

## Human Niche Construction: Noongar Evidence in Pre-colonial Southwestern Australia

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### Abstract

Through a lens of Human Niche Construction theory, we examine *Noongar* (an indigenous people of south western Australia) relationships with southwestern Australian flora and suggest influences of these relationships on contemporary botanical patterns in this global biodiversity hotspot. By conducting a review of historical and contemporary literature and drawing upon the contemporary knowledge of *Noongar* Elders, we examine the merits of five key hypotheses of human niche construction theory in relation to this large cultural group. We find compelling evidence that supports *Noongar* niche construction, but caution that further research is required to test its likely ecological and evolutionary outcomes. We suggest that further collaborative, multi-disciplinary research that applies *Noongar* and Western science will lead to a greater understanding of the biological assets of southwestern Australia.

**Keywords:** human niche construction, Noongar, indigenous knowledge, biodiversity hotspot, biological diversity, OCBIL

### INTRODUCTION

Despite best individual and organisational efforts, biological assets of the South West Australian Floristic Region (SWAFR, *sensu* Hopper and Gioia 2004) (Figure 1) continue to face human-induced pressures that threaten their survival (Laurance et al. 2011).

To this end, new approaches need to be explored. Given current widespread interest in incorporating traditional knowledge into environmental management (Bird et al. 2012; Ens et al. 2015; Lyver et al. 2015; Middleton 2013) and a long occupancy by *Noongar* Aboriginal people (Turney et al. 2001), traditional knowledge and practices of the SWAFR's first people appear valuable, and to date largely unexplored, resources for contemporary conservation managers of southwestern Australian biodiversity.

In this paper, our primary aim is to present evidence of pre-colonial human manipulation of plant communities of the SWAFR that can provide a useful starting point from which the role of Human Niche Construction (HNC) (Odling-Smee et al. 2013) in the evolutionary biology and ecology of the SWAFR can be further examined by ourselves and others. In turn, we anticipate that this process may lead to successful

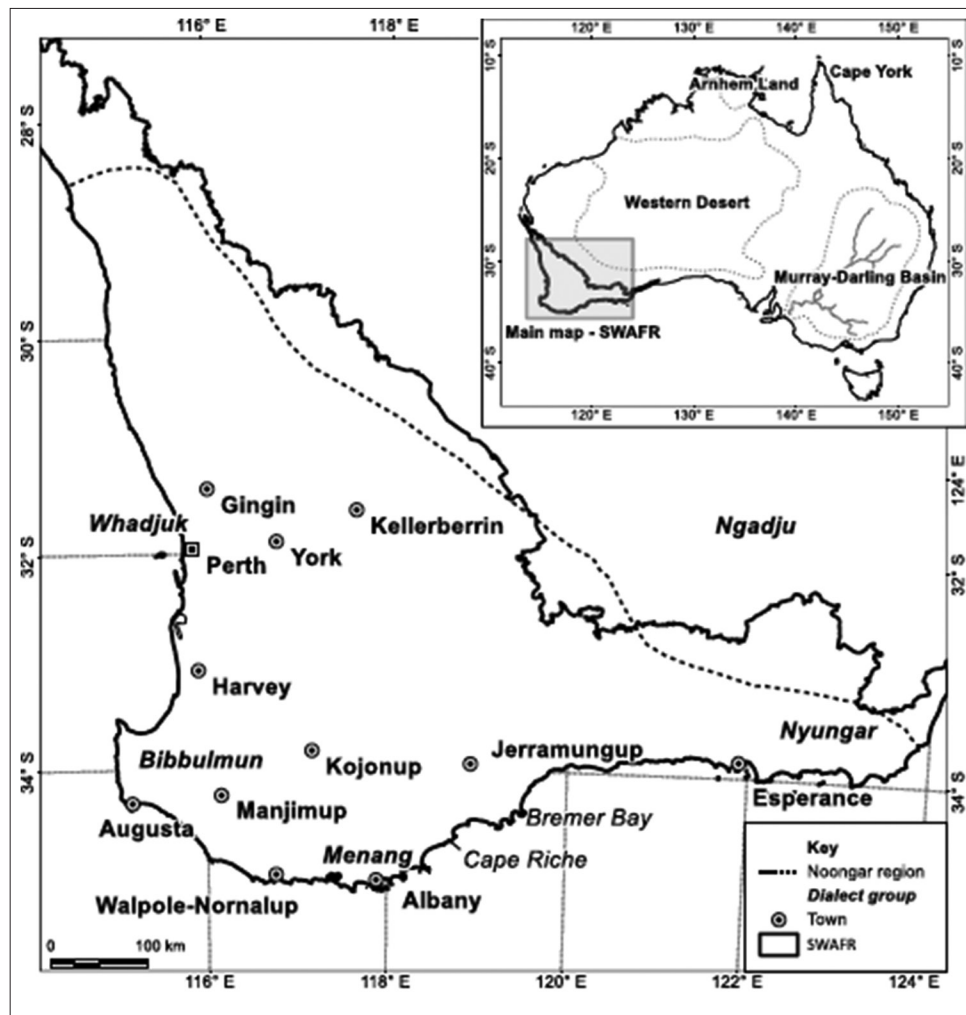
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**Figure 1**  
*Location of Noongar country, South West Australian Floristic Region and localities of interest*

collaborative conservation strategies based on *Noongar* and Western science within the SWAFR.

Few ecosystems have persisted entirely to the present day without human influence (Halpern et al. 2008; Sanderson et al. 2002). As such, HNC has been identified (alongside climatic and geological processes) as a fundamental driver of ecosystem dynamism by archaeologists, anthropologists and increasingly by ecologists (Bird et al. 2013; McNiven 2008; Odling-Smee et al. 2013; Smith 2011a). Several researchers have identified the use of fire, disturbance of soils and organisms, habitat modification, and specific protection measures, all applied according to cultural practices, as means by which innumerable generations of humans interacted and developed with ecosystems prior to global industrialization (Amundsen-Meyer 2013, Bird et al. 2008; Rowley-Conwy and Layton 2011; Smith 2011a).

While we recognise that niche constructing activities per se do not necessarily represent activities that promote conservation of biological assets, in this instance, HNC provides a useful framework for identifying some key processes in which pre-colonial human activities probably

influenced biological communities of the SWAFR since the late Pleistocene. Equally, the SWAFR's exceptional contemporary biological diversity occurs in the context of human occupation spanning tens of millennia and indicates that there may well be broader lessons that *Noongar* culture can provide for biological conservation.

*Noongar* niche construction was identified by Hallam (1975, 1989) and has been explored from a zoo-archaeological perspective by Dortch et al. (2014). However, the influence of HNC on the flora of southwestern Australia has gone largely unexplored to date. Following a brief outline of the evolutionary background, conservation considerations and pre-colonial *Noongar* occupation of the SWAFR, we review HNC as a framework for examining human ecological influence, prior to focusing on evidence of HNC from the southwest Australian ethnographic record relating to vegetation management.

### **The SWAFR and its first human inhabitants**

The exceptionally species rich SWAFR occupies 302,627 sq.km in the southwest corner of the Australian continent, and

contains an estimated 8000 native plant species, of which 49% are endemic (Hopper and Gioia 2004). A maritime climate that dates to the Jurassic, along with relative geological stability since the Permian, has enabled the persistence of *relictual taxa*, with some lineages arising in the Cretaceous (Hopper and Gioia 2004; Hopper et al. 1996). This ancient heritage, combined with adaptations to weathered, nutrient poor soils (Lambers et al. 2010), and more recent late Tertiary and Quaternary adaptations to aridity and explosive speciation associated with climatic oscillations, has resulted in the SWAFR's complex, rich and highly evolved contemporary flora (Hopper 1979, 2000).

The inland SWAFR boundary corresponds approximately to the circumcision line (Tindale 1974) which culturally bounds the *Noongar* culture block from desert and semi-desert groups to the north and east. *Noongar* habitation of many parts of southwestern Australia has been dated to the late Pleistocene, and to at least 48,000 years BP (Before Present) in the extreme southwest corner of the continent (Turney et al. 2001). On a geological timescale, human occupation of the SWAFR is a last-minute inclusion in a long and complex evolutionary history of southwest Australian flora. On a human timescale, *Noongar* occupation of the SWAFR provides an example of sustained human ecological influence (Dortch 2004), made all the more intriguing by its long and complex evolutionary history.

There can be little scientific certainty about *Noongar* customs of the distant past. However contemporary oral and early colonial accounts offer insights into the recent past (Robertson et al. 2016) and appear to corroborate archaeological evidence of persistent resident populations before and during the Last Glacial Maximum (30-19,000 years BP) and increasing populations afterwards (Balme 2014; Williams et al. 2015). While the *Noongar* identify as a single ethnic group, fourteen smaller cultural units within the area are also recognized (Tindale 1974). *Noongar* cultural and linguistic characteristics include varying systems of both patrilineal and matrilineal descent and a diversity of totemic laws, while a deep attachment to land through mytho-ritual ties is universal (Berndt 1980). Connectedness to country by a descent group provides rights to its resources, rights to share its resources with others (Meagher and Ride 1980), and also responsibilities to manage natural resources and look after spiritual affairs (Berndt 1980).

Resource availability, social motive, ceremonial purpose and climate dictated past broad patterns of *Noongar* movement (Meagher 1974; Nind 1831) and were formalised through a six season calendar in which specific plant and animal life-stages were indicative of seasonal chronology (Collard and Harben 2010; Meagher 1974). The seasonal calendar remains important to contemporary *Noongars* (Bindon and Walley 1992; Scott and Brown 2005; SWALSC 2010). Land and resource rights as well as trading among *Noongar* groups have been well documented (Barker 1830; Berndt 1980; Drummond 1853a, b; Grey 1841a, b; Hassell 1975; Hercocock 2014; Moore 1884; Nind 1831; Oldfield 1865; Ommanney 1840; Singleton

1846). Although not universal, totemic laws dictated specific responsibilities of individuals, families, bands and clans for protection of particular plant and animal taxa (Grey 1841b; Hassell 1975) and many contemporary *Noongars* continue to identify with plant and animal totems (Collard 2009; Knapp 2011; Little 1994; Nannup 2013; Scott and Brown 2005; Yorkshire-Selby 2011a, b).

### OCBIL Theory

Hopper (2009) identified Old, Climatically Buffered Infertile Landscapes (OCBILs), and, converse to these, Young, Often Disturbed Fertile Landscapes (YODFELs). While OCBILs are globally rare but prominent in the SWAFR, YODFELs occupy most of the earth's terrestrial surfaces, particularly of the Northern Hemisphere (Hopper 2009). The SWAFR is one of at least 12 of the 35 known terrestrial biodiversity hotspots in which OCBILs occur interspersed amongst YODFELs in a complex mosaic (Hopper et al. 2016). Ancient lineages, long-lived individuals and a high degree of localised endemism are preeminent among OCBIL flora, which often exhibit special biological traits to enable survival in infertile conditions and unusual resilience to fragmentation (Hopper 2009). Such biological traits (eg. high levels of woody perennality, low growth rates, investment in underground persistence structures such as tubers) suited to spatially restricted and low fertility soil habitats make OCBIL flora highly vulnerable to accelerated disturbance regimes (Hopper 2009; Hopper et al. 2016; Leao et al. 2014).

Given their dominance in the most heavily human-populated northern hemisphere, YODFELs are the basis of most collective and widely accepted western conventional ecological understanding (and corresponding approaches to conservation management) (Hopper 2009; Hopper et al. 2016). Biodiversity and endemism retained by OCBILs, however, is disproportionately high across biodiversity hotspots (Hopper et al. 2016) and herein lies a discrepancy. Conservation strategies employed for a significant proportion of global biodiversity assets may be based on inappropriate YODFEL-derived ecological theory (Hopper 2009). *Noongar* ecological knowledge has originated and developed in the OCBIL-dominated SWAFR (Robertson et al. 2016). In the SWAFR, both OCBILs (e.g. granite inselbergs and kwongkan sandplain) and YODFELs (e.g. depositional river valleys, wetlands and coastal dunes) are intrinsic to *Noongar* culture (Bird 1985; Hallam 2014; Hopper and Lambers 2014; Robertson et al. 2016; Smith 2011b). An increased understanding of landscape-differentiated *Noongar* niche constructing activities may well be key to improved conservation outcomes for OCBIL flora of the SWAFR.

### Human Niche Construction

Niche construction theory, in its broadest sense, was introduced by Lewontin (1982), and affords a useful means of understanding ecosystem dynamism and its evolutionary

impacts. It provides a unifying framework for studies of ecology, with its focus on energy and matter flow, and evolutionary biology, focused on information flow (ie DNA heritability) (Odling-Smee et al. 2013). While the relative roles that niche construction and Standard Evolutionary Theory (SET) play in gene selection and the evolution of life itself remain contentious, (Laland et al. 2016; Odling-Smee et al. 2003; Turner 2016), at the very least, niche construction is a useful means of addressing feedback from organisms (including humans) to their environment. Proponents of Niche Construction Theory (NCT) (e.g. Smith 2015) hypothesise that the key point of difference between SET-based and NCT-based frameworks is a controversial assumption of unidirectional adaptation, which is that organisms adapt to changes in their environmental circumstance, in the former, while the latter assumes two way interaction between organisms and their environment (Smith 2015).

This hypothesised theoretical divide has extended to inquiry into early domestication and its role in transitions from forager to agriculture-based human life strategies, with HNC being offered as an opposing alternative to SET-based optimal foraging theory (Gremillion et al. 2014; Smith 2015). In this paper, we are primarily focused on the processes by which pre-industrial societies have modified their ecosystems rather than the possible evolutionary consequences. We use HNC frameworks explored by others (Amundsen-Meyer 2013; Bird et al. 2013; Rowley-Conwy and Layton 2011; Smith 2011a) as a point of reference for examining evidence of *Noongar* ecosystem modification in the SWAFR. This should not be construed as rejection of the value and validity of SET-based models when considering biological and cultural evolution, especially as such models have embraced the concept of co-evolution since the time of Darwin's (1859) 'Origin of Species'. An evolutionary approach to human-plant interaction may also be criticised for bias towards economically rational behaviour (Barton and Denham. In press ). However, HNC counteracts such bias as it allows for social or cultural practices that may be motivated primarily by cultural identity and habitus (cf. Rusack 2011). Some societies may see plants and animals not as resources to be managed (in the contemporary, "western" sense) but as entities to be protected or propagated to satisfy ritual or mythological obligations and traditions (Keen 2004). HNC may not be capable of distinguishing the motivation for specific human actions, but it does offer tools for identifying the actions themselves.

Fundamental to the concept of HNC is the premise that humans are an embedded component of their natural environment, rather than an interacting but separate entity (McNiven 2008; Odling-Smee et al. 2013; Rowley-Conwy and Layton 2011; Smith 2011a) and thus, play an active role in shaping it. HNC in some form or another is considered universal amongst forager societies (Amundsen-Meyer 2013; McNiven 2008; Rowley-Conwy and Layton 2011) and may include (for example) the concentration of wild resource plants into useful stands, small-scale plant cultivation, removal of vegetation to encourage resource species, various hunting

techniques and protection or enhancement of useful taxa and expansion of habitat ( Bird et al. 2013; Hynes and Chase 1982; Rowley-Conwy and Layton 2011; Smith 2011a).

HNC does not, in itself, equate to sustainment of all biological resources. Laudine (2009) argued that biodiversity conservation as an aspirational notion was unlikely a conscious objective of forager societies, while Smith and Wishnie (2000) asserted that although sustainable resource management often leading to positive biodiversity outcomes is widespread among small-scale societies, voluntary conservation is rare.

Although there are numerous examples of large-scale destruction of natural resources by pre-industrial societies (Diamond 2005; Ostrom et al. 1999; Smith and Wishnie 2000), there are examples of sustained societal management of natural resources over thousands of years (Dietz et al. 2003; Ostrom et al. 1999). Based largely on evidence from small-scale, pre-industrial societies, Ostrom et al. (1999) and Dietz et al. (2003) have identified specific societal characteristics probably required to manage resources sustainably, including: access to good environmental information and an understanding of its uncertainties; localised resource control nested within larger institutions; a means of dealing with conflict; effective rule compliance; physical, institutional and technological infrastructure; and processes to deal with change. Evidence exists of each of these characteristics in the *Noongar* ethnographic record (Berndt 1980; Hammond 1933; Hassell 1975; Howard 1980; Meagher and Ride 1980; Nind 1831; Scott and Brown 2005) and is the subject of continuing work by the authors. Ostrom et al. (1999) also point to optimal settings around the reliability, condition, diversity and limits of natural resources in shaping successful governance of them.

In a global study of HNC examples, Middleton (2013) concluded that a general decline in ecosystem heterogeneity is evident following cessation of traditional management approaches. In New Zealand, Lyver et al. (2015) determined that conservation and Maori cultural actions are interconnected due to a worldview that does not separate humans from their environment, while Bird et al. (2012) asserted a compatibility between the *Martu* (an Australian indigenous people of the Western Desert) concept of 'healthy country' and the conditions that contemporary conservation managers would consider best for biodiversity outcomes. A comprehensive review of traditional knowledge inclusion in Australia by Ens et al. (2015) highlighted examples where indigenous knowledge has informed both conservation research and management. Ens et al. (2015) also identified current gaps (including a general absence of indigenous knowledge in biodiversity hotspot conservation management), and opportunities for further cross-cultural collaboration. These examples appear to validate a case for closer alignment between context specific indigenous traditional and Western science knowledge, practice and values to improve conservation and cultural outcomes of conservation management ( Bird et al. 2012; Christie 1990; Lyver et al. 2015; Middleton 2013).

Following examination of HNC activities among North American indigenous societies, as well as characteristics of

their target species, Smith (2011a) proposed that broad patterns in HNC activity are evident. That there are general patterns of universality in the HNC activities of small-scale societies was broadly supported through further testing of Smith's (2011a) model by Amundsen-Meyer (2013) and is also corroborated by evidence from tropical Australia (Hynes and Chase 1982, McNiven 2008) and other global locations (Terrell et al. 2003). A comparison of these studies also highlights a degree of bias in HNC activities (and the study of them) toward their environmental context. Such biases include, for example, Smith's (2011a) emphasis on seasonal replenishment through seeding of annual taxa in predictable riparian zones due to annual snow-melt in parts of North America, and McNiven's (2008) emphasis on quarantine and translocation likely more relevant to the Torres Strait islands, than mainland locations. Smith (2011a) recognised a tendency for anthropological strategies involving wild populations to have natural analogues specific to their environment. Further, Bird et al. (2013) asserted that cultural practices fine-tuned to local environmental conditions come with time, enabled by eco-evolutionary feedback to human decision-making processes. Similarly, but at a larger scale, Ostrom et al. (1999) asserted that extensive trial and error learning by parallel, self-organised groups greatly reduces the risk of disastrous regional resource depletion.

Based on these assertions, we would expect that, although broadly reflective of general HNC patterns, with increasing length of occupation, the niche constructing activities of a particular society would increasingly reflect a bias toward local natural analogues that suit the survival of local communities of organisms on which humans depend. Exploration of this expectation is particularly compelling in the SWAFR, given its long history of *Noongar* occupation. However, given minimal scientific exploration of *Noongar* HNC to date, particularly in relation to plant communities, our aim in this paper is to present evidence of *Noongar* niche constructing activities within a broader global HNC framework that can be used as a basis for more specific investigation.

## METHODOLOGY

An extensive review of global HNC peer-reviewed literature was undertaken. In particular, general patterns of HNC previously proposed by others (Amundsen-Meyer 2013; Hynes and Chase 1982; McNiven 2008; Smith 2011a) were examined to determine relevant broad categories of HNC activities applicable to the study area in question. Five broadly universal categories were identified, taking into account likely biases relating to climate and geographic setting. Identified categories resulting from this review include—1) firing to reset successional sequences and create mosaics/edges; 2) in-situ management and protection of specific plant taxa; 3) extension of the geographical range of perennial plant taxa; 4) habitat modification to increase local resource abundance; and 5) restrictions and territorial markers. The results and discussion are presented under each of these categories. A

summary of global HNC literature relevant to each category is presented as a synopsis under each heading.

Historical and contemporary sources were examined to identify *Noongar* HNC activities. Historic sources examined included the Exploration Diaries from 1827 to 1857 held by the Western Australian Government Department of Lands and Survey, and early colonial accounts of *Noongar* custom.

Personal oral recollections of *Noongar* authors (Ron (Doc) Reynolds, Carol Pettersen) and other contemporary southern coastal *Noongars* were also drawn upon to supplement documented sources. Identified *Noongar* HNC activities were assigned to the categories broadly identified in the global literature (Table 1). *Noongar* evidence is presented in the results and discussion as a discrete section under each category heading following the global synopsis of each category. *Noongar* names of organisms published here are based on recordings by the linguist C.G. von Brandenstein and are shown in italics (see von Brandenstein 1977, 1988).

## RESULTS AND DISCUSSION

For each category of HNC investigated, a synopsis, followed by *Noongar* evidence of HNC in the SWAFR is presented below.

### Firing to reset successional sequences and create mosaics/edges

#### Synopsis

Periodic alteration of vegetation community composition, usually through the use of fire, is a widely documented activity employed by forager societies (Amundsen-Meyer 2013; Smith 2011a). By increasing the relative abundance of early successional stage plants through disruption to later stage, slow growing plants, and increasing interface areas between successional stages of vegetation, firing can result in a higher availability of human (and animal) food plants across a broad range of environments (Amundsen-Meyer 2013; Bowman and Prior 2004; Hallam 2014; Jones 1969; Rowley-Conwy and Layton 2011; Smith 2011a). The mosaic of varied plant communities of multiple successional stages created by small-scale firing also results in increased in-patch diversity, providing a greater suite of available food plants and habitats for prey animals (Bird et al. 2008; Bird et al. 2012; Bird et al. 2013; Smith 2011a).

Documented reasons for firing of vegetation among forager societies include encouragement of green pick to attract game (Amundsen-Meyer 2013; Fuhlendorf et al. 2008; Jones 1969; Kost 2013; Murphy and Bowman 2007; Rowley-Conwy and Layton 2011; Russell-Smith et al. 1997), increasing yields of plant resources (Atchison 2009, Shipek 1989), increasing habitat availability for game (Bird et al. 2012; Bird et al. 2013), improving access for movement and camps (Amundsen-Meyer 2013; Kost 2013; Rowley-Conwy and Layton 2011; Russell-Smith et al. 1997) demonstrating rights to country (Bliege Bird et al. 2008; Rowley-Conwy and Layton

**Table 1**  
*Summary of terrestrial Noongar HNC activities in southwestern Australian vegetation communities in historic and contemporary ethnographic record*

HNC Sub-Category	Noongar Example in SWAFR	Reference
Creating mosaics/edges and resetting successional sequences through firing		
Firing for game attraction	General conclusions and detailed specific incidents of Noongar firing between Perth and Albany	Hallam (2014)
	Description of fired country in vicinity of Harvey south of Perth	Grey (1841a, p141-2)
	<i>Family recollection of patch burning for resource renewal in Albany area</i>	<i>D. Coyne, 2014 pers. comm</i>
	<i>Personal memory of patch burning for resource renewal in Esperance area</i>	<i>D. Reynolds, 2014 pers. comm</i>
	Burnt ground and emergent green grass on the Hay River near Albany	Roe (1831) in Hercock (2014)
	Native fires, good grass and game on Gairdner River in vicinity of Bremer Bay	Roe (1835) in Hercock (2014)
	November 3 <sup>rd</sup> 1848 localised burning of grassland alongside 'thicket' and 'scrub' near the Bremer Range, northwest of Esperance	Roe (1848) in Hercock (2014)
	Recently burned 'good country' on Blackwood River near Augusta	Bussell (nd)
	Frequent fire and abundance of resources near Albany	Collie (1831)
	'Grassy understorey' and evidence of fire near Mt Barker (50 km north of Albany)	Collie (1832)
	Recent fires and abundant resource plants. (Grassland inferred but not present due to fire)	Bunbury (1836)
	Recently burned "very good ground" and feasting on kangaroo west of Albany	Barker (1830) P 260
	Burning for wallaby, kangaroo and other small macropods close to Albany	Barker (1830) P 262; P 378-380. P 382
	Burning of grassland near Kojonup	Clark (1840)
	Burning of grassland near Perth	Moore (1884)
	Burning of grassland near Jerramungup to attract game	Hassell (1975) p41
Description of a dreaming story that highlights high value of burnt ground and green grass close to water	Hassell (1975) p203	
Firing for plant resource renewal	Burning of resource plant, <i>Typha domingensis</i> near Perth	Grey (1841b)
	Plentiful <i>Haemodorum</i> , a staple resource plant, on densely populated Swan Coastal Plain near Perth	Grey (1841b)
Firing for access to country	<i>Personal memory of patch burning for access to country, especially at regular campsites</i>	<i>D. Reynolds, 2014 pers. comm</i>
	<i>Common practice of frequent burning of vegetation at campsites</i>	<i>T. Woods, 2014 pers. comm</i>
Firing restrictions and controls	Comment regarding permission to burn country, spatial control, and roles of men and women near Albany	Nind (1831)
	<i>Can only speak for country with which he has connection</i>	<i>Kelly (1998)</i>
	Burning not able to proceed until owner of country present near Albany	Barker (1830) P 382; P 386
	Small-scale spatial variation in firing of forest near Harvey (100 km south of Perth)	Grey (1841a)
	Burning for grassland renewal and hunting of game in late summer and autumn	Hassell (1975) p110
	Corroboree to mark the beginning of firing season near Jerramungup in late summer	Hassell (1975) p113
In-situ management and protection of perennial and annual species		
In-situ management	Harvest of <i>Dioscorea hastifolia</i> and resultant uneven grounds north of Perth	Grey (1841b); Drummond (1840b); Moore (1884); Oldfield (1865)
	Digging for <i>Platysace deflexa</i> tubers and resulting soil disturbance	Hassell (1975) p24
	Noongar man near Albany insistent on planting old stalk in ground during Barker's demonstrating potato harvest	Barker (1830) P 384
Protection of vegetation communities	<i>Protection of spearwood thickets, and wallaby and quokka habitat from fire on south coast</i>	<i>Kelly (1998)</i>

Contd...

**Table 1**  
**Contd...**

HNC Sub-Category	Noongar Example in SWAFR	Reference
	Firing of vegetation adjacent to dense vegetation for hunting of medium-sized macropods	Grey (1841a)
	Group surrounding and trampling of dense vegetation for hunting near Albany	Nind (1831)
	Use of dense Eucalypt thickets for hunting of small macropods east of Toodyay (east of Gingin)	Drummond (1853b)
	Very dense vegetation in vicinity of mallee fowl ( <i>Leipoa ocellata</i> ) mound sightings in the central SWAFR	Roe (1836) in Hercock (2014)
	Use of Proteaceae flowers in thick vegetation inland of Esperance	Roe (1848) in Hercock (2014)
Protection of individual plants	Tracking and hunting of <i>Trichosurus vulpecula</i> demonstrating value of aged, hollow-bearing trees	Nind (1831); Grey (1841b); Hassell (1975) p10
	Sourcing of fresh water from hollows in <i>Eucalyptus wandoo</i> , demonstrating value of aged, hollow-bearing trees	Roe (1835) in Hercock (2014); Nind (1831); Moore (1835); Drummond (1853a)
	Large individuals of <i>Nuytsia floribunda</i> , <i>Eucalyptus occidentalis</i> , <i>Macrozamia dyeri</i> as well as <i>Xanthorrhoea platyphylla</i> amongst grass near highly populated Esperance Bay suggestive of close management	Roe (1848) in Hercock (2014)
	<i>Xanthorrhoea preissii</i> amongst clear grassland near Denmark 50 km west of Albany, suggesting protection of this taxa within managed landscape	Roe (1831) in Hercock (2014)
Extension in geographical distribution of perennial plant species		
Transportation of resource plants possibly resulting in new populations	General comment regarding vegetable foods being transported to camp, (based on a comprehensive review of historical accounts)	Meagher (1974)
	Musings regarding pre-colonial human spread of edible members of <i>Carpobrotus</i> (Aizoaceae), <i>Acacia acuminata</i> , <i>Santalum acuminatum</i> and <i>Macrozamia reidlii</i> and ease with which Noongars in his post-colonial employ cultivate introduced garden taxa	Drummond (1843a)
	Bringing of edible roots to camp near Albany	Nind (1831)
	Carrying of edible roots in Noongar woman's bag	Grey (1841b) p109
	Carrying of edible roots in Noongar woman's bag near Albany	Moore (1884) p23
	Transport and processing of <i>Acacia acuminata</i> and <i>A. microbotrya</i> seed near Jerramungup	Hassell (1975) p21-22
	Transport of fruit from <i>Exocarpos sparteus</i> and <i>Santalum spicatum</i> near Jerramungup	Hassell (1975) p23
	Trading of seeds of <i>Macrozamia</i> (species could be <i>reidlii</i> or <i>dyeri</i> ) near Jerramungup	Hassell (1975) p25
	Sharing of seeds of <i>Macrozamia reidlii</i> by Noongars north of Perth	Grey (1841b) p42
	Roots and seeds ground at Noongar campsite near Walpole, 110 km west of Albany	Roe (1836) in Hercock (2014)
	Description of detoxification of <i>Macrozamia</i> seed, suggesting transport of seed to location where water available	Moore (1835); Drummond (1840b); Grey (1841b) p119; Moore (1884) p32; Hassell (1975) p25; Barker (1830) p304
	<i>Occurrence of Acacia cyclops at particular non-coastal sites considered indicative of past Noongar camp</i>	<i>L. Knapp, 2015 pers. comm</i>
	Noted <i>Macrozamia reidlii</i> growing adjacent to fish traps near Denmark	Barker (1830) P 258
Habitat modification to increase local resource abundance (aside from use of fire)		
Resource increase	<i>Deliberate cultivation of Hakea drupaceae at granite outcrops to enhance reptile habitat near Albany</i>	<i>L. Knapp, 2014 pers. comm</i>
	<i>Deliberate gnamma creation and enhancement at southern coastal granite outcrops</i>	<i>G. Yorkshire-Selby, 2014 pers. comm</i>
	Breaking down of <i>Xanthorrhoea preissii</i> and <i>X. platyphylla</i> tops to attract <i>Bardistus cibarius</i> larvae	Nind (1831); Grey (1841b) p116; Eyre (1841)
	<i>Regular cleaning of gnammas to remove buildup of sediment</i>	<i>L. Blight, 2014 pers. comm</i>

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**Table 1**  
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HNC Sub-Category	Noongar Example in SWAFR	Reference
Restrictions and territorial markers		
Restrictive law	Outline of laws relating to land and resource 'ownership'	Grey (1841b) p97-98, 120
	Marriage laws as an instrument for gaining and restricting land access	Nind (1831); Grey (1841b) p96
	<i>Disturbance of Nuytsia floribunda by Menang Noongar restricted aside from certain times of the year and certain people (near Albany)</i>	<i>L. Blight, 2014 pers. comm</i>
	Laws that prohibit individuals from harming a totem species	Grey (1841b) p97; Hassell (1975) p86
	Restriction of taking tubers or rhizomes when resource plant is in seed	Grey (1841b) p99-100
	Restriction on spearing kangaroo	Barker (1830) p289
	Property rights to <i>Xanthorrhoea</i> sp., kangaroo, wallaby and <i>Macrozamia reidlii</i> seed caches	Barker (1830) p309
	Displeasure of Menang Noongars of unknown Wilomon man arriving uninvited to Albany area	Barker (1830) p323
	Restrictive use of a water body near Albany, only used for drinking when ill and never camped near	Barker (1830) p342
	Restriction of wild dog young to elders only	Hassell (1975) p75
	<i>Restrictive access to mountainous areas in southern Noongar country</i>	<i>C. Pettersen, 2016 pers. comm</i>
	Restrictive access to kwongkan sandplain and mountainous areas	Oldfield (1865), Hassell (1975)
	Restriction on eating of emu flesh	Grey (1841b) p114
Territorial markers	<i>Eucalyptus pleurocarpa</i> as a marker of being in one's own country	<i>D. Reynolds, 2014, G. Yorkshire-Selby, 2014, L. Knapp, 2015 pers. comm</i>
	<i>Extensive patch of Nuytsia floribunda</i> a territorial boundary where entry forbidden	<i>Little, 1994</i>

2011), entrapping or flushing out game during hunting (Kost 2013; Russell-Smith et al. 1997), promoting resource plants through removal of competing plant taxa (Amundsen-Meyer 2013; Russell-Smith et al. 1997; Walsh 1990) protection of particular resource-bearing plants or habitats through back-burning (Amundsen-Meyer 2013; Kelly 1998; Kost 2013; Russell-Smith et al. 1997) and reducing populations of pest organisms (Amundsen-Meyer 2013).

### Noongar Evidence

Burning of country by *Noongar* people to alter vegetation mosaics of the SWAFR has been well-documented in historical accounts (Grey 1841a; Hercocck 2014) and contemporary literature (Abbott 2003, 2014; Hallam 2014; Kelly 1998; Kost 2013) and is also remembered by some contemporary *Noongar* Elders. A contemporary *Menang Noongar* Elder relayed his father's description of patch burning as "creating next year's Coles New World" (an Australian supermarket chain) (Dallas Coyne pers. comm. 2014), while one of the authors (Ron (Doc) Reynolds), an Esperance *Nyungar Noongar* Elder, remembers *Nyungar* men burning through wetlands in the Esperance area, both to ease welking through country and to attract food animals, in particular *kalaia* (the Australian Bustard, *Ardeotis australis*). Abbott (2003) identified 229 *Noongar* firing events recorded before and during early European settlement extending throughout all areas of *Noongar* country.

Throughout the detailed observations recorded by Roe in his 1830-1840s exploration diaries, frequent reference is made to *Noongar* burning activities (Hercocck 2014). For example, Roe

noted on December 10<sup>th</sup> 1831 that country in the Hay River valley near Albany "would have been troubled alike with a thick underwood had not a portion of it been burnt off, and admitted of a young green grass", while on November 29<sup>th</sup> 1835, he noted good grassy land extending along the banks of the Gairdner River east of Bremer Bay, and that traces of game were numerous near an old native hut that had "probably been occupied by the natives whose fires we had seen here yesterday". Importantly, Roe also noted that *Noongar* burning regimes varied according to ecosystem, such as an observation on November 3<sup>rd</sup> 1848 during an expedition from Cape Riche to the Russell Ranges east of Esperance of localised grassland burning, where adjacent close thicket and scrub (likely kwongkan sandplain, an OCBIL) remained unburned.

As Roe's primary exploration objective was to identify suitable pastures for the expansion of colonial livestock production, the location and extent of grasslands as well as less productive lands were well-documented, and, for example, often referred to sandplain as 'useless scrub' or 'impenetrable brushes'. Roe also noted an association between important *Noongar* resource tree species such as *Eucalyptus occidentalis* (Myrtaceae) and *Acacia* (Fabaceae) species with the occurrence of grasses, freshwater, kangaroos and other game animals. Thus, in addition to direct observations of *Noongar* burning, Roe's diaries appear to extensively describe the results of burning activities, namely the grassed woodlands occurring low in the landscape (likely YODFELs) offering an abundance of food plants for humans and resource animals. This point was also noted by Abbott (2014) in a synopsis of



the fauna and ecology recorded in Roe's exploration diaries and corroborated by other early colonial records (Barker 1830; Bunbury 1836; Bussell nd; Clark 1840; Collie 1831, 1832; Hassell 1975; Moore 1884), that link descriptions of 'open land' with firing activities.

Although most records of *Noongar* burning relate to the procurement of animal resources, Gott (1982), in part based on Grey's (1841b) observations on the Swan Coastal Plain, suggested that firing likely promoted the availability of staple plant underground storage organs through return of nutrients to the soil, reduced leaf litter, clearing spaces for seed germination, maintaining an open vegetation structure and through exploitation of their ability for rapid regeneration following fire (Pate and Dixon 1982). Gott (1982), in a description of the resource plant, *Typha domingensis* (Typhaceae), of which the rhizome was usually collected, pounded and roasted into cakes (Drummond 1842c; Eyre 1841; Grey 1841b; Moore 1884) suggested that heavy harvesting and burning of *Typha* species (also a recorded Aboriginal practice in Eastern Australia) likely promoted growth of young plants and prevented unwanted spread across large shallow water bodies (presumably to which access was required for gathering other fresh water resources). Grey (1841b) suggested that "the natives must be admitted to bestow a sort of cultivation upon this root, as they frequently burn the leaves of the plant in the dry seasons in order to improve it". Grey (1841b) also commented that "Haemodorum are very plentiful" in the "sandy desert country which surrounds for many miles the town of Perth", which may suggest promotion of this genus through burning or other means by the dense *Noongar* population (Hallam 2014) of the Swan Coastal Plain. Promotion of plant resource abundance may also account for other early colonial observations such as those of Roe on 12<sup>th</sup> and 13<sup>th</sup> February 1835 respectively of firing "ironstone country" on ridges in *Eucalyptus marginata*, *Corymbia callophylla* (Myrtaceae) and *Eucalyptus wandoo* woodland near Albany (Hercocock 2014), habitat for *Pteridium esculentum* (Dennstaedtiaceae), numerous Orchidaceae taxa and members of *Haemodorum* (Haemodoraceae), all of which constitute *Noongar* staples (Daw et al. 2011; Drummond 1842a, b; Meagher 1974).

That *Noongar* burning regimes were strictly controlled is demonstrated in the early colonial literature of Barker (1830) and Nind (1831), the latter of whom documented that "all of them have a right to break down grass trees, kill bandicoots, lizards, and other animals, and dig up roots; but the presence of the owner of the ground is considered necessary when they fire the country for game". Kelly (1998) also asserted that firing regimes were ecosystem- and ownership- specific, and that he, as a *Noongar* man of the Manjimup district, could not speak of firing activity across *Noongar* country more broadly, but only for his own country. Likewise, Grey (1841a) described country in the vicinity of Harvey as "thickly clothed with mahogany trees" (*Eucalyptus marginata*) that in some places was "completely destroyed by the native fires" and in others was "encumbered by the fallen trunks", suggesting a tightly controlled and small-scale firing regime. Also of note,

is Hassell's (1975) comment on the seasonality of firing for grassland renewal, which, she reported, was carried out in late summer and early autumn, prior to the first winter rains and following completion of nesting for ground-dwelling birds and mammals. Kost (2013) categorised some historical *Noongar* firing events according to the Interim Biogeographic Regionalisation of Australia (IBRA; Thackway and Cresswell 1995) although caution is required due to high botanical spatial variation at a much finer scale (Hopper 1979). Kost (2013) also documented some recollections of firing by contemporary *Noongars*, and noted a broad consistency with historical records in relation to seasonality, control and intent.

### In-situ management and protection of specific plant taxa

#### Synopsis

Observed concentrations of economically valuable plants close to well-used sites have been considered the result of deliberate or accidental cultivation, protection or in-place encouragement of specific taxa in preference to taxa of limited value for human use (Atchison 2009; Hynes and Chase 1982; Kelly 1998; Russell-Smith et al. 1997; Smith 2011a). Such activities in relation to resource plants have been well-documented for both temperate and tropical environments. These include specific harvest methods for edible, underground storage organs to protect plant propagules (Gott 1982; Hynes and Chase 1982; Russell-Smith et al. 1997) and create suitable conditions for resource growth (Amundsen-Meyer 2013; Gott 1982; Smith 2011a), protection from trampling (Hynes and Chase 1982) and fire (Amundsen-Meyer 2013; Atchison 2009; Kelly 1998; Russell-Smith et al. 1997), deliberate non-use for firewood or building (Byrne et al. 2013; Smith 2011a), selective removal of competing vegetation (Gott 1982; Smith 2011a) and ownership of trees (Hynes and Chase 1982; Kitagawa and Yasuda 2008). Specific actions aimed at increasing crop size and quality (Amundsen-Meyer 2013; Fowler 2000; Kitagawa and Yasuda 2008; Smith 2011a) are also documented.

#### Noongar Evidence

The most heavily documented *Noongar* root crop is the yam-like, *Wuagarn* (*Dioscorea hastifolia* (Dioscoreaceae)). Frequent observations of *Wuagarn* harvest and of resulting dug-up grounds were made by Grey (1841b), Drummond (1840b) and Oldfield (1865) in *Noongar* country north of Perth. Moore (1884) recorded near Gingin, having to "change our course on account of the ground which here consisted of a deep red loam, being so cut up into holes as to be almost impassable. The native "Yam" seems to be very abundant here." Hallam (1989) asserted that the well-documented abundance of *Dioscorea hastifolia* in fertile areas north of Perth was due in part to frequent, seasonal harvest by *Noongars*. Root harvest of *Yaindyert* (*Typha domingensis*), was also well documented on the Swan Coastal Plain (Drummond 1836, 1842c; Grey 1841b; Hallam 1989, 2014; Moore 1884) and across *Noongar* country (Oldfield 1865). Hallam (1989, 2014) considered pre-colonial *Noongar* occupation of the Swan Coastal Plain and

its hinterland to be largely sedentary, due to an abundance of both *Dioscorea hastifolia* and *Typha domingensis* which have complementary seasonal availability (September to May and May to August respectively). Likewise, in northern *Noongar* country Grey (1841b) described a “thickly populated” district among fertile *Wuagarn* grounds and freshwater swamps from which *Yaindyert* was harvested. Other *Noongar* root crops that appear heavily harvested include numerous members of the Orchidaceae (Drummond 1842b), several members of *Platysace* (Apiaciae) (Drummond 1840a, 1843b, 1853b; Hassell 1975; Moore 1884; Nind 1831) members of *Haemodorum* (Haemodoraceae) (Drummond 1840b, 1842a; Hassell 1975; Oldfield 1865), particularly *H. spicatum* (Grey 1841b; Nind 1831) and members of *Thysanotus* (Asparagaceae) (Drummond 1842a). Indeed, in the Jerramungup area, Hassell (1975) noted long trenches of disturbed soil made by women digging for the much relished tubers of *Joowaq* (*Platysace deflexa*) (Figure 2).

That particular resources and habitats were protected from fire in *Noongar* country is clearly apparent in early colonial

records and was also highlighted by Kelly (1998). Nind (1831), Grey (1841b) and Drummond (1853b) gave detailed accounts of hunting for medium-sized macropods (likely the Western Brush Wallaby, *Macropus irma* or Tammar Wallaby, *Macropus eugenii*) in which a dense thicket of vegetation was surrounded, trampled at its outer boundary, with wallabies flushed out and becoming entangled in the knocked down vegetation. This description highlights the value of dense vegetation as game habitat resource to *Noongar* people and likely deliberate protection of some habitats from fire disturbance. Similarly, Roe’s October 13<sup>th</sup> 1836 diary entry (Hercock 2014), concluding that “numerous fallen trees or saplings which crossed each other, and sometimes defied a passage” were due to an infrequency of fire was likely not merely coincidental to his recording of two *Ngauw* nests (the Mallee Fowl, a mound-building megapode, *Leipoa ocellata*) on the same day in country in the vicinity of Kellerberrin. Due to its requirement for extensive leaf litter, the *Ngauw* is particularly fire-sensitive (Parsons and Gosper 2011) and also an important *Noongar* food source (Hassell 1975; Scott and Brown 2005).

*Noongars* used the seed cones (Hassell 1975; Nind 1831), flowers (Bates 2004; Meagher 1974; Nind 1831) and seeds (Lynette Knapp pers. comm. 2014) of members of the Proteaceae family. Roe’s November 19, 1848 observation of finding bark baskets filled with “honey flowers” (likely a Proteaceae species) amongst “thicket and scrub” (likely OCBIL kwongkan sandplain) indicates that Proteaceae resources may also have been protected from frequent fire (Hercock 2014).

Accounts of hunting for *Quumarl* (Western Brush-tailed Possum, *Trichosurus vulpecula*), requiring tracking of an individual to its tree-hollow nest (Grey 1841b; Hassell 1975; Nind 1831), and the sourcing of fresh water from hollows of the *Warnda* (*Eucalyptus wandoo*) tree (Drummond 1853b; Hercock 2014; Moore 1835, 1884; Nind 1831) suggest that certain trees (particularly of age enough to bear hollows) were highly valued, and were likely afforded protection from disturbance. Likewise, specific reference to shrubs and trees that offered cover for game hunters in grassland is also indicative of a heightened value worthy of protection (Eyre 1841; Grey 1841b).

On the return leg of his expedition from Cape Riche to the Russell Ranges, Roe observed near Esperance Bay on December 10, 1848 clumps of *Nuytsia floribunda* (Loranthaceae) and *Eucalyptus occidentalis*, *Macrozamia dyeri* (Zamiaceae) (Figure 2) of “gigantic size” as well as “tolerable grass among dwarf grass trees” (*Xanthorrhoea platyphylla* (Xanthorrhoeaceae)) in a river valley close to Esperance Bay, which on the preceding day he had described as “somewhat better peopled” (Hercock 2014). Each of Roe’s noted plant species is of high and multi-faceted importance in *Noongar* culture and their prominence in a highly-populated area appears due to management practices. In addition, Roe’s numerous observations of both “wattle” (likely *Gnaamarur*, *Acacia cyclops* (Figure 2) or *saligna*) and “yeit” (a misapplied *Noongar* name referring to *Eucalyptus cornuta* that we now



**Figure 2**

(Clockwise from top left), seeds of *Acacia cyclops*, eaten by south coast *Noongars*; *Djuljuruk* (*Eucalyptus pleurocarpa*), a marker of country for south coast *Noongar* families; *Macrozamia dyeri*, of which the seeds (*pauyin*) were eaten, adjacent to lizard traps on granite inselberg east of Esperance; *Pain*, fruit of *Carpobrotus modestus*; *Wonyill*, fruit of *Santalum acuminatum*, *Quadin*, rhizomes of *Haemodorum discolor*; *Joowaq*, tubers of *Platysace deflexa* (centre). Photo credits: A. Lullfitz, S. Hopper

understand referred to *Mauw* (*Eucalyptus occidentalis*) in otherwise grass-covered valleys on the south coast (Hercok 2014) are again likely the result of deliberate protective measures. Likewise, Roe's observation near Wilson Inlet (40 km west of Albany) on December 12, 1831 of "very good grassy land, sometimes wet, with grass trees and requiring very little clearing" (Hercok 2014) may indicate the employment of measures to protect and promote members of the important resource plant genus *Xanthorrhoea* in favour of other taxa.

### Extension of the geographical distribution of plant taxa

#### Synopsis

Extension beyond a species' wild range is a niche constructing activity with evolutionary consequences for that target species and possibly others (Rowley-Conwy and Layton 2011). The present day distribution of some human-used perennial plant taxa populations has been attributed to human agency (Kondo et al. 2012; Rangan et al. 2015) as a result of collection and transport of fruit or seed (Amundsen-Meyer 2013; Gott 2008; Head et al. 2002; Hynes and Chase 1982; Rowley-Conwy and Layton 2011; Smith 2011a), processing (Allen 1974) and deliberate broadcast of seed (Smith 2011a; Walsh 1990), and transplanting of tubers (Hynes and Chase 1982; Russell-Smith et al. 1997).

#### Noongar Evidence

That long distance movement of plant propagules was customary among *Noongar* is indisputable with numerous early European records of the deliberate movement of roots (Grey 1841b; Moore 1884; Nind 1831), seeds (Grey 1841b; Hassell 1975) and fruits (Hassell 1975). Through such custom, *Noongars* may well have (deliberately or inadvertently) influenced current distribution patterns of some SWAFR plant taxa (Gott 1982). Meagher (1974) cited numerous records of plant foods being brought to camp by women and children, while Nind (1831) mentioned specifically the transporting of roots, and Roe on November 14, 1835 observed where roots and seeds had been ground at a campsite near Nornalup (Hercok 2014). Dense occurrences of the staple, tuberous food plant, *Platysace trachymenioides*, observed by the authors (Alison Lullfitz, Stephen Hopper, Ron (Doc) Reynolds, David Guilfoyle) around culturally important granite outcrops inland north of Esperance, may also be the result of *Noongar* movement and in-situ cultivation.

Drummond (1843a) suggested that an unusual occurrence of the important resource plant, *Maanqaart* (*Acacia acuminata*) and the widespread occurrence of the regularly transported food plant, *Wonyill* (*Santalum acuminatum* (Santalaceae)) (Figure 2) and fruit resource, *Pain*, (*Carpobrotus* (Aizoaceae)) (Figure 2) as likely due to *Noongar* cultivation. In addition, Drummond (1843a) noted the presence of important seed resource, *Macrozamia*, at favourite *Noongar* campsites. Use of leaching technology to detoxify the seed of *Macrozamia dyeri* (Figure 2) in the Esperance area and *Macrozamia reidleyi* further west has been employed by *Noongars* since at least the late Pleistocene (c. 13,200 BP) (Smith 1982). That the

seeds were a staple food and procedures for detoxification were well documented by early Europeans (Barker 1830; Drummond 1840b; Grey 1841b; Hassell 1975; Moore 1884) and required the collection, soaking or long-term underground storage, drying and roasting prior to eating (Smith 1982). This likely included the transport of seed to specific locations, and particularly to locations where fresh water was available (eg *gnammas* (rock pools)). Hassell (1975) observed the use of *Macrozamia* fruit by *Wirlomin Noongars* in the Jerramungup area, but also commented that, as it did not occur in the area, it was procured through trade following removal of the seed, suggesting cultural restrictions around their procurement and use, possibly linked to its toxicity.

Among some contemporary *Menang Noongar* Elders, the occurrence of certain *Acacia* species is considered indicative of past campsites (Lynette Knapp pers. comm. 2015). In observations of the *Wirlomin Noongar* group during the 1870s, Hassell (1975) documented the collection, transport to camp, processing at camp and storage for later use of the seed of *Maanqaart*, *Acacia acuminata* and *Manna*, *A. microbotrya*, describing the grinding of seed as "a source of great merriment" due to the seeds "hopping about all over the place". Inevitable (but possibly unintentional) broadcasting during seed processing, as well as the common practice of frequent burning of vegetation at campsites (recalled by Ron (Doc) Reynolds and *Menang Noongar* Elder, T. Woods (pers. comm. 2014)) would likely have enhanced opportunities for seedling establishment through increased soil nutrient availability and reduced competition from other plants.

Several phylogeographic studies have been carried out in recent years on plant taxa that feature prominently in *Noongar* culture (although none were specifically aimed at detecting the influence of pre-colonial human agency) (Figure 3).

Such taxa include *Eucalyptus occidentalis* (Elliott and Byrne 2003), *E. marginata* (Wheeler et al. 2003), *E. wandoo* (Dalmaris et al. 2015), *Acacia acuminata* (Broadhurst and Coates 2002; Byrne et al. 2002), *Santalum spicatum* (Byrne et al. 2003) and *Macrozamia reidleyi* (Byrne et al. 1997). To varying degrees, all of these studies show intraspecific DNA variation consistent with a hypothesis of human dispersal in *Noongar* country, and indicate the value of more targeted studies in this field.

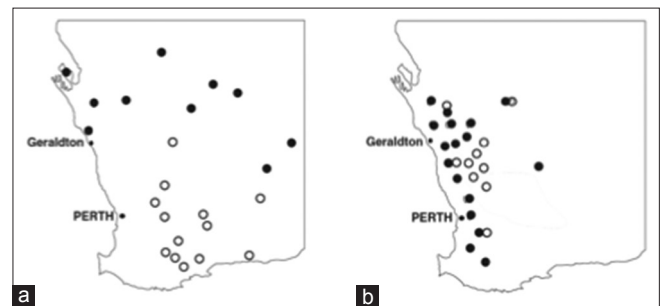


Figure 3

Geographical locations of lineages observed in phylogeographic studies of a) *Santalum spicatum* and b) *Acacia acuminata*, where closed and open circles represent separate lineages (Byrne 2007)

## Habitat modification to increase local resource abundance

### Synopsis

Examples of both plant (Amundsen-Meyer 2013; Fowler 2000; Smith 2011a) and animal (Lourandos 1983; Smith 2011a) resource enhancement through habitat modification have been documented. Smith (2011a) suggested that prey abundance increase strategies consist of either enhancement of a habitat to attract or increase numbers of prey, or constraint of prey movement to assist with capture. Others have highlighted that resource renewal activities occur within a broader social and religious context which may include rituals for deceased ancestors (Amundsen-Meyer 2013) or expressions of oneness with totems (Laudine 2009).

### Noongar Evidence

In southwestern Australian estuaries, fish traps were extensively employed (Grey 1841b; Moore 1884; Shenton and Wells 1837) as both a habitat modification and prey constraint, while *karda mia* (lizard ‘traps’), consisting of a granite slab propped by a smaller rock to catch reptile prey on granite outcrops, are hypothesised to have been used throughout Noongar country (Bindon 1997; Guilfoyle et al. 2013; Rossi 2014; Smith 1993). A contemporary Menang Noongar Elder described the deliberate cultivation of a particular plant species, *Hakea drupacea* (Proteaceae) at the edge of granite outcrops in the Albany area as a means of enhancing granite exfoliation to gain flat slabs for use in lizard trap construction (Lynette Knapp pers. comm. 2014).

The southern coastal Noongar practice of *gnamma* creation and enhancement through localised firing of granite was primarily intended to increase supply of fresh water for human consumption (Gail Yorkshire-Selby pers. comm. 2014). However, the resultant increase in freshwater habitat availability was valued by a range of fauna (Hassell 1975) and undoubtedly had positive outcomes for edible aquatic plants such as *Cycnogeton lineare* (Juncaginaceae) and *Myriophyllum petraeum* (Haloragaceae), eaten by Esperance Nyungars, including one of the authors (Ron (Doc) Reynolds). Regular cleaning of *gnammas* according to protocol that ensures retention of seed store and microbes would also likely have assisted aquatic plant survival on granite outcrops (Jenkin et al. 2011).

The breaking down of *Xanthorrhoea priessii* (Grey 1841b; Nind 1831) and *X. platyphylla* (Eyre 1841; Nind 1831) tops to attract the highly-savoured (Barker 1830; Drummond 1840b; Wilson 1829) *Bardi*, larvae of the beetle *Bardistus cibarius*, was a widely used Noongar habitat modification technique. Although simple in technique, contemporary accounts (Larry Blight pers. comm. 2014b) as well as Nind’s (1831) record of the Menang Noongar procedure demonstrate that the method was tightly controlled by strict laws and that there were serious consequences for individuals who did not abide.

## Restrictions and territorial markers

### Synopsis

Although most studies of Aboriginal interactions with plants are focused on resource exploitation, specific plants and vegetation communities are important markers of ceremonial use, territoriality and how well country is cared for (Bird et al. 2008; Chase 1989; Hynes and Chase 1982). Chase (1989) and Amundsen-Meyer (2013) highlighted complexities in custom relating to use of particular plant resources from temporal, spatial and human perspectives (eg a particular plant may be utilised for a specific purpose, by a specific age/gender, at a particular ceremony and site, whereas its use may vary in a different time, place or social context).

### Noongar Evidence

*Menang*, *Bibbulmun* and *Whadjuk* Noongar laws ascribe great spiritual importance to the plant, *Muattyaur* (*Nuytsia floribunda*) and its disturbance is prohibited by these groups of the western coast of south western Australia (Hopper 2010). However, its disturbance for use as a food (Hassell 1975) and for personal adornment (Hopper 2010) is recorded among other Noongar groups, and is allowable at certain times by specific people in Menang Noongar country (Larry Blight pers. comm. 2014a). In addition, Little (1994) described an area just south of Perth in which *Muattyaur* grew extensively as a territory boundary where entry was restricted. Similarly, Esperance Nyungar Noongar Elders (including Ron (Doc) Reynolds) describe *Djuljuluk* (*Eucalyptus pleurocarpa*) (Figure 2) as a marker of being in one’s own country (Gail Yorkshire-Selby pers. comm. 2014) and its north-easternmost distribution appears closely correlated with the granite inselbergs that mark the boundary between Noongar and Ngadjju country. Restrictions regarding Noongar movement through kwongan sandplain due to an association with ‘evil spirits’ was documented by Hassell (1975) in the Jerramungup area and Oldfield (1865) further to the north, while spiritual beings in mountainous areas (also OCBILs) are documented historically (Hassell 1975) and well known to contemporary south coast Noongars (including author Carol Pettersen) among whom access remains restricted.

Laws relating to land ownership and marriage instituted strict and specific controls over access to Noongar land, as well as its plant and animal resources (Grey 1841b). Both Nind (1831) and Grey (1841b) described authorisation between neighbouring groups to gather particular resources from each others’ land at certain times, and also described marriage as an instrument for connection (and therefore land access) between groups. Certain laws reserved particular foods for particular people (Grey 1841b), such as the reserving of wild dog young for old people (Hassell 1975) and young men being unauthorised to eat emu flesh (Grey 1841b); prevented individuals from harming their totems (Grey 1841b; Hassell 1975) and dictated seasons and life stages for gathering of plant and animal resources (e.g. that plant resources should not be

gathered when bearing seed) (Grey 1841b). It appears that Noongar law instituted both sustainability of resources and societal wellbeing through such prescriptions. Further, stories inherited by contemporary Noongar Elders (e.g. Knapp 2011) and accounts of dreaming stories documented in the early colonial literature (e.g. Hassell's recounting of a story in which the grinding and baking of *Acacia acuminata* seed is central) reflect the longstanding, intrinsic position of Noongar people and their law among the biota and landforms of southwestern Australia.

## CONCLUSION

Given the long time-frame for fine-tuning of Noongar niche construction activities in the OCBIL-dominated SWAFR, it appears that knowledge and behaviours congruent with maintaining biological diversity and institutionalised in traditional Noongar law probably resulted in changes to Noongar culture and the ecosystems in southwestern Australia through the late Pleistocene and Holocene. This brief review indicates that disturbance-inducing Noongar niche constructing activities were likely greater in the SWAFR's YODFELs than OCBILs, but highlights several avenues for further investigation of the role that humans have played in shaping the biota of the SWAFR. Study of past and contemporary distributions of plant taxa at community, species and intraspecific levels in combination with ethnographic and archaeological evidence, contemporary testing of the ecological outcomes of traditional disturbance processes, and reinterpretation of previous studies (such as in plant phylogeography) through a niche construction lens are likely to shed new light on our understanding of southwest Australian biota.

HNC is a useful theoretical framework for examination of specific Noongar niche construction practices and their likely influences on the state of SWAFR ecosystems, although we suggest that a SET-based approach is equally valid and probably complementary. Examination of such human interactions with SWAFR flora in the context of its long and complex evolutionary history can direct new perspectives for its conservation. In particular, a strategy of targeted fire and soil disturbance and highly localised conservation management appears consistent with both past Noongar practice and emerging knowledge of rapid species turnover and high genetic differentiation across SWAFR landscapes. Collaborative research engaging traditional owners, ecologists and archaeologists, that examines the likely ecological and evolutionary implications of past Noongar practice on country, is an important step for conserving the extraordinary biological communities of southwestern Australia.

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