Bunya Mountains, Annotated Bibliography and Field Research Hypotheses

Huon Morton

Queensland University of Technology (QUT)

BVB204: Ecology

Professor Jennifer Firn

15 August 2024

1.0 Annotated Bibliography

Moravek, S., Luly, J., Grindrod, J., & Fairfax, R. (2013). The origin of grassy balds in the Bunya Mountains, southeastern Queensland, Australia. *The Holocene*, *23*(2), 305–315. https://doi.org/10.1177/0959683612460792

Moravek et al. (2013) considered the argument regarding the origin of montane grasslands (grassy balds) in the Bunya Mountains. Soil samples were used for radiocarbon dating, fossil pollen and phytolith analysis, and Tauber pollen traps were used to gauge the pollen signal yielded by each vegetation type. Using these analyses from Dandabah swamp, the article reconstructed the vegetational history and supposed fire regimes to determine the ecological history of the Dandabah grassy bald. The results suggest that the grasslands likely persisted due to human agency, and further research into why grasslands came to dominate the landscape early in the Holocene would be an important consideration.

The four authors named in this study all show experience within their fields, with Fairfax being a strongly recognised author for Australian ecosystems and referenced among other articles mentioned in this bibliography. The article is within *The Holocene*, a peer-reviewed journal, indicating its credibility. It conducts unbiased, extensive and well-structured analytical research, as a continuation of the long-running argument for the origin of the grassy balds.

This source provides a strong knowledge base for the soil matrices, surrounding vegetation, and the cultural relevance of the site. It will be particularly valuable as evidence for interpretations of the changing ecosystems in the Bunya Mountains considering that the origin of grassy balds has been heavily debated (Fensham & Fairfax, 2006a; MacDermott et al., 2017a; Webb, 1964).

Butler, D. W., Fairfax, R. J., & Fensham, R. J. (2006). Impacts of tree invasion on floristic composition of subtropical grasslands on the Bunya Mountains, Australia. *Australian Journal of Botany*, *54*(3), 261. https://doi.org/10.1071/BT05070

This article examines the effect of tree invasions on vascular plant diversity and distribution across 13 adjoining sites of grassland in the Bunya Mountains to describe the antagonistic effects trees have on montane grasslands. Frequencies of different plants at varying canopy levels were analysed across three habitats in each site, no more than 150 m apart and further divided into 8 3 x 4 m quadrats placed 3 m apart. Additionally, surface soil samples, diameter at breast height (DBH) measurements, and crown cover measurements were recorded. The results suggest that the compositions of adjoining ecosystems regarding forbs and grasses are relatively similar, yet they are all under threat of encroaching Eucalypts. Management of the encroachment will only be accomplished through regular burning.

All three authors in this paper are experienced within their respective ecological fields. The article is included in the *Australian Journal of Botany*: a credible journal. The article provides a vast collection and analysis of floristic compositions and their intrinsic differences, further detailing the work by Moravek et al. (2013), making it an important source for research.

This article will provide highly detailed context to many observations made while conducting research regarding vegetation compositions. The article is informative, very easy to follow, and supports several articles in stating that the grasslands can only be maintained through regular burning. However, Fensham, an author of this paper mentioned in a later, co-authored study, that regular burning fails to mitigate the development of savannas.

Cooke, P., Ens, E., Clarke, P., Chang, H., Rossetto, M., Crayn, D., Turpin, G., & Ferrier, A. (2024). Not All Edible Nuts Are Eaten: Evidence for Continued Aboriginal Cultural Use and Dispersal of Bunya Pine (*Araucaria bidwillii*) in Southern But Not in Northern Queensland. *Journal of Ethnobiology*, *44*(2), 129–140. https://doi.org/10.1177/02780771241246853

Cooke (2024), an indigenous Gungalida man, investigated pre- and postcolonial seed dispersal with a focus on possible ethnographic causes by utlising geospatial information software (GIS) and interviewing 13 indigenous cultural authorities. The study specifically aimed to link the northeastern and southeastern occurrences of the seeds in Queensland to local community histories and to signify the importance of Aboriginals as harbingers of ancient cultural knowledge. It was found that nine of the thirteen Aboriginal groups were strongly connected to the Bunya pines as a food source and cultural inspiration.

Cooke has published several articles, displaying a vast experience in the humanitarian sciences and is accompanied by several credible authors. The article is featured in the peer-reviewed *Journal of Ethnobiology*, which is a strong indicator of credibility. The description of complex histories between Aboriginal communities and the correlated dispersal of Bunya seeds will prove to be a valuable resource for research; however, not strictly from an analytical point of view.

The influence of cultural practices will become an important consideration when understanding the composition of the pines and other dominant trees in the Bunya Mountains and so this article will be valuable to refer to. The study was easily navigated and includes primary accounts of cultural networks and histories which is a highly useful point for any research.

Shen, J.-P., Esfandbod, M., Wakelin, S. A., Bacon, G., Huang, Q., & Chen, C. (2019). Changes in bacterial community composition across natural grassland and pine forests in the Bunya Mountains in subtropical Australia. *Soil Research*, *57*(8), 825. https://doi.org/10.1071/SR19111

The article investigated the distribution and response mechanisms of soil bacteria in the changing tree-grass mixtures to give evidence for the sensitivity of microbial diversity.

The site of study was around Baker Creek, close to the township of Dandabah. Three 40 x 40 m plots, at least 50 m apart, were chosen for soil sampling, leading to 12 samples, where they were analysed through a series of chemical and biological tests. The findings indicated clear variations in microbial communities between biomes, making an emphasis on the depth of relative biodiversity and inherent threats relating to tree invasions.

Shen has published several articles and has been heavily cited, particularly for their research in ammonia-oxidising bacteria. The study is featured in the *Soil Research* journal as a testament to its credibility. The article heavily analyses the soil composition within the chosen areas using several recognised statistical tests, which will prove to be valuable for understanding the ecological constituents of the Bunya Mountains.

The analyses in this study are robust and the knowledge of soil properties and microbial responses to vegetational changes for the Bunya Mountains will aid in future interpretations. Many sources were referenced in this study that could assist in further understanding the site's ecosystem.

Smith, G., Fensham, R., Ferguson, D., Hogan, L., & Mathieson, M. (2015). Fauna of the grassland-forest landscape mosaics of the Bunya Mountains, eastern Australia. *Australian Zoologist*, *37*(3), 302–310. https://doi.org/10.7882/AZ.2014.035

This article assessed fauna assemblages among four different vegetation types and three edge types between grassland and wooded habitats within the Bunya Mountains. The author's intentions were to highlight the effects that vegetation types have on species diversity through statistical analyses of abundance. Seven sites were used for each of the seven habitat types and were set out as 100 x 50 m plots, varying in distance from edge habitats. It found similar fauna compositions between floristically distinct habitats, except for

the grassy balds. They argue that if the grassy balds were to disappear, there would be little biodiversity loss; however, there would be an increased pressure on edge fauna.

The authors were more difficult to find from the article; however, Fensham was noted as a co-author and the article is featured in the *Australian Zoologist*, indicating a high credibility. The text is primarily analytical, driven by well-structured statistical methods and supported by many reputable articles, making it a strong paper for considering both general and specific faunal compositions.

The article provided additional knowledge on ecosystem changes, specifically for faunal compositions, which will prove to be useful when analysing ecological differences. The article was well written and included references to previously mentioned articles (Butler et al. 2006; Moravek et al. 2013).

Leonard, S., & Kingdom, D. (2017). Disturbance ecology of Tasmanian highland grassland — an overview and implications for conservation management. Papers and Proceedings of the Royal Society of Tasmania, 151, 1–10. https://doi.org/10.26749/rstpp.151.1

Leonard and Kingdom give an overview of fire regimes and ruminant grazing as management strategies for maintaining the biodiversity of grasslands in the highlands of Tasmania. The authors reviewed over 60 articles with the intention of providing evidence for the impact that these disturbances have on the ecological health of the grasslands and ecosystems alike. From their findings, they state that grazing alone will have no significant benefits as the ruminants are prone to selective consumption. Thus, fire regimes will prove to be important for the indifferent reduction of *Poa* biomass and thick tussocks. They do acknowledge, however, that a combination of these grasses is necessary for the endangered Ptunarra Brown Butterfly, thus, regimes should be conducted cautiously.

The peer-reviewed article was published in the *Papers and Proceedings of the Royal Society of Tasmania*, with Leonard as the lead author. Leonard has published several articles in fire and conservation ecology and has been cited in over 1500 instances, counting toward the credibility of this paper. The writing is engaging and well-structured; however, it is more descriptive and only refers to secondary analyses.

Leonard provides in-depth insights on the management of grasslands in the highlands of Tasmania, establishing a greater understanding of the impacts that land management changes have on comparable ecosystems such as the grassy balds in the Bunya Mountains. Despite the similarities between ecosystems, ruminants play a significant role in habitat modification; considering this, inferences from this study should be made with caution.

Fensham, R. J., & Fairfax, R. J. (2006). Can burning restrict eucalypt invasion on grassy balds? *Austral Ecology*, *31*(3), 317–325. https://doi.org/10.1111/j.1442-9993.2006.01560.x

Fensham and Fairfax investigate whether regular burning can restrict the invasion of *Eucalyptus tereticornis* into the grassy balds of the Bunya Mountains. The study conducts four separate seedling burn trials over three forest-grassland boundaries and a logistic model to analyse the impact of fire intensity and lignotuber size on seedling mortality. The results suggest that while young seedlings are highly vulnerable to fire, 5-year-old established eucalypts can survive regular burning, implying that Aboriginal biennial fire regimes may not prevent the spread of eucalypt forests into grasslands.

The article is published in *Austral Ecology*, a reputable peer-reviewed journal, which enhances its credibility. The study is analytical, using empirical data and robust statistical methods to explore the relationship between fire management and eucalypt invasion.

This source provides major insights into the effectiveness of fire management practices in maintaining the grassy bald ecosystems of the Bunya Mountains. The source

focuses on many ways eucalypts may have begun to invade the grassy balds, exploring the argument for the effectiveness of aboriginal fire regimes, giving it excellent grounds for comparisons to adjacent studies.

Webb, L. J. (1964). An Historical Interpretation of the Grass Balds of the Bunya Mountains, South Queensland. *Ecology*, *45*(1), 159–162. https://doi.org/10.2307/1937117

Webb begins by suggesting that the origins of the grassy balds are inadequately described by Aboriginal fire management, a previously accepted theory. The paper explores the ecological and historical context of the region by comparing the Bunya balds to the grasslands in the Southern Appalachians and South Brazil. From a paleoclimatic interpretation, Webb concludes that the Bunya Mountains were once dominated by mossy forestlands and were subsequently modified by drier periods, which more frequently invoked harsh events such as wildfires, thus developing Eucalypt forests, woodlands, and grassy balds.

The article was published in *Ecology*, a credible, peer-reviewed journal. Webb used an analytical approach to considering the origin of the balds using ecological and historical references. The comparison between similar occurrences of grassy balds provides a solid foundation to challenge the prevailing theories; however, the argument would be more potent if they included direct empirical evidence.

The historical interpretations of the grassy balds by Webb provides an excellent perspective to help broaden the scope of research. It gives more reason to consider abiotic factors more in depth, such as the climate of the current era, which is also mentioned by Fensham & Fairfax (2006) in their paper on the limits of burning to maintain eucalypt invasions.

Wood, S. W., Ward, C., & Bowman, D. M. J. S. (2017). Substrate controls growth rates of the woody pioneer Leptospermum lanigerum colonizing montane grasslands in northern Tasmania. *Austral Ecology*, 42(1), 9–19. https://doi.org/10.1111/aec.12390

Wood et al. bring forward a major consideration regarding the edaphic factors that contribute to the encroachment of woody pioneer tree species (*Leptospermum lanigerum* in this case) into grasslands, cautioning against the notion of fire as having an exclusive role in determining vegetation patterns. Using tree-ring chronologies, the study assesses the impacts of substrate types and fire history on tree growth and their encroachment into grasslands. The findings indicated that geological substrates, particularly basaltic substrates, had a significant effect on diameter growth rates for the invasive trees. Additionally, it was noticed that distances further from the forest edge became increasingly inhibitory to successful establishments, to which they made several feasible conclusions.

The article was published in the peer-reviewed article *Austral Ecology*; a credible source; and using elegant statistical tests, it gives an unbiased and concise analysis of correlations between vegetation dynamics, edaphic factors, and fire histories. Despite the effectiveness of the study in describing the encroachment, further research into more detailed biotic and abiotic factors such as relative C, N, and P concentrations would be extremely useful to researchers and conservationists.

The source has proven to be very useful by enhancing the knowledge on ecological succession and conservation of grassland ecosystems, such as the grassy balds in the Bunya Mountains. The methods used in this study have been insightful for the correlation between edaphic factors and vegetation patterns.

MacDermott, H. J., Fensham, R. J., Hua, Q., & Bowman, D. M. J. S. (2017). Vegetation, fire and soil feedbacks of dynamic boundaries between rainforest, savanna and grassland. *Austral Ecology*, 42(2), 154–164. https://doi.org/10.1111/aec.12415

MacDermott et al. investigate not just the interplay between vegetation and fire, but the site-specific qualities as well. They test the associated feedback systems and subsequent transitions between biomes through stand structure assessments, fuel load analysis, experimental combustion tests, bark thickness measurements, and soil nutrient profiling. The results from the study greatly solidified several conclusions made by adjacent studies that mention topics such as fire suppression thresholds, specifically in the context of rainforests and the resilience of savanna species to fire, among others.

Published in *Austral Ecology*, this peer-reviewed article is credible and highly relevant for understanding fire-vegetation-soil dynamics in grassland mosaics. The authors utilise a broad and complimentary range of methodologies and strong analyses to tackle the scope of the study, combining ecological fieldwork with experimental techniques. However, their statements on nutrient cycling in uniform substrates directly oppose that of Wood et al. (2017) and will need to be substantiated further.

Fire-vegetation-soil feedback systems are extremely complex, and this study aims to begin making effective quantifications on this concept so that further research, on a broader scope, can benefit from an increased quality of analysis. Their considerations will be very useful for further developing robust methods in my own research and they present insightful arguments to previously considered distributions to woody establishments: i.e., observations made by Wood et al. on the controlling effects of substrates.

Law, B. S., & Dickman, C. R. (1998). The use of habitat mosaics by terrestrial vertebrate fauna: implications for conservation and management. *Biodiversity and Conservation*, 7(3), 323–333. https://doi.org/10.1023/A:1008877611726

This paper covers the fundamental concepts of fauna lifecycles in habitat mosaics. It highlights the close relationships that fauna develop with each habitat, mentioning that changes in habitat use can be due to daily requirements, seasonal differences, and the age and

sex of specific fauna. They then emphasise the implications of these complex relationships in relation to conservation biology, arguing that conservation efforts focused solely on high-profile habitats, such as rainforests, may be inadequate.

The authors substantiate their arguments for habitat mosaics with numerous examples from different species in Australia. The evidence on species behaviours across habitats, is heavily referenced and well-structured; however, direct empirical evidence would provide a stronger argument to their claims.

This paper compliments the study by Smith et al. (2015), which mentions that the Bunya Mountains' faunal compositions featured a remarkable number of generalists. When considering the complex utilisations of mosaics by fauna, mentioned in this study, it highlights the importance of cautioning against preserving habitats in isolation. This was an important concept that was yet to be considered, which will provide greater context for developing appropriate research questions. The article was easy to follow and strongly supported the findings by Smith et al.

2.0 Hypotheses

The Bunya Mountains are a 30-km-long basaltic massif, featuring significant ecosystem diversities and distinct, sometimes anomalous, changes in floristic composition. The current literature provides an extensive coverage of floristics for these habitat mosaics. Habitat types include wet rainforests, dry rainforests and vine thickets, open savanna woodlands, eucalypt forests, and montane grasslands or grassy balds. The wet rainforests present a tall and dense canopy, dominated by bunya pine (*Araucaria bidwillii*) emergents, with an open ferny understorey. The dry rainforests and vine thickets are located on lower slopes and are dominated by hoop pines (*Araucaria cunninghamii*), with a dense understorey of prickly shrubs and forbs. The savanna woodlands are found on the northern and western slopes with open canopies, similar in composition to that of the eucalypt forests, yet with lesser canopy cover. Finally, the grassy balds are jarring in composition, featuring almost

exclusively grasses and forbs, and show very little biodiversity (Butler et al., 2006; Queensland Government, 2023).

The significant changes in floristic composition of the Bunya Mountains have been heavily analysed within the context of bottom-up and top-down drivers, such as edaphic properties, intra- and interspecific competition, and abiotic controls. (Fensham & Fairfax, 2006; MacDermott et al., 2017; Wood et al., 2017). MacDermott et al. and Wood et al. highlight the importance of soil nutrient dynamics in the development of woody encroachments, suggesting that decreasing nutrient gradients and proximity to mature trees can inhibit establishments. In addition to soil properties, Wood acknowledges in their paper that interspecific competition may exist in the form of dense ground cover, denying seedlings the opportunity to reach maturity. MacDermott also mentions in their development of a preliminary vegetation-soil feedback model, that the factor of regular burnings causes the soil to become old, with slow to effectively no soil organic carbon (SOC) turnover rates.

Fire is a dominant controlling factor in the drier regions of the Bunya Mountains and has subsequently developed an entire ecosystem. The exact origins of the grassy balds are still contested, their persistence however, has been substantiated by several studies. Post-Holocene, indigenous Australians regularly burned areas of the Mountains as a form of tradition (Fensham & Fairfax, 2006; Moravek et al., 2013). This was one of the earliest recorded forms of land management and holds great significance for not only the First Nations people, but the scientific community as well. The burnings have provided an opportunity to analyse the effects of reduced SOC concentrations, the propagative ability and resilience of Eucalypts and other pyrophytes, and changes in local biodiversity, among other areas of research.

The current literature holds immense knowledge on the vegetation history and the progression of woody invasions. Thus, this study will seek to substantiate the existing hypotheses made by both MacDermott et al. (2017) and Wood et al. (2017), that grasslands

will become increasingly inhibitory closer to their centre. Another hypothesis of MacDermott's will be investigated, being the interspecific competition between eucalypt seedlings and dense ground cover. Lastly, Smith et al. (2015) mentions a surprising number of generalist fauna among habitats in their paper, implying that although the ecosystems are diverse; factors such as canopy cover, light conditions, and resource availability may be extremely similar. Considering this, these properties will be measured for a significant difference. The following hypotheses will be investigated to support these claims:

1. The rate of woody invasions into all grassy balds across the Bunya Mountains will be significantly slowed in relation to the topography and soil of the landscape.
2. Different species of grass will exhibit a significant effect on the population of invading tree species into grasslands.
3. Forested areas in the Bunya Mountains will show similar qualities regarding canopy cover, canopy levels, light conditions, and water quality.

3.0 Additional References

Queensland Government. (2023, September 26). Parks and forests. Department of Environment, Science and Innovation.