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ARTICLE

The effect of retouch intensity on mid to late Holocene unifacial and bifacial points from the Kimberley

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ABSTRACT
Stone points have provided key data for studies of hunter gatherer lifeways in several parts of the world. Point technologies occur widely across northern Australia, appearing around the mid-Holocene and persisting into the European Contact period. These points exhibit high-morphological variation, and include bifacial, unifacial and other forms. In the Northern Territory and north Queensland, points have been shown to form part of a reduction continuum. However, in the Kimberley region of Western Australia, similar reconstructions of artefact life history have not been conducted. Using a recently excavated assemblage with a large sample of retouched unifacial and bifacial points ($n = 137$), we examine the effect of retouch intensity on changing point morphology. Quantification of point reduction reveals a complex artefact life history having compelling parallels with point assemblages from other parts of northern Australia. Drivers for the inception of point technology in northern Australia are likely to be multiple, including environmental change, population change and social signalling.

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Reduction continuum; stone points; Holocene; Kimberley; typology

Introduction

Australian archaeologists have debated the meaning of morphological variation in stone point technologies for close to a century (Clarkson 2007:102–110; Davidson 1935:160–162; Flood 1970; Hiscock 1994a; Macintosh 1951; McCarthy and Setzler 1962; Schrire 1982:246). Many facets of this debate centre on the effect of reduction intensity on tool morphology, which has occupied the attention of stone tool analysts around the world (e.g. Andrefsky 2009; Dibble 1995; Shott 2003). In the last two decades Hiscock (1994a, 2006, 2009, 2011) and Clarkson (2006, 2007) have used technological criteria to examine the morphological variation of points in assemblages from the Northern Territory [NT] and northern Queensland [Qld] (Figure 1), demonstrating a reduction continuum from unifacial to bifacial forms. Their findings have prompted a reconsideration of the relationship between point form and reduction in the Kimberley archaeological record, where the point reduction continuum has lacked analogous examination (Akerman et al. 2002:15; Blundell 1975:393; Flenniken and White 1985:148; O'Connor 1999:76). While Blundell (1975:288) entertained the possibility of a continuum in the Kimberley, other researchers have not found compelling evidence to demonstrate the transformation of unifacial points into bifacial points (Akerman et al. 2002:15; Blundell 1975:393; Flenniken and White 1985:148; O'Connor 1999:76). Instead, they have most often used typological approaches to describe assemblages (i.e. Dortch 1977) and remain fairly ambivalent as to whether unifacial and bifacial points are indeed discontinuous, as was recently suggested (Moore 2015:937).

The typological approach identifies shared qualitative traits of artefacts as 'types', and by implication, conceives of these types as mutually exclusive products. This approach has been useful in compartmentalising complex phenomena from the archaeological record into easily recognised units. Stone tool typology is largely seen as an essentialist construct which views observed artefacts as discrete products of their makers' design, and in doing so, either discounts or downplays the process by which stone artefacts are created, used, reshaped and discarded – the reduction process (Shott et al. 2007:204–205).

As all flaked stone artefacts are reduced, the reduction sequence approach seeks primarily to reconstruct this sequence with remaining artefacts. The method creates a model of artefact life history including production, use, modification, maintenance, reconfiguration, discard, recycling, and occasionally archaeological recovery (Andrefsky 2008:6; Schiffer 1972:158, 1976:46). While the reduction

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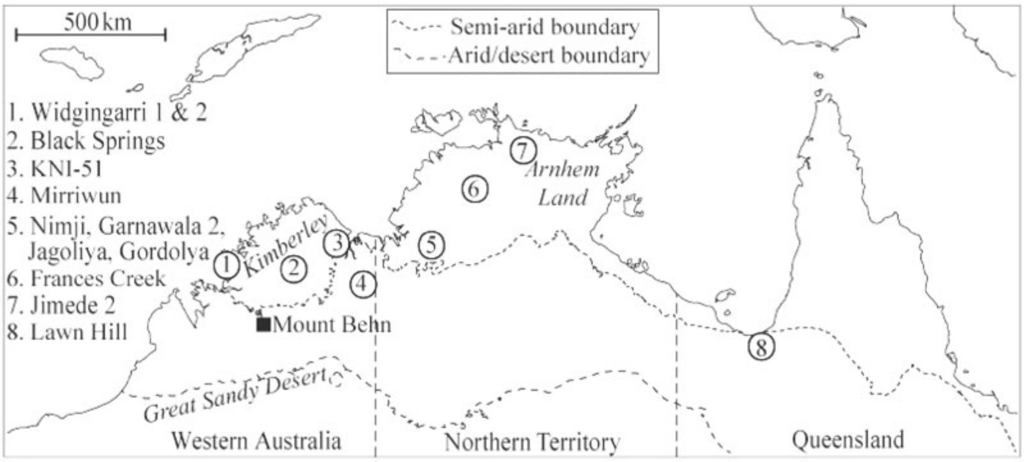

Figure 1. Northern Australia showing location of Mt Behn, other sites mentioned in text, and modern state boundaries. The boundaries of arid and semi-arid zones are shown by dashed lines.

sequence approach has often been employed to test and refute typologies (e.g. Brumm and McLaren 2011; Dibble 1984; Hiscock and Attenbrow 2003) archaeologists are now concerned with explaining why these reduction sequences were followed, and this is our primary aim here. The underlying causes of various technological strategies, including reduction sequences, are often discussed under theoretical frameworks of technological organisation. Stone technology is thought to have had a close relationship with subsistence in hunter gatherer societies (Kuhn 1995; Nelson 1991:58; Torrence 1989:58), and as such, technologies are often conceived as adaptive problem-solving strategies in people's life ways. Interpretive frameworks have used the progressive modification associated with reduction sequences to model changing mobility (Kuhn 1995), reactions to foraging risk (Bleed 1986), and investment of time and energy into technology (Torrence 1989). In Australia, Clarkson used such interpretive frameworks to suggest that changes in point reduction from the NT throughout the mid to late Holocene were sensitive to environmental changes (Clarkson 2007). Increased efforts to continually reduce and rejuvenate bifacial points, suggested to be multifunctional and highly adaptable tools, were interpreted as reflecting efforts to keep tools usable for longer during periods of increased foraging risk.

The archaeological understanding of Holocene point technology in northern Australia was chiefly founded on typological approaches (Davidson 1935), which rest on speculations about function largely based on ethnographic analogies. This typological approach divides unifacial and bifacial points (Figure 2) as mutually exclusive implements and researchers have suggested that function, design, or cultural identity drove the need for these apparently discrete tools (e.g. Flenniken and White 1985; Flood 1970:9; Schrire 1982). Researchers were more pragmatically concerned with identifying spatial and temporal trends using these types, as exemplified by Dortch (1977), rather than exploring the relationship between reduction and tool form. In this sense, point typology was a useful practice for identifying broad, inter-assemblage technological change, but it is not well suited to modelling the role these tools played in people's lives. Furthermore, in application the categorical division of these point types has been ad hoc. For example, points from the Kimberley with some degree of bifacial retouch, have often been described as unifacial points (Blundell 1975:250; Flenniken and White 1985:148; Mulvaney 1975:219; O'Connor 1999:72, Figure 5.13, no. 2), or as an intermediate category independent of either type (Dortch 1977:113; Flood 1970:41).

A significant reason for the lack of point reduction continuum models in the Kimberley has been the prominence in this region of another point reduction sequence involving the enigmatic Kimberley points. These are pressure flaked bifaces with marginal serrations (Figure 2(B)), produced as functional hafted projectiles, trade items, and prestige goods (see Akerman 1980; Akerman and Bindon 1995; Akerman et al. 2002; Harrison 2002, 2006; Moore 2015). Maloney et al. (2014) demonstrate that these pressure-flaked bifaces first appear in the archaeological record only within the last 1000 years BP. The manufacture of Kimberley points has been widely observed in historical times (see Akerman et al. 2002:18–19; Love 1936:93–95). A paramount feature of these bifaces, not shared with the points examined in the studies by Clarkson (2006) or Hiscock (1994a), is the staged reduction of bifacial preforms (Akerman et al. 2002:19; Moore 2015) which are often technically cores, as they lack any ventral surface (Figure 2(A)). Thus, Kimberley points are produced by a reduction process that is radically different from unifacial and bifacial points made on flakes. One proponent of what would later be defined as the divergent model in the NT

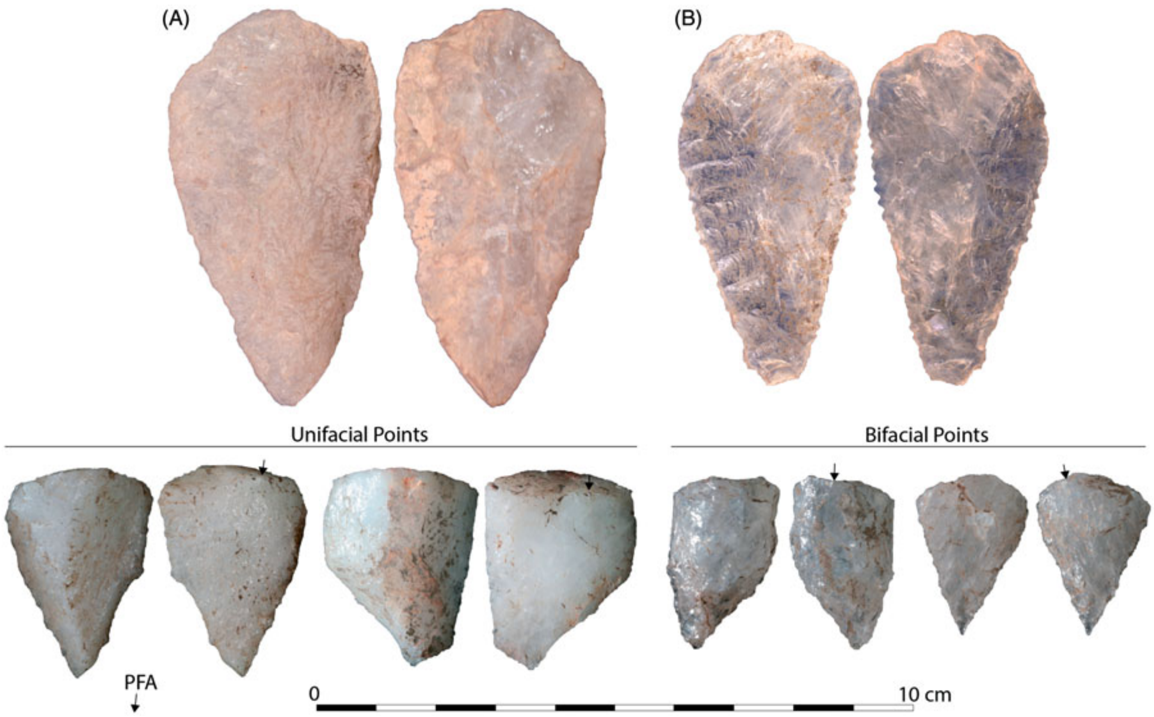

Figure 2. (A) Bifacial preform used in the production of pressure-flaked Kimberley points (B) Kimberley point. Examples of both unifacial and bifacial points recovered from the Mt Behn excavation, including some white vein quartz (Photographs by Tim Maloney).

suggested that bifacial points from the Kimberley were reduced from cobbles, and unifacial points from blades (Blundell 1975:89, 275, 288). This does suggest that Kimberley researchers were initially contrasting the Kimberley point reduction sequence, which is exclusively bifacial, with the direct percussion points which exhibited greater diversity.

A further problem besetting earlier studies of points in the Kimberley region has been the consistently small samples recovered from datable contexts (Fullagar et al. 1996:764; Harrison 2004:4–5; Maloney et al. 2014; O'Connor et al. 2014:17; Veitch 1996; Ward et al. 2006:8, 13). For instance, the 42 mostly unifacial points from Widgingarri Shelters 1 and 2 comprise one of the largest point assemblages from dated contexts in the region (O'Connor 1999:64–78). One interpretation of this still fairly small point assemblage, was that unifacial and bifacial points were not contemporaneous, so could not be part of a reduction continuum (1999:76–77). The only other sizeable assemblages from dated contexts are those from Monsmont ($n = 117$) and Miriwun ($n = 83$) rockshelters in the Ord Valley (Dortch 1977; Dortch and Zlatnik nd:38, 50) and the 86 points analysed by Bradshaw (1986) from five sites in the east Kimberley (1986:239, Table 108). Other point assemblages are either undated or surface collections (Blundell 1975; Moore 2015). It is conceivable that the lack of support for the reduction continuum model in the Kimberley is in part a result of the small sample sizes that are incapable of capturing the diversity of artefact life history.

The point assemblage recovered at Mt Behn presents an opportunity to examine point reduction on a larger sample of points ($n = 137$) from an excavated and dated context in the Kimberley. With a single exception, points do not resemble the pressure-flaked bifaces or Kimberley points but superficially resemble those from other northern Australian sites such as Nimji, Garawala, Jagoliya, Gordolya [hereafter referred to as the Wardaman sites], Jimede 2, and Lawn Hill (Figure 1), and thus provide a good comparative sample.

We use morphological and reduction sequence analyses to examine the relationship between unifacial and bifacial points from Mt Behn, in the southern Kimberley (Figure 1). We describe the site chronology and use the sizable assemblage of points ($n = 137$) to provide the first evidence of a point reduction continuum in the Kimberley region between 5,500 cal. BP and modern times. We examine our data in the light of models that seek to explain the appearance of point technology in Australia, and discuss results within the theoretical frame works that have formed the basis of other studies of bifacial point technologies.

The Mt Behn rockshelter

In 2012 two adjacent 1 m^2 squares were excavated close to the central back wall of the Mt Behn rockshelter (Figure 3). The deposit in Square 1 was excavated to bedrock at 70 cm depth, but excavation was discontinued at 50 cm depth in Square 2 when

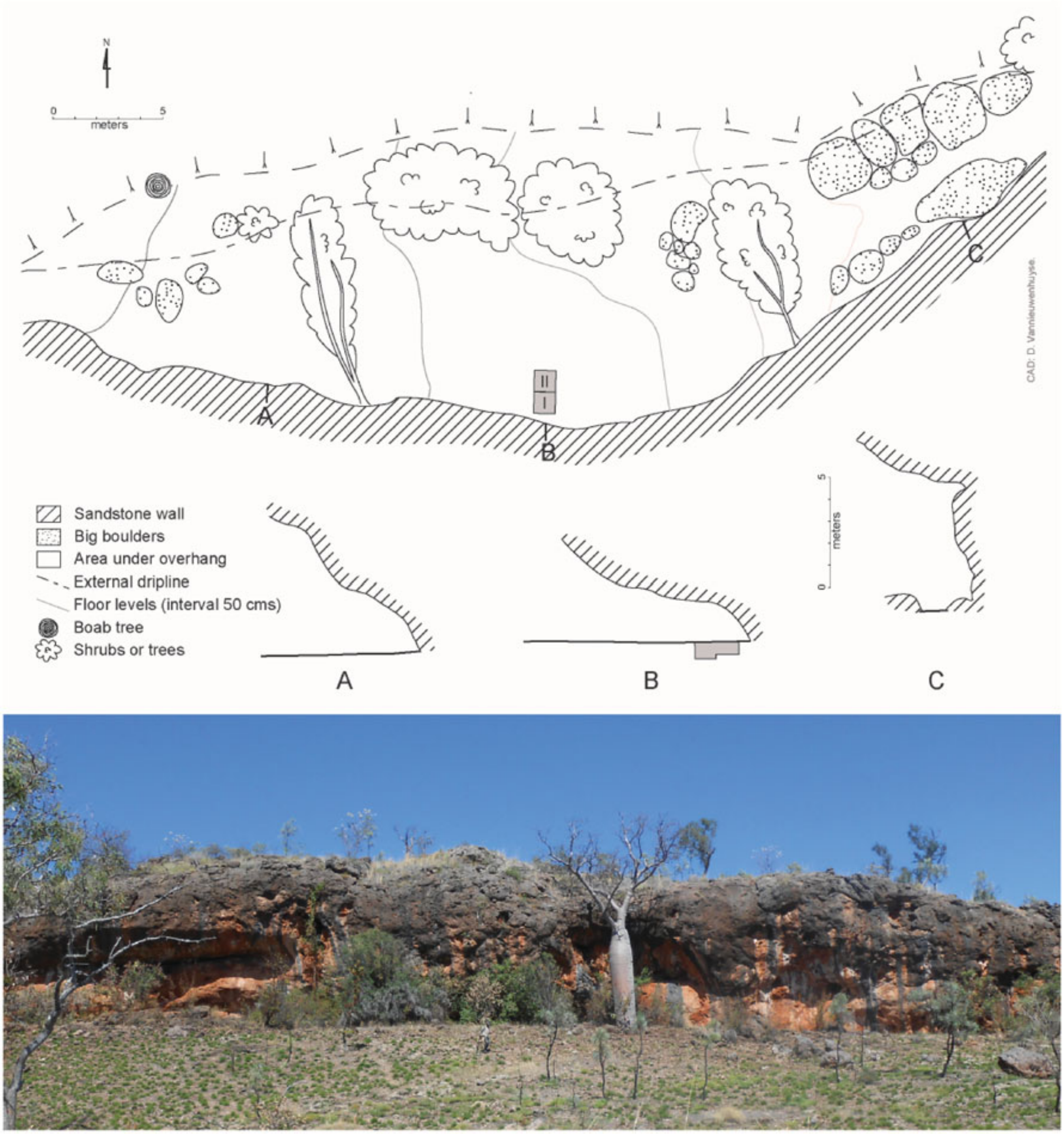

Figure 3. Site plan showing location of excavation squares, slope and extent of shelter floor, and three cross sections. Photograph showing outside of shelter (Photograph by Tim Maloney).

culturally sterile sediments were encountered (Figure 4).

Seven stratigraphic units [SU], based on colour and textural changes, were identified (Vannieuwenhuyse 2016). The lower half of the sequence (SU7 and SU6) is composed of archaeologically sterile decomposed bedrock. The upper half of the sequence (SU5 to SU1, 40–50 cm below surface level) is archaeologically rich (see SU description in Figure 4) and contains all the analysed artefacts. Twenty-two radiocarbon dates were obtained for the sequence (Table 1). The oldest radiocarbon estimate is from a scaphopod bead from SU5 which returned an age range of 5531–5304 cal. BP (ANU-33033). Most of the occupation evidence derives from SU4 and SU3, bracketed by dates of 3815–3575 cal. BP (ANU-33031) and 1835–1710 cal. BP (ANU-46907), with the uppermost SU containing several dates within the last few hundred years. Table 2 lists the number of stone points recovered from the five stratigraphic units.

While we recognise that some points may have moved vertically within the deposit, there is no evidence of size sorting in the analysed sample of flakes (Square 2 Quadrant A), using univariate statistics for mass ($F = 1.245$, df $= 32$, $p = .245$) and percussion length ($F = 0.945$, df$=32$, $p = .616$). Furthermore, the vertical distribution of points relative to stratigraphic unit, shows a strong and positive correlation with numbers of artefacts (Table 2), returning an r^2 value of 0.949, indicating that the number of points increases relative to the total number of artefacts, as would be expected if points were deposited during episodes of knapping rather than via vertical movement (sensu Hiscock 1993).

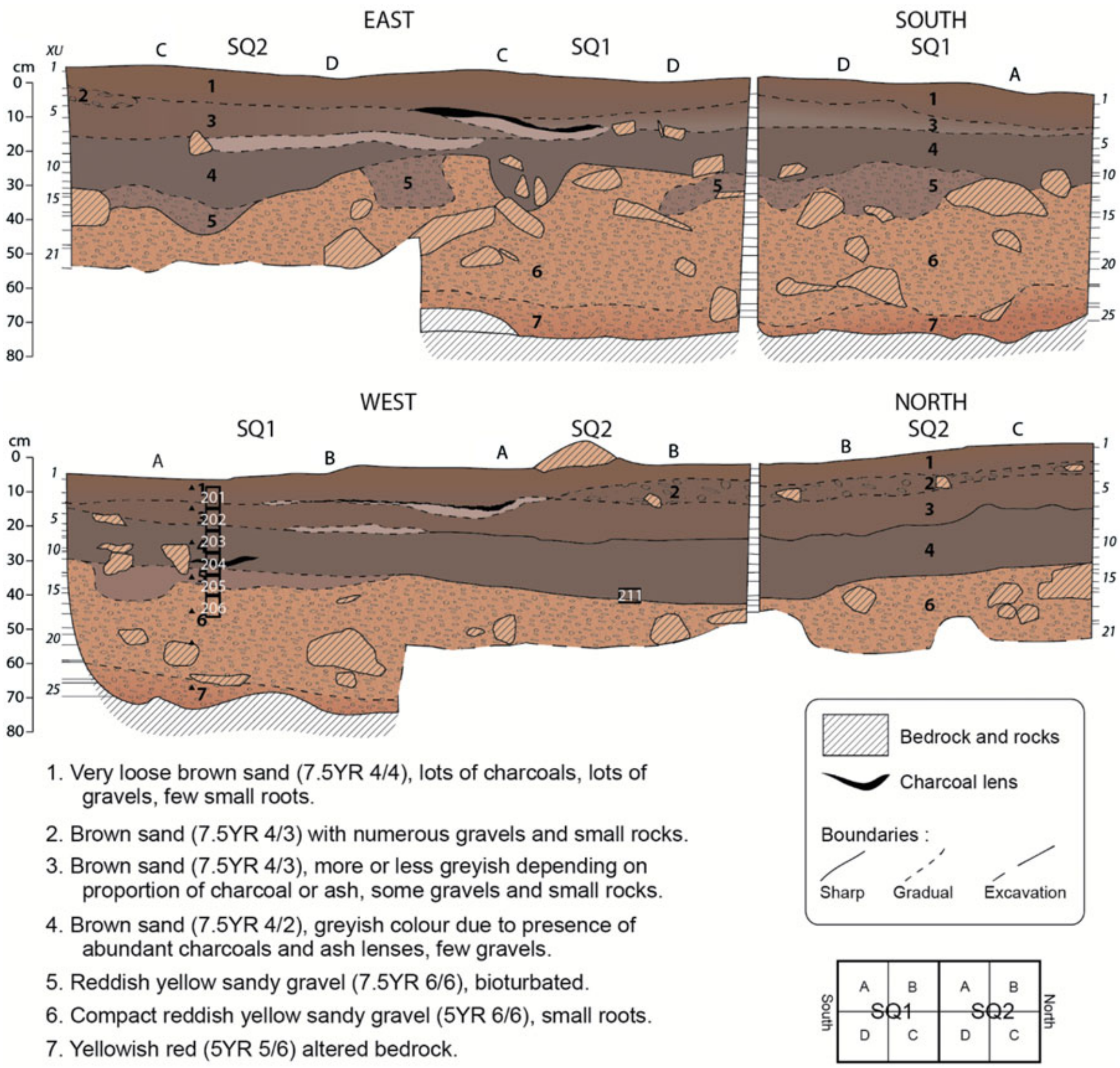

Figure 4. Stratigraphic profile of Mt Behn excavation showing stratigraphic units.

Methods

In order to test the reduction model proposed by researchers in the NT, we have largely followed their methods (i.e. Clarkson 2006; Hiscock 2009, 2011). Stone points are here identified by their converging retouched margins, following Hiscock (2009:84, 2011:76). For the sake of simplicity, we refer to points with one or more retouch scars initiated from a single surface as unifacial, regardless of the extent of scar invasiveness, and refer to points with retouch scars initiated from two surfaces as bifacial.

Point morphology was quantified using the linear measurements and indices of shape developed by Clarkson (2006:99–103, 2007:101–111). Reduction indices were employed to test typological validity. Following Hiscock and Tabrett (2010), the Index of Invasiveness (Clarkson 2002), was deemed to be a powerful way to quantify the distribution and extent of retouch. Statistical tests were performed with SPSS v24. Shapiro–Wilk tests of normality were used to determine appropriate tests, with Pearson's Chi-squared tests used for non-normally distributed data, such as type counts, and Analysis of Variance [ANOVA] tests used for normal data.

For the Mt Behn assemblage, ventrally initiated retouch was recorded as 'dorsal retouch', and dorsally initiated retouch, as 'ventral retouch'. Where bifacial retouch occurs, with scars initiated from one surface truncating scars initiated from the opposite surface, the latter surface was the last to be retouched. Using this premise, the retouch order of points was recorded as dorsal only, dorsal last, ventral only, or ventral last. Where bifacial points were rotated multiple times, the original order of retouch could be obliterated, creating an ambiguous bifacial retouch order.

To further quantify the distribution of retouch, the order of retouch was analysed within quartile divisions (0–0.25, 0.25–0.5, 0.5–0.75, 0.75–1) of the Index of Invasiveness (Clarkson 2007:102). These divisions represent arbitrary stages of reduction intensity and are used to depict how retouch spread across point surfaces. Anvil rested backing retouch

Table 1. Radiocarbon dates recovered from Mt Behn excavation.

	Lab. code	SU	XU	Sampling context	Depth below surface (cm)	Curve	Material	d^{13}C	C14 Age	Age cal. BP 2 sigma 95.4%
Square 1	ANU 46909	1	2	Sieve Res.	5.6–8.66	SHCal13	Charcoal	−28	224 ± 25	301–144
	ANU 33107	1	2	Sieve Res.	5.6–8.66	Marine13	Scaphopoda sp.	1	3,730 ± 40	3,799–3,550
	ANU 33026	3/4	4	Sieve Res.	11.6–14.4	Marine13	Scaphopoda sp.	−4	2,740 ± 35	2,612–2,334
	ANU 33027	3/4	6	Sieve Res.	16.8–19.3	Marine13	Scaphopoda sp.	−7	2,505 ± 35	2,293–2,066
	ANU 32507	4	7	Sieve Res.	19.3–22	SHCal13	Celtis	−25	1,955 ± 30	1,930–1,785 (88.7%) 1,773–1,747 (6.7%)
	ANU 33029	4	8	In situ	23.5	Marine13	Scaphopoda sp.	−6	2,225 ± 40	1,930–1,710
	ANU 33106	4	8	In situ	23	Marine13	Scaphopoda sp.	9	2,995 ± 35	2,849–2,705
	ANU 33030	4	9	Sieve Res.	23.2–25.7	Marine13	Scaphopoda sp.	−7	3,695 ± 40	3,728–3,476
	ANU 46907	4	9	Sieve Res.	23.2–25.7	SHCal13	Charcoal	−28	1,884 ± 26	1,835–1,710
	ANU 33031	4	10	Sieve Res.	25.7–27.3	Marine13	Scaphopoda sp.	−6	3,755 ± 40	3,815–3,575
	ANU 33032	4	11	Sieve Res.	27.3–29.9	Marine13	Scaphopoda sp.	−6	3,310 ± 40	3,297–3,020
	ANU 33033	5	12	Sieve Res.	29.9–32.6	Marine13	Scaphopoda sp.	−4	5,060 ± 40	5,531–5,304
	ANU 46910	6/5	14	Sieve Res.	34.5–37.6	SHCal13	Charcoal	−27	1,254 ± 26	1,258–1,059
	ANU 46911	6/5	15	Sieve Res.	37.6–39.6	SHCal13	Charcoal	−25	1,936 ± 26	1,905–1,745
Square 2	ANU 46912	1	1	Sieve Res.	0–1.8	SHCal13	Charcoal	−29	108 ± 26	254–0
	ANU 32510	1	1	Sieve Res.	0–1.8	Marine 13	Melo Sp.	−7	3,050 ± 35	2911–2739
	ANU 32631	1	3	In situ	6.5	SHCal13	Charcoal	−25	265 ± 35	439–401 (4.8%) 390–379 (0.8%) 328–262 (44.5%) 223–146 (45.2%)
	ANU 32514	1	4	Sieve Res.	6.9–9.9	SHCal13	Charcoal	−32	135 ± 25	258–233 (17.0%) 145– … (78.4%)
	ANU 32509	3	5	In situ	12	SHCal13	Seed	−22	2,020 ± 35	2,008–1,867 (92.1%) 1,854–1,838 (3.3%)
	ANU 32513	4	10	Sieve Res.	23.86–25.9	SHCal13	Charcoal	−32	2,460 ± 35	2,700–2,632 (17.8%) 2,618–2,585 (6.7%) 2,575–2,563 (1.2%) 2,541–2,349 (69.7%)
	ANU 32632	4	15	Sieve Res.	35.1–36.7	SHCal13	Charcoal	−26	2,775 ± 35	2,925–2,756
	ANU 32512	4	16	In situ	39	SHCal13	Charcoal	−31	2,715 ± 45	2,875–2,735

The dates were calibrated using Ox Cal v4, with the southern hemisphere curve [SHCal13] for charcoal (Hogg et al. 2013) and the marine curve [Marine13] (Reimer et al. 2013) for shell. A delta R correction of ΔR = 54 ± 37 was applied to the shell dates (O'Connor et al. 2010).

Table 2. Number of points recovered from each stratigraphic unit.

Stratigraphic Unit	Number of stone points	Total number of artefacts	Points as % of total assemblage
1	26	13,475	0.19%
2	5	2,794	0.18%
3	32	10,634	0.30%
4	70	26,272	0.27%
5	1 (+ 3 from 4/5 mix)	606	0.66%

on points was identified following the criteria of Maloney and O'Connor (2014:150), including retouched edge angle, bidirectional scars, and crushing on one or both initiation surfaces.

Following these methods, all complete points were recorded to test the reduction continuum model and quantify reduction. If the unifacial and bifacial points represent distinct types, the following consistent differences are expected:

- Retouch intensity and distribution should not overlap between the two point types.
- The size of points should be different, as the types are expected to be manufactured in discrete production systems, as suggested by Flood (1970), and Allen and Barton (1989) who advanced the typological model in the NT.
- The order and placement of retouch should reveal different retouch strategies for unifacial and bifacial points, respectively. Flenniken and White (1985:148) suggested that bifacial points would follow a dorsal last retouch order, based on replicative experiments.
- The blanks selected for point reduction are expected to be morphologically different, reflecting this design aspect of bifacial thinning.
- Different raw materials may be selected for the different types (see Schrire 1982).

We acknowledge that some of the unretouched flakes excluded from our tests of point typology could perhaps have been used for similar functions as the retouched points discussed here. Brindley and Clarkson (2016), for example, recently included pointed flakes lacking retouch in their study of NT point assemblages. Given that we are interested primarily in retouch intensity variation and how this relates to the proposed artefact types in the Kimberley, unretouched artefacts are not appropriate to this aim. Furthermore, the focus on retouched flakes allows us to explore the progressive modification of these tools.

Results

The stone artefact assemblage recovered from the two excavation squares is enormous ($n = 54{,}294$). Table 3 provides a summary of technological classes, including unifacial and bifacial points, and the total number of artefacts per excavated unit (3 mm and 1.5 mm sieve fraction). Here we present a summary of observed trends from a sample of the total assemblage, to provide context for the analyses of the stone points. This sample includes all artefacts from Square 2, quadrant A ($n = 4{,}457$), representing 8.2% of the assemblage.

This sample reveals that raw material exploitation was focused on the locally available, high-quality crystal quartz (94.1%). There was only occasional exploitation of the locally abundant quartzite (2.1%), or more exotic siliceous materials like chert (1.5%), jasper (0.1%), and chalcedony (0.2%). Notably, white vein quartz is abundant but this material was rarely exploited (0.5%).

Stone points

The analysed sample of stone points includes 109 complete points and 28 point fragments. Both unifacial and bifacial points are present throughout the deposit (Tables 2 and 3). A single pressure flaked Kimberley point was found (reported in Maloney et al. 2014:138); all other stone points are reduced from flakes, not cores/bifaces, as identified by remnant ventral surfaces. Points constitute a small component of the overall Mt Behn stone artefact assemblage (1.6%), but this is not unusual in Australia. Points generally make up very small components of assemblages across northern Australia (Clarkson 2007:66–77, App B–E; Hiscock 2011:76; O'Connor 1999:64–65, Table 5.8), and the low percentage within Mt Behn probably reflects the fact that our total number of artefacts includes those recovered from the 1.5 mm sieve fraction which are often not reported in early studies.

All the expectations of the typological model for point reduction were shown to be false. There is overlap between unifacial and bifacial points in both morphology and retouch intensity. There is no significant difference in point retouch intensity between non-crystal quartz points ($n = 35$) and the dominant material ($U = 1075$, $p = .614$), suggesting that retouch intensity was not influenced by raw material. There is no significant difference in retouch intensity between unifacial and bifacial points ($\chi = 1.642$, df $= 1$, $p = .200$), and no difference in size, using either length (ANOVA $F = 1.753$, df $= 1$, $p = .188$), width (ANOVA $F = 1.665$, df $= 1$, $p = .200$), or mass (ANOVA $F = 2.917$, df $= 1$, $p = .090$). The overlap of unifacial and bifacial points relative to the marginal spread of retouch is depicted in Figure 5. The spread of retouch around the perimeter of points relative to scar invasiveness is significant (ANOVA $F = 10.715$, df $= 25$, $p = .001$). This indicates that the more margins were retouched, the more invasive retouch scars became, rather than simply becoming invasive early in the reduction sequence, as would be expected if bifacial points were consistently reduced from blanks. In fact, bifacial retouch often occurs very early in the reduction sequence and is not exclusively associated with heavily reduced points at all. Collectively, these tests indicate that while there are multiple reduction pathways for individual points, neither artefact group exhibits any real difference in the extent of retouching.

Following Clarkson (2006:102), lineal platform measurements of points were used as a proxy for blank morphology, which facilitates a comparative test between the alleged types (due to the translucency of crystal quartz 3-D laser scanning was not feasible for these measurements). No statistically significant difference was found between unifacial and bifacial points in either platform width ($W = 0.993$, $p = .885$; $F = 1.131$, $p = .336$) or thickness ($W = 0.986$, $p = .339$; $F = 1.335$, $p = .176$) suggesting that all the Mt Behn points began modification from approximately the same blank morphology. To expand on this, the analysed sample of flakes from Square 2 quadrant A was used as a comparative measure of potential point blanks. Figure 6 shows that points with intact or remnant platform surfaces cluster between platform widths of 10 mm and 25 mm and platform thickness values of 5 mm and 12 mm, despite most flakes from this sample being smaller than 10 mm in either dimension. These data suggest that point blanks are selected from the larger flakes within the sample, which morphologically resemble the 'lancet' described by Clarkson (2007), or the macro blades described by Moore (2015). Overall, these data show that there is no difference in blank selection for unifacial and bifacial points.

Order of retouch is observable on 115 points, 109 of which are complete points, and a further six have minor distal breaks that allow reliable identification of retouch order. Table 4 shows these observations, divided into quarters of the Index of Invasiveness. These trends are shown in Figure 7, using percentages within the same divisions. The data reveal that there is no discrete retouch order for bifacial points. Most of the discarded points have retouch across one margin only, typically the right dorsal. Even in these lightly modified points retouch scars tend to be superimposed rather than scalar. It appears that

Table 3. Stone artefact classes for squares 1 and 2 of Mt Behn.

Technological Class	XU	Total Artefacts	Bifacial Points	Unifacial Points	Kimberley Point	Backed Points	Point Fragments	Adze Tula	Ground-edge Adze	Ground-edge Axe	Grindstone Fragment	Edge Ground Flakes
Square 1	**1**	2,060	2	1			1	1				1
	2	1,661	2	1			1				3	
	3	1,519		1	1		1					
	4	1,085	2									
	5	1,058		1			1					
	6	1,404	2	2		2						
	7	1,543		3		2	2					
	8	2,036		1		1	1					
	9	1,718		4			2					
	10	1,433	1	3		1	1					
	11	1,293	1	3			1					
	12	511		1								
	13	153										
	14	96										
	15	76										
	16	31										
	17	31										
	18	31										
	19	4										
	Total	**17,743**	**10**	**21**	**1**	**6**	**11**	**1**	**0**	**0**	**3**	**1**
Square 2	**1**	2,927		7							1	5
	2	1,936		3		1	2	1				1
	3	2,263		3							1	3
	4	2,784	1	1			1					1
	5	2,616	3	3							1	
	6	2,435	1	8			2			1		
	7	2,943	3	4			1				1	
	8	2,754	2	6			3					
	9	3,369	2	6			4					1
	10	3,120	1	4		1	3		1			
	11	2,751		3			1					
	12	2,065		1								
	13	1,755		3		1						
	14	2,146		3								
	15	403										
	16	194										
	17	38										
	18	45										
	19	3										
	20	3										
	21	1										
	Total	**36,551**	**13**	**55**	**0**	**3**	**17**	**1**	**1**	**1**	**4**	**11**

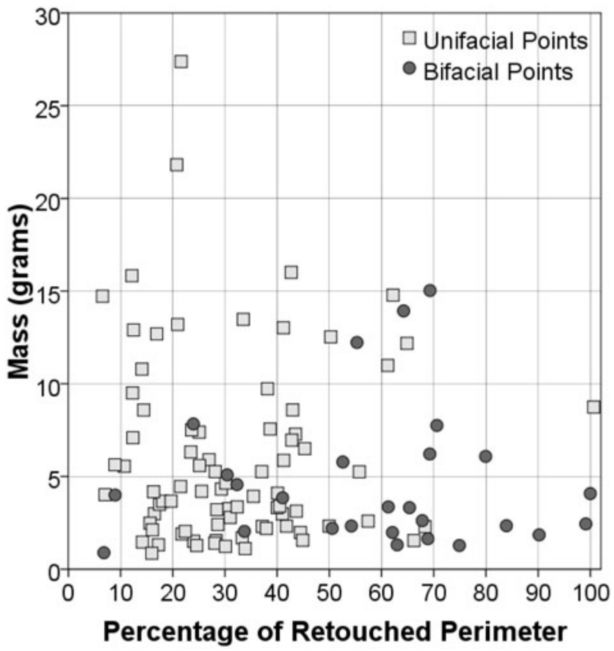

Figure 5. Mass against the percentage of retouched perimeter on complete points, showing overlap in retouch intensity between unifacial and bifacial points.

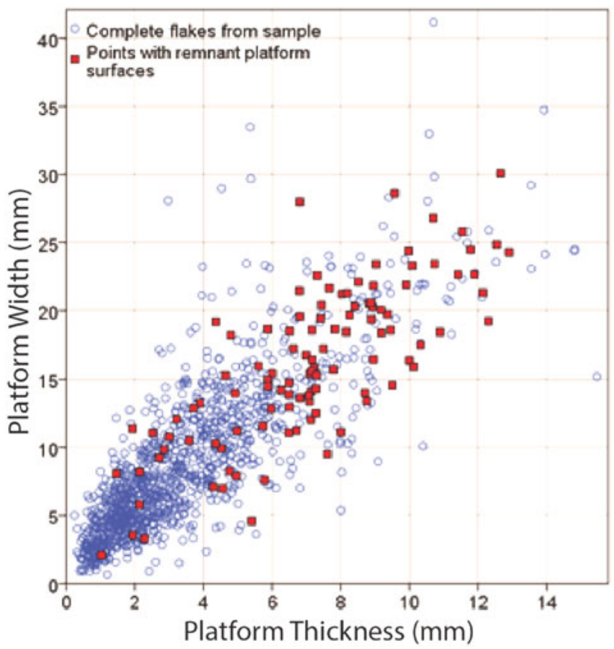

Figure 6. Overlay of platform width and thickness for points with remnant platform surfaces and all complete flakes.

most unifacial and bifacial points were initially retouched in this way, and if reduction continued, bifacial points could potentially have followed multiple reduction pathways (contra Flenniken and White 1985:148). For example, five complete bifacial points with Index of Invasiveness values between 0.5 and 0.75 exhibit ventral last retouch and four display dorsal last retouch, although retouch was restricted to the margins. Of the eight cases representing the highest intensities of reduction, three exhibit ventral last retouch, two show dorsal last retouch, and three

Table 4. The sequential order of retouch on points, divided into quarters of the Index of Invasiveness.

	0–0.25		0.25–0.5		0.5–0.75		0.75–1		Total	
Point Retouch Order	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Dorsal only	66	86.5	12	52	0	0	0	0	78	100
Ventral last	5	7	3	13	5	50	3	37.5	16	100
Ventral only	2	3	2	9	0	0	0	0	4	100
Dorsal last	1	1.5	2	9	4	40	2	25	9	100
Ambiguous bifacial	1	1.5	2	4	1	10	3	37.5	8	100
Total	75	100	22	100	10	100	8	100	115	100

had bifacial retouch continued to such an extent that recognition of the retouch order was impossible. Also of note is that many bifacial points, particularly those with Index of Invasiveness values around 0.5, exhibit a dominance of retouch on a single surface, with the initial stages of bifacial retouch emerging on a second. This suggests that some unifacial points were reduced bifacially, at a stage of artefact life history when they would have most resembled the unifacial point typology. The order and placement of retouch not only reveals overlap between the types, but suggests retouch was gradual and focused on maintenance.

While the unifacial and bifacial points from Mt Behn appear to be part of a reduction continuum, there is evidence of specialised design in backed points. Nine backed points were identified, with average retouched edge angles between 82 and 90 degrees along one steeply retouched margin with bidirectional crushing. Reduction indices indicate that backed points were only lightly modified with this form of retouch before discard. The backed points were selected from the same pool of blanks as the other points, but were exclusively retouched by anvil rested backing and not transformed or recycled into other morphologies, supporting the results of an earlier study (Maloney and O'Connor 2014). While the function of these implements is unknown, their unique morphology and production suggests specialised tools were manufactured.

Recycling of points did occur following transverse snaps, where multiple burinate flakes were initiated from the fractured surface ($n = 4$), radically transforming the implement into a new morphology. This transformation also presumably suited a different task, involving either the production of small sharp burinate flakes, or the curved negative initiation surface of the burinate scars.

Whether any of the stone points were hafted is unclear. Resin was not detected on any of the points, or flakes and flake fragments from the quadrant A sample. Other indications of hafted projectile use, in the form of diagnostic impact fractures (following Brindley and Clarkson 2016:84–85), are infrequent. For example, two points have probable impact burination, one point has a bending initiated

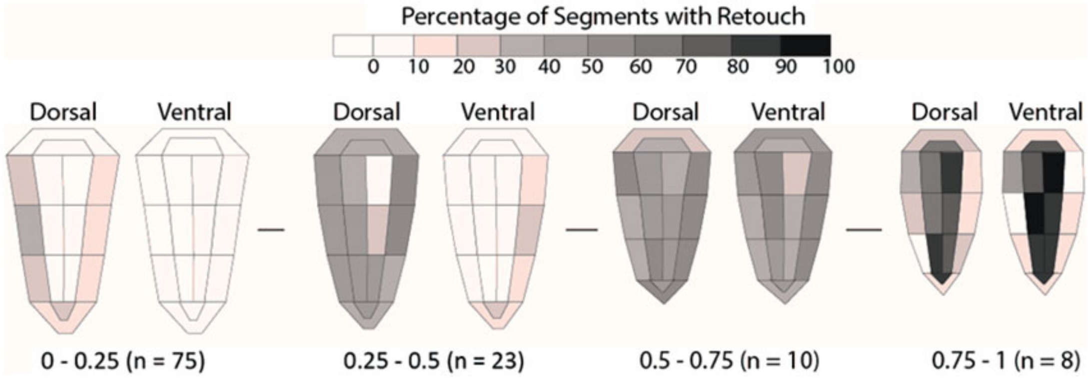

Figure 7. The distribution of retouch scars across both surfaces of points, relative to the 16 segments of the Index of Invasiveness, and divided into quartile values of this index.

step fracture, and another a unifacial spin-off scar. This low frequency of diagnostic impact fractures ($n = 4$, 3%) is not surprising, given the recent study on a much larger point assemblage from the NT ($n = 1{,}157$), which concluded that evidence of projectile use was infrequent (Brindley and Clarkson 2016). In support of this, proximal thinning, where retouch is thought to thin the proximal area of points to suit hafting mechanisms, is also rare ($n = 6$). It is likely that points were multipurpose implements, employed in many different tasks, which goes some way to explaining the regular maintenance of margins throughout life history and the recycling of broken points.

In summary, the outlined hypotheses for the typological model, which holds unifacial and bifacial points to be discontinuous tools, were demonstrated to be false. A point reduction continuum is evident in the Mt Behn assemblage. Most points began modification as unifacial points with retouch across one margin. If not discarded, those points that were continually retouched could potentially have followed multiple reduction pathways within this continuum. The fact that all retouch scars are superimposed throughout the sequence rather than scalar suggests that resharpening and maintenance rather than design was the focus of point reduction.

Discussion and conclusion

An underlying reduction continuum for unifacial and bifacial points during the mid to late Holocene now appears common to northern Australia, and regional patterns are emerging. For example, in the Wardaman assemblages (Figure 1), Clarkson (2007) found that points typically begin being retouched on the dorsal face first, with an initial focus on the distal right margin (2007:104, 109), similar to those at Mt Behn. As retouch intensity increases, the distribution of retouch is increasingly likely to become bifacial, with the first stages of bifacial retouch typically added to the proximal portions of points (2007:104, 109). This pattern is not dissimilar to that demonstrated in the Jimede 2 and Lawn Hill assemblages by Hiscock (1994a:77–80, 2006, 2009:84, 2011:78). Proximal thinning of the Jimede 2 points was not found to relate to increasing retouch intensity, or the curvature of the proximal portion (or butt) (Hiscock 2009:77). Two honours theses on NT surface sites also revealed a point reduction continuum (Maloney 2010:91–97; Roddam 1997), and additionally found that patterns in proximal thinning resemble the Wardaman point assemblages, where proximal thinning was typically practised late in the reduction sequence.

Regional differences in point life histories include methods of recycling, where broken implements are either rejuvenated or transformed into a different morphology. In the Wardaman sites, recycling took the form of burinate retouch following transverse snaps. Instances of burinate recycling following transverse snaps were also reported by Dortch and Zlatnik (nd:44) from Miriwun rockshelter in the east Kimberley. Points from Jimede 2 in west Arnhem Land were heavily reduced into small ovoid bifaces that totally lack the pointed shape (Hiscock 2009:84–85, Figure 6.3). On current evidence, it appears that these heavily reduced bifacial forms are restricted to Arnhem Land and as far west as Frances Creek (Maloney 2010), but absent in Wardaman and Kimberley sites, where other forms of recycling were practised (Figure 1).

Owing to the pointed distal end and elongation of many stone points, as well as historical and anthropological observation, researchers in Australia have largely assumed that points were primarily manufactured to be hafted projectiles (Allen and Akerman 2015; Banning 2002:155; Davidson 1935:150; Holdaway and Stern 2004:266; Kamminga 1982:81; McCarthy 1967:40; Mulvaney and Kamminga 1999:237). An alternative interpretation sees points as adaptable, multifunctional tools including, but not limited to, hafted projectiles (Hiscock 1994a:78, 1994b:277–278, 286, 2006:78).

The only residue analysis so far conducted is from the west Kimberley sites of Widgingarri 1 and 2 where plant materials were the dominant residues identified (Wallis and O'Connor 1998). Recent experimental work into diagnostic impact fractures also supports their multifunctional use (Brindley and Clarkson 2016). The multipurpose nature of point technology is supported by the morphological diversity, emphasis on maintenance, and low frequency of diagnostic impact fractures found in the Mt Behn assemblage.

In terms of technological organization, the Mt Behn point assemblage can be seen as part of an overall strategy, which emphasises extendibility and adaptability. The ability to continually reduce these tools facilitates extensive resharpening, minimizing the need for frequent replacement. The transformation of points throughout their life, also indicates the capacity for these tools to be changed to achieve multifunctional demands. Following Nelson's (1991:70) definition, points were both multifunctional and highly flexible. This would allow a small number of highly extendible and adaptable tools to be carried, and in circumstances where suitable raw material was unavailable, a tool would be at hand.

Currently within Australia there are two main models that seek to explain the technological change associated with the inception and proliferation of point technology: the risk reduction model, and the social-signalling model. The risk reduction model proposes that environmental change, particularly periods of aridity in the mid to late Holocene, would have increased foraging risk for Indigenous people. This risk is the probability and severity of failure to gain resources (Bamforth and Bleed 1997:112–113; Torrence 1989:59). Hiscock (1994b) argued that, with deteriorating climate in the mid-Holocene, people became increasingly mobile in response to less productive and predictable environments. Moreover, if environmental change made the distribution of resources such as fresh water, edible plant species, and game less predictable, people would increase their territorial range (Kuhn 2012:76). Australia's stone points are argued to have reduced foraging risk, by providing an adaptable, standardized technology, which was highly maintainable (Clarkson 2006, 2007, 2008; Hiscock 2006, 2009, 2011).

Researchers proposing the risk model, have used records of El Nino-Southern Oscillation [ENSO] strength to model probable changes in ecological resources with the transition from a tropical humid climate with intense predictable rainfall in the early Holocene, to a much drier climate where the summer monsoon was either absent or intermittent beginning in the mid-Holocene (Clarkson 2006, 2007, 2008; Clarkson and Wallis 2003; Hiscock 1994a, 1994b, 2006; Veth 1995, 2005; Veth et al. 2011; Williams et al. 2010). Although there is intra-regional variation, proxy records generally indicate intensified ENSO beginning around 5,500 years ago, or slightly later, followed by increasing aridity and rainfall periodicity and a phase of extreme aridity between about 2,400 and 1,200 BP (Conroy et al. 2008; Denniston et al. 2013; Donders et al. 2007, 2008; Gagan et al. 2004; McGowan et al. 2012; Moy et al. 2002; Rein et al. 2005; Rodbell et al. 1999; Schulmeister 1999). Points first appear in southern Kimberley sites about 5,500 years ago, and, even allowing for the poor temporal resolution at Mt Behn, most points were discarded within the envelope of increasing aridity, between 3815–3575 cal. BP (ANU-33031) and 1835–1710 cal. BP (ANU-46907).

Elsewhere in the world, population increase has been linked to technological innovations and their widespread adoption (Dennell 2009:433–437; Henrich 2004:209; Kuhn 2012:74–76; Lycett and Norton 2010; Powell et al. 2009; Shennan 2001:15; Shennan et al. 2013). Moore (2011) has suggested that population increase during the mid- to late Holocene in Australia was a major driver of technological change. This model proposes that in response to the increased social interaction accompanying population increase, cultural groups developed more elaborate information systems which included points, allowing them to signal and demarcate individual and group identity (Moore 2011:145, 2015; see also White 2011:68–69 for similar arguments regarding backed artefacts). Although there is evidence that populations in Australia increased significantly during the Holocene (Williams et al. 2010, 2015; see Attenbrow and Hiscock 2015 for a counter view), the inability to explain how points could have been used for social signalling when this and earlier studies indicate that point technology was similar across the north of the continent raises issues for this model. It also seems plausible that as standardised implements were typically made on high-quality materials, and were used by many groups across northern Australia, points probably served as trade items during periods of increased intergroup contact.

Social drivers of technological change do not necessarily preclude risk reduction strategies, or vice versa, as pointed out by Kuhn (2011:70, 2012:76) and Hiscock (2006:86), and it is probable that a complex interplay of factors allowed populations to continue to grow and flourish in mid to late Holocene Australia even in the face of deteriorating climate. Researchers are now beginning to explore multiple, rather than exclusive, drivers of change (Hiscock and Maloney 2017), which is bound to reflect better the changes in technology, ecology, and society across the north of Australia during the mid-Holocene.

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