dunes on Permian clays share many species with WSW, but also have a higher abundance of Permian substrate species, such as <i>Corymbia maculata</i>, <i>Eucalyptus moluccana</i>, <i>Allocasuarina luehmannii</i> and <i>Eucalyptus crebra</i>. These areas are not considered to be part of this community, except in ecotones where there is a dominant abundance of the common and characteristic species listed above, particularly where a thin, sandy veneer overlies the Permian substrate." (p5)</p>