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Retouched, rejuvenated, recycled and occasionally hafted as projectiles: stone points of Holocene Australia

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ABSTRACT

Macroscopic evidence for projectile use of stone points across the Kimberley region of northern Australia is examined using archaeological assemblages from the mid to late Holocene. There is scant evidence to support more than occasional projectile use. High rates of rejuvenation, recycling and continuous resharpening contribute to the low frequency of impact damage. The extent and location of edge damage, interpreted as probable use-wear, is demonstrated to have distribution patterns consistent with multipurpose functions. Projectile use was merely one, albeit infrequent function of these versatile tools. This study uses use-wear data to engage with technological organisation theory and discusses rates of use, resharpening, rejuvenation and recycling. Standardisation and an emphasis on maintainability provide the best explanation as to why people produced these tools during the Holocene.

Keywords: lithic, use-wear, projectile, Holocene, Australian

RESUME

Les preuves macroscopiques de l'utilisation de pointes de pierre à l'aide de projectiles dans la région de Kimberley, dans le nord de l'Australie, ont été examinées à l'aide d'ensembles archéologiques datant de l'Holocène moyen à tardif. Il existe peu de preuves pour appuyer davantage que l'utilisation occasionnelle de projectiles. Les taux élevés de rajeunissement, de recyclage et de réaffûtage continu contribuent à la faible fréquence des dommages par impact. L'étendue et l'emplacement des dommages sur les bords, interprétés comme une usure probable, présentent des schémas de distribution compatibles avec les fonctions polyvalentes. L'utilisation de projectiles n'était qu'une des fonctions, même si elles étaient peu fréquentes, de ces outils polyvalents. Cette étude utilise des données d'usure pour porter sur la théorie de l'organisation technologique et pour discuter des taux d'utilisation, de réaffûtage, de rajeunissement et de recyclage. La normalisation et l'accent mis sur la maintenabilité fournissent la meilleure explication sur la raison pour laquelle les gens ont fabriqué ces outils pendant l'Holocène.

Mots-clés: lithique, tracéologie, projectile, Holocene, Australien

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INTRODUCTION

Archaeologists most often interpret flaked stone tools as adaptive problem-solving strategies, engaging with technological organisation theory to understand rates of use and resharpening. Technological organisation theory refers to the structuring of technology around subsistence and settlement patterns (e.g. Bamforth 1986; Bamforth & Bleed 1997; Kuhn 1994). In many parts of the world, popular themes inferred by Palaeolithic archaeologists include time, energy and foraging risk (Torrence 1983, 1989). Quantifying rates of tool use and resharpening is critical to these concepts and form a significant corpus of studies from outside Oceania (e.g. Andrefsky 2008; Lombard & Pargeter 2008; Rots 2013; Rots *et al.* 2017;Schoville 2010; Young & Bamforth 1990). Discussion of technological organisation within Australian archaeology has had a significant focus on risk minimisation and stone points from Holocene northern Australia (e.g. Hiscock 1994a; White 2011). A continuing enigma surrounding these Holocene tools is their performance, if any, as hafted projectiles.

Points are recognised by converging retouched margins (Figure 1), both unifacial and bifacial. Convergent flakes, which approximate the morphology of point blanks with unretouched converging margins (Figure 1a), are also recognised as points (following Brindley & Clarkson 2015: 82). Direct percussion stone points were first produced

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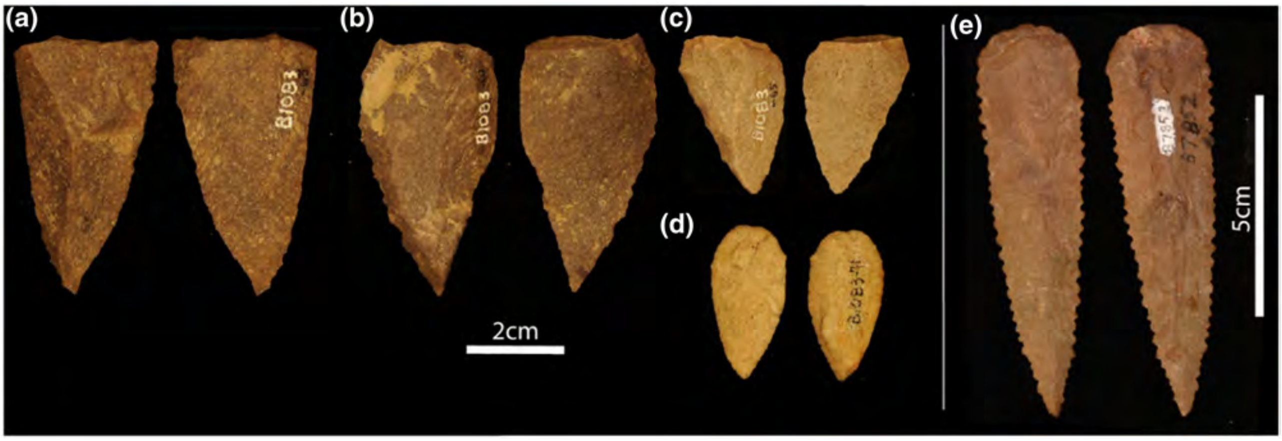
Figure 1. Points and convergent flakes from the study area: (a) convergent flake (b) unifacial point with marginal retouch, (c) unifacial point with invasive retouch, (d) bifacial point with invasive retouch and (e) pressure-flaked biface or Kimberley Point.



across northern Australia between 7000 and 5000 BP (Hiscock & Maloney 2017). Point production increases between 4000 and 1500 calBP, before in some areas changing or declining within the last millennium (Allen & Akerman 2015: 90; Clarkson 2007; Maloney 2019). Pressure flaked bifaces (Kimberley Points) (Figure 1e), first widely occur around 1000 calBP (Maloney *et al.* 2014) and are recognised by distinctive pressure flaking and marginal projections (Akerman & Bindon 1995).

The Holocene is well known for significant environmental change. Archaeologists have produced explanatory models which posit technological and social responses to increased foraging risk, brought on by environmental changes to subsistence resources. This theory and modelling have a global focus for stone tool analyses, and results of this study provide global relevance to risk minimisation discussion, which rarely incorporates use-wear methods (Brindley & Clarkson 2015; Fuentes *et al.* 2019: 11–12; Robertson *et al.* 2009). North American studies, where hafted bifaces were used both as projectile points and as knives (Ahler 1971; Kay 1996; Truncer 1990), can help inform on the technological organisation and systemic use of Australian points. Summaries of Holocene archaeology in Australia, with particular reference to stone tools and inference of technological organisation, can be found in White (2011), Clarkson (2007), and Hiscock (2008: 154–61).

Multi-functionality and projectile use has been central to archaeological explanations of the development of point technology in Australia. Their systemic use, however, remains unclear, due to a scarcity of use-wear analyses. Potential hafted stone projectiles are here synonymous with range weaponry, thrown by hand or with spear-throwers similar to those from recent times (Akerman & Bindon 1995). It is possible that thrusting or jabbing tools could have been used (Milks et al. 2016). This study examines the role of stone points as projectiles and multi-functional tools during the mid to late Holocene.

Technological organization and Australian points

Unifacial and bifacial points have been demonstrated to be part of a reduction continuum, where increasing retouch intensity transformed point morphology. This is the consensus from all recent studies of excavated point assemblages, including Mt. Behn (Maloney 2015; Maloney *et al.* 2017a), Garnawala, Nimji, Gordolya, Jagoliya (Clarkson 2006, 2007), Jimede 2, and Lawn Hill (Hiscock 1994b: 79–82, 2009); as well as surface scatter studies (Maloney 2010; Roddam 1997); see Figure 2. Points recovered from mid to late Holocene contexts in Wardaman Country (Victoria River district, Northern Territory) rarely preserve evidence of projectile use, yet between 50% and 60% had marginal use-wear (Brindley & Clarkson 2015: 89). All of these studies argue points were multi-purpose, highly maintainable, standardised technologies; which contributed to a technological response to minimise foraging risk. It is unclear what role projectile use plays in the risk minimisation model. The rates of use, including projectile, are not well known, nor are ratios of use to retooling and resharpening.

The nature of hafting arrangements for points in the mid to late Holocene also remains elusive. The sporadic recovery and poor preservation of organic hafting technology, in the form of binding agents or shafts, has led archaeologists to extrapolate hafting arrangements from tool morphology, experimentation and ethnographic analogy. These extrapolations have also encouraged an assumption that points, as the name suggests, were undoubtedly spearheads (Holdaway & Stern 2004: 266; Mulvaney & Kamminga 1999: 237). Even models which demonstrate morphological diversity of Australian points retain varied emphases on the effectiveness of points as projectile tips (Clarkson 2006: 104; Hiscock 1994b: 278, 2009: 84–85; Maloney 2015: 264). Similar assumptions surround discussion of point assemblages elsewhere in the world (Iovita & Sano 2016), despite a scarcity of use-wear studies.

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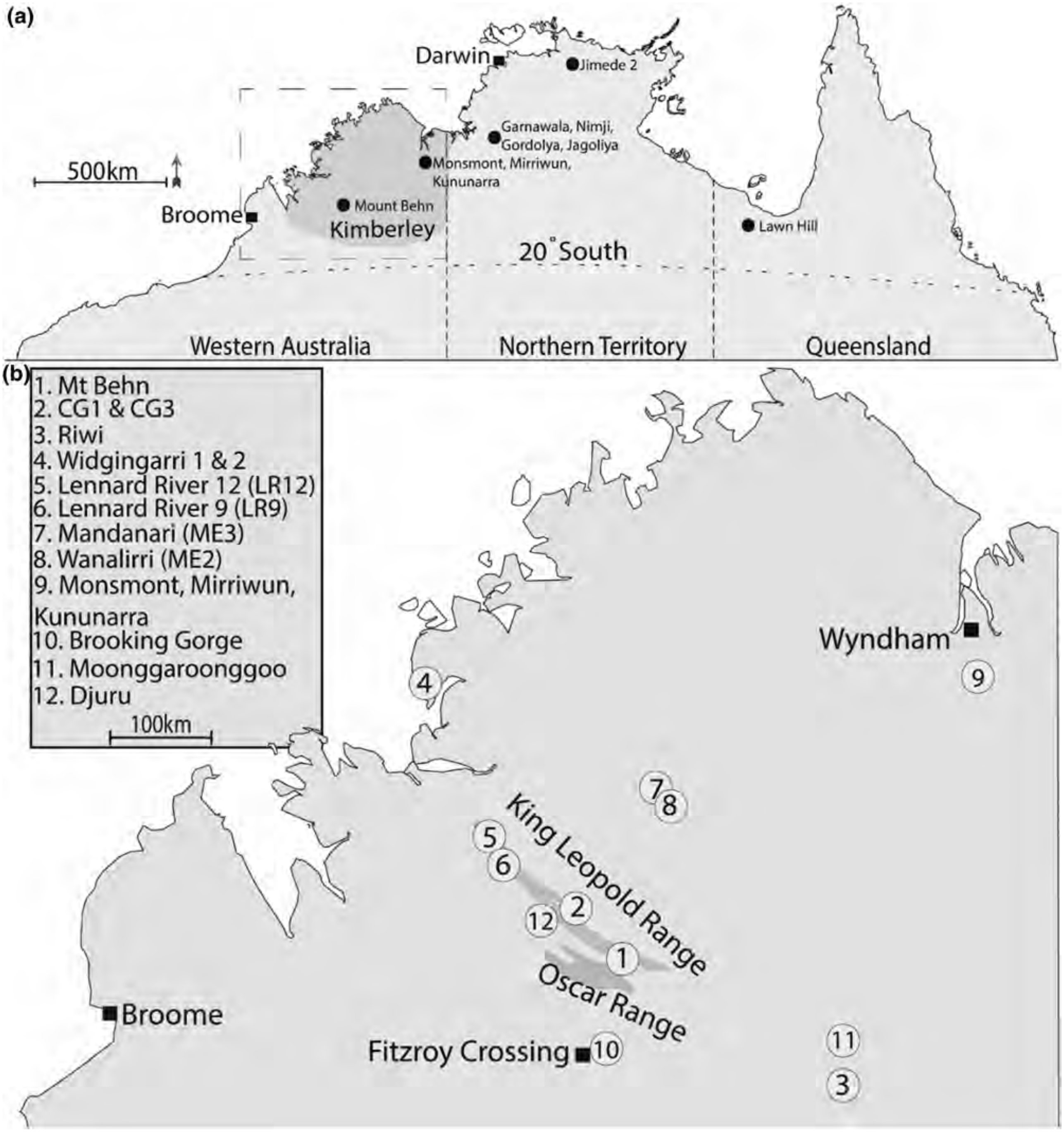
Figure 2. (a) Northern Australia. Bifacial points are generally found north of 20° latitude. (b) Location of Kimberley sites analysed in this study.



In the Kimberley, more recent forms of hafting are better informed with ethnographic observation, museum collection and the memories and stories of Indigenous people (Akerman 1978: 486; Akerman *et al.* 2002: 21-22; Blundell 1975; Newman & Moore 2013: 2614). Haftings of these more recent points are dissimilar to the single recovered mid to late Holocene find of a hafted point fragment (Maloney *et al.* 2015). Consequently, the implications drawn from recent spear types (Allen & Akerman 2015) are avoided here, to focus on archaeological data only. The single residue analysis conducted on a mid to late Holocene point assemblage from Australia, comes from Widgingarri 1 and 2, in the western coastal Kimberley (Wallis & O'Connor 1998). Akerman *et al.*'s (2002) residue study of pressure flaked bifaces is from predominantly historical collections. The critical limitation on all these studies is poor organic preservation.

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SAMPLES

Excavations in the Kimberley region seldom recover more than 20 retouched points, and typically represent between 0.1 and 10% of assemblages (Maloney 2015: 18). This study analysed two groups of samples. The first is from excavated rock shelter deposits. Sites with points include Mount Behn ($n = 137$), Riwi ($n = 9$), Widgingarri 1 and 2 ($n = 42$), Carpenters Gap 3 ($n = 9$), Carpenters Gap 1 ($n = 2$), Djuru ($n = 3$), Brooking Gorge ($n = 1$), and Moonggaroonggoo ($n = 14$) – see Figure 2 (Balme *et al.* 2019; Maloney *et al.* 2015, 2016, 2017a, 2017b, 2018a, 2018b ; O'Connor 1999; O'Connor *et al.* 2014). These studies provide the background to specific sites, each of which are limestone rock shelters in the semi-arid to arid areas of the Kimberley, within Bunuba and Gooniyandi country. In total, the excavated sample includes 217 direct percussion points and 710 convergent flakes from the mid to late Holocene.

The second set of samples is surface collections from two PhD theses: Blundell (1975) and Maloney (2015). Sites include Lennard River 12 (LR12), Lennard River 9 (LR9), Mandanari (ME3), Wanalirri (ME2) (Blundell 1975: 197–98, 218–36), and Mount Behn surfaces 1, 2 and 4 combined as a single sample (Maloney 2015: 338). Each of these surface collections is located within rock shelters, expect the Mount Behn surfaces, located on the approach to a rock shelter. No radiocarbon dating is available for any of the surface collections, although a consistent association of glass and metal artefacts, as well as Kimberley Points, hints at a more recent phase. Supp. File A section 1 describes each surface sites' collection and lists technological classes. In total, the study includes 1536 points and convergent flakes.

METHODS

This study recorded use-wear observable with low magnification (following Lee & Sano 2019; Schoville 2010), using 20× and 50× magnification. Supp. File A section 2 lists and illustrates all measurements and observations.

Diagnostic impact fractures

When hafted stone projectiles contact hard material, such as bone, stone, or wood; they can form diagnostic impact fractures (DIF). There has been extensive review and experimental verification of impact fractures (e.g. Dockall 1997; Iovita *et al.* 2014; Iovita & Sano 2016; Lombard *et al.* 2004; Lombard & Pargeter 2008; Pargeter 2011). Between 40% and 60% of points used against animal targets produce DIFs in experimental studies (e.g. Iovita *et al.* 2014; Lombard *et al.* 2004; Rots *et al.* 2017). These studies reveal complexities in DIF recognition and show that taphonomic processes can also produce similar fractures from other loading forces, particularly spin-off fractures. Accordingly, my results present unifacial and bifacial spin-off fractures where identified, as well as discussing frequencies with these observations excluded. Experimental studies also imply that actual projectile numbers could be around double that of observed DIF. Modes of hafting as well as projectile delivery mode may also affect projectile damage.

The Australian experimental and archaeological work by Brindley and Clarkson (2015: 84–85) and Brindley (2011: 22–32) is the most relevant to this study. Their work replicated points from northern Australian mid to late Holocene sites, which share many features and raw materials with the point reduction sequences found in this study's assemblages (Maloney 2015: 196–235). They found that points from rock shelter contexts in Wardaman Country rarely exhibit impact damage and suggested multifunctionality as the best explanation of the observed use-wear. Their study recognised DIF as fractures initiated from the distal portion of points, as unifacial and bifacial spin-off fractures; bending initiated scars with a step or hinge termination, or single burin scars (Brindley & Clarkson 2015: 84–85). These definitions and protocols are followed in this study. While researchers have suggested different scar size cut-offs for DIF (Fischer *et al.* 1984; Lombard 2005), this study follows Brindley and Clarkson (2015: 84) in using 6 mm.

It is also apparent that DIF recognition is prone to interobserver error and confusion with taphonomic forces (Brindley & Clarkson 2015: 84; Lombard & Pargeter 2008; Pargeter 2011; Rots & Plisson 2014). DIF are initiated from the distal tip of a point. DIF scars are analogous in shape and initiation to adjacent retouch scars, but these are exclusively initiated from the margins. DIF frequencies without raw material-specific empirical data, such as presented in this study, are best taken as indicators of probable projectile damage.

Macroscopic edge damage as use-wear

Inferring use from marginal edge damage, which includes pronounced edge rounding, chattering, notching and polish, has also had multiple experimental and archaeological studies (Bird *et al.* 2007; Rots *et al.* 2006; Shea 1992; Wadley *et al.* 2004; Wurz 2000; Young & Bamforth 1990). Due to the variability in these results, this study follows the approach of Schoville (2010: 380) in not attributing causation to individual occurrences of edge damage. This approach is best achieved in combination with residue analysis (e.g. Fuentes *et al.* 2019). The isolated occurrence of edge damage observations as well as their "freshness" is taken as diminishing the possibility of taphonomic causes, where rounding would be irregularly distributed (Kononenko *et al.* 2015: 259; Vaughan 1985: 23–25).

Edge damage location is quantified on tool margins using a systematic grid. Supp. File A section 2 illustrates and defines each edge damage variable and the grid system. One problem with this grid method is that point margins are not proportionately even – most points are "leaf" shaped (see Figure 1). The proximal margins of each point contain more millimetres of edge than the medial margins, for

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Table 1. Frequency of DIF for points and convergent flakes from excavated sites.

Site	Points	Convergent flakes	Unifacial spin-off	Bifacial spin-off	Single burin scar	Bending initiated	% points with DIF	Percentage points/convergent flakes with DIF
CG1	2	224			2		0	0.8
CG3	9	76			3	2	33.3	5.8
Djuru	3	211			1		33.3	0.5
Riwi	9	141			1		0	0.7
Mount Behn	137	58	2	1		1	2.9	2
Widgingarri 1 and 2	42	0					0	0
Brooking Gorge	1	0					0	0
Moonggaroonggoo	14	0					0	0

Table 2. Edge damage distribution across point surfaces.

	Dorsal				**Ventral**				
Points with edge damage	**Proximal**	**Left medial**	**Right medial**	**Distal**	**Proximal**	**Left medial**	**Right medial**	**Distal**	**Hafting residues/polish**
CG1 (*n* = 2)		1	1	2		1	1	1	1
CG3 (*n* = 6)	1	4	4	2	1			1	
Djuru (*n* = 1)	1				1		1	1	1
Mount Behn (*n* = 9)	1	3	2	3		2	3	2	
Widgingarri (*n* = 28)	4	7	10	5	1	1	1		2
Riwi (*n* = 1)					1	1	1		1

example. Consequently, the total perimeter length of each point was calculated by summing lineal measures taken with callipers (Supp File A section 2 Figure 6), and distributions of edge damage also compared with this value.

Shape indices

Point morphology is quantified to examine relationships with use. The measurements and indices of shape developed by Clarkson (2006: 99–103, 2007: 101–11) are followed (see Supp. file A section 2). The index of invasiveness (Clarkson 2002) is used to quantify retouch intensity. Australian points lack tanged (Lee & Sano 2019) or notched (Andrefsky 2005: 37) proximal associated with hafting. Bifacial retouch could be used to thin the proximal end. The presence and extent of proximal thinning, including relative proximal thickness, as well as the proximal curvature index (Supp. File A section 2) was recorded.

RESULTS

The frequency of DIF, observations of recycling, fragmentation, distribution of edge damage, hafting residues and morphological results are now presented for the excavated samples, followed by the surface samples. Supp. Files B and C include all data used in this study.

Excavated sites

Each of the excavated samples' lithic assemblages have been published elsewhere, including all associated radiocarbon dates (Balme *et al.* 2019; Maloney *et al.* 2017a, 2017b, 2018a, 2018a; O'Connor 1999; O'Connor *et al.* 2014), which associate all direction percussion points within the mid to late Holocene (Maloney *et al.* 2014).

Tables 1–3 summarize DIF, edge damage, hafting residue observations and rejuvenation rates. Supp. File A section 3, Tables 4 and 5 lists all point fragments recovered.

Table 3. Rates of recycling and rejuvenation of points from excavated sites.

Site	Broken points	Rejuvenated points	Use-wear over DIF	Recycled points: burin cores	Percentage points rejuvenated or reused
CG1	1			1	0
CG3	1		1		11.1
Djuru				1	3.3
Riwi	4			1	11.1
Mount Behn	20	1	1	4	3.6
Widgingarri	25	1			2.4

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Table 4. Frequency of DIF on the surface sample assemblages.

Site	Points	Convergent flakes	Unifacial spin-off	Bifacial spin-off	Single burin	Bending initiated	Percentage points with DIF	Percentage points/ convergent flakes with DIF
LR9	110	13	3		6	3	10.9	10
LR12	89	58	1			2	3	4
Mount Behn surfaces	27	13				1	4	2.5
ME3 Mandanari	27	16	3	1	4	5	48	30
ME2 Wanalirri	39	24					0	0

The points recovered from both Brooking Gorge ($n = 1$) (Maloney *et al.* 2018b), and Moonggaroonggoo ($n = 14$) (Maloney *et al.* 2017b) did not retain DIF.

The CG1 excavation (Maloney *et al.* 2018a) recovered a single exemplary example of a hafted crystal quartz point (Figure 3a), directly dated to 3160–2954 calBP (SANU-39039). This artefact is a distal point fragment with adhering resin and edge damage scars on the left distal margin (see Maloney *et al.* 2015). Another point recovered from this site, which displays no DIF, has pronounced edge rounding along medial and distal margins, as well as proximal retouch (Figure 3b). Of the convergent flakes ($n = 224$) from the Holocene units of CG1 [Square A2 phase 6: Spits 5 to surface (Maloney *et al.* 2018a)]; two retained single burin scar DIFs. A single burin core, recycling a transversely snapped point, was also recovered.

From CG3, three points with DIF were identified. A bifacial point reduced from hornfels retains a bending initiated scar on the distal right ventral margin, terminating with a slight hinge (Figure 3c). A crystal quartz bifacial point displays a bending initiated and step-terminating DIF, with superimposed use-wear scars (Figure 3d) – indicating possible recovery and use, after projectile damage. Another crystal quartz bifacial point displays a single burin scar DIF, with pronounced marginal edge damage (Figure 3e). Similar edge rounding and chattering occurs on five other points from CG3 (Table 2) and almost absent on all other flakes. Only two points from CG3 have proximal retouch. Two burin scar DIF were identified from the 76 convergent flakes from the Holocene units of the site [spits 16 to surface (O'Connor *et al.* 2014)].

Of three points reported from Djuru by Maloney *et al.* (2016), one bifacial point retains a single burin scar, initiated from a fine distal tip (Figure 4a). This point also has potential resin staining or residues on its proximal surface, as well as edge damage on medial and distal margins. A burin core was also recovered, recycling a broken point.

The Riwi excavation (Balme *et al.* 2019) recovered nine points, none with DIF. A convergent flake with DIF burin scar propagating along the right margin was recovered, which also contained polish on the ventral proximal surface (Figure 4b). The convergent flake sample from square five ($n = 141$) [stratigraphic unit 1 of square 5 (Balme *et al.* 2019: 40-41)], which contained all of the sites' points, revealed no other DIF or resin staining. A single burin core with spalls initiated from a transverse snap reveals recycling of at least one broken unifacial point.

The Mount Behn excavation recovered 137 points, and from a sample of 4457 flakes (Maloney *et al.* 2017a: 7), 58 are here recognised as convergent flakes. Four points retained DIF; including two unifacial and one bifacial spin-off scars, and one bending initiated step-terminating scar (e.g. Figure 4c, d). The latter artefact displays edge damage scars superimposed over DIF (Figure 4d), indicating probable recovery and use after damage. Recycling of transversely broken points as burin cores is also present ($n = 4$). Only one of four points with DIF had any proximal retouch. No DIF was present on the convergent flakes. Edge damage scars in the form of chattering and edge rounding were detected on nine points, predominately on medial and distal margins (Table 2) and were otherwise absent from the flake sample.

The Widgingarri assemblages include 42 points and point fragments (O'Connor 1999: 34, 64-65, Table 4.5), and

Table 5. Instances of recycling and rejuvenation of points from surface sites.

	Point fragments	Rejuvenated points	Use-wear over DIF	Recycled points: burin cores	Hafting traces/ stains/polish
LR9	30	6	1	1	
LR12	0	4	1	1	1
Mount Behn surfaces	5				
ME3 Mandanari	7	1			2
ME2 Wanalirri	16			1	

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Figure 3. Points recovered from CG1 and CG3. (a) Distal point fragment embedded in resin (from Maloney *et al.* 2015). (b) Other recovered point reported in Maloney *et al.* (2018a), showing marginal edge rounding and proximal retouch. (c) Hornfels bifacial point with bending initiated scar on right ventral margin, terminating with a hinge (from O'Connor *et al.* 2014: 21). (d) Crystal quartz bifacial point with bending initiated step-terminating DIF and superimposed edge damage scars (from O'Connor *et al.* 2014: 21). (e) Crystal quartz point with single burin scar DIF, marginal edge rounding and chattering. [Colour figure can be viewed at wileyonlinelibrary.com]

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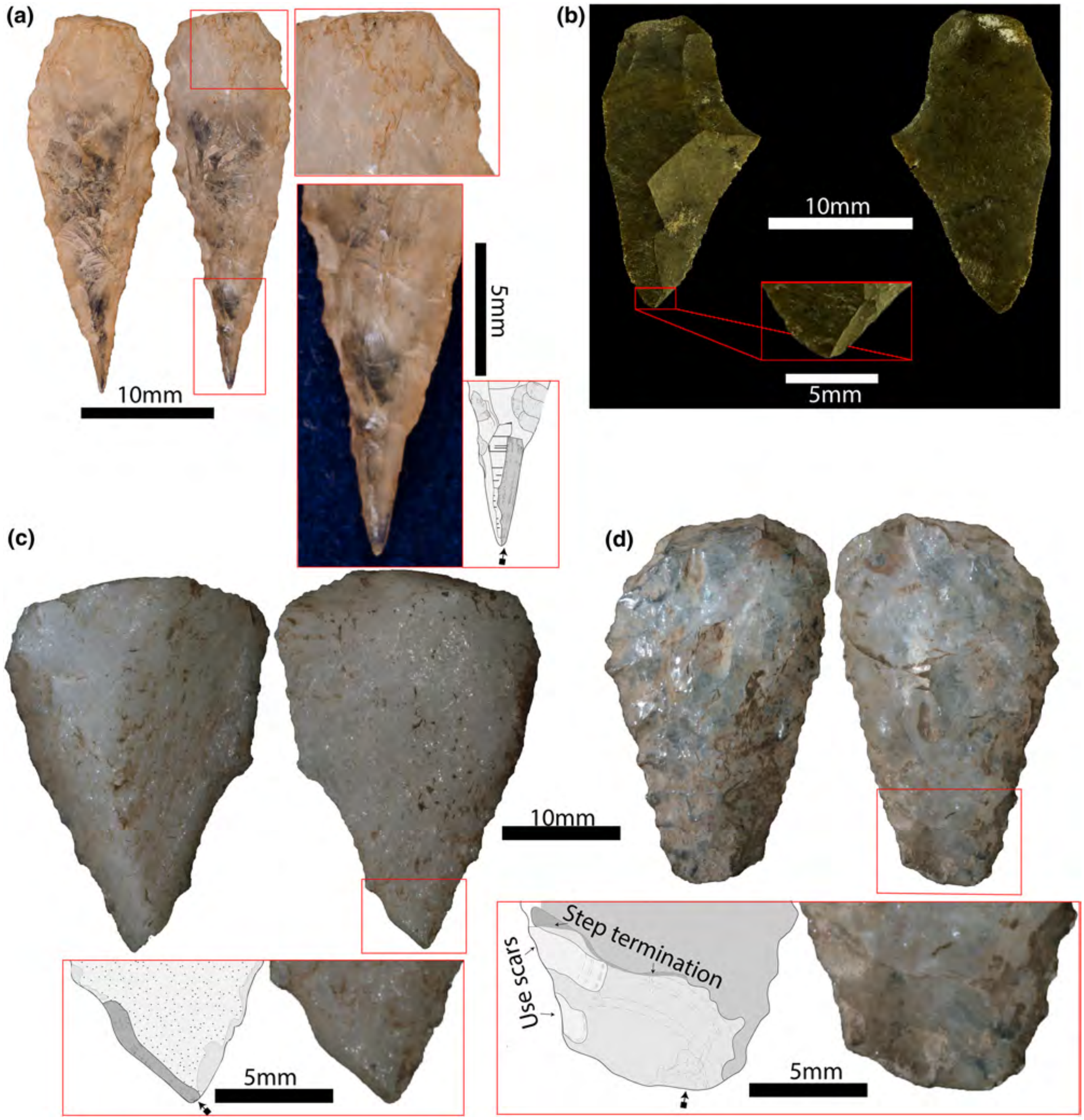
Figure 4. (a) Bifacial point from Djuru with single burin scar, on the right distal and possible resin staining on the proximal surface. (b) Riwi convergent flake with single burin scar on right dorsal margin and polish on the ventral proximal and parts of the ventral medial margins (photo credit Juliet Meyer). (c) Mount Behn quartz unifacial point with single burin on left ventral margin. (d) Mount Behn crystal quartz bifacial point with bending initiated, step-terminating scar and superimposed edge damage scars.



a single DIF observation. Of 25 point fragments discarded, one showed possible signs of recycling or rejuvenation (see O’Connor 1999: 71, Fig. 5, artefact 1). Edge damage is present on 28 points (Table 2), with a trend towards ventrally initiated, dorsal medial propagating scars. In an analysis of these same points, Wallis and O’Connor (1998: 165) found that the majority of residues were starch and cellulose. In this same study, three tools displayed strong evidence of contact with blood plaques and two cases of possible hafting.

Taking these DIF frequencies as probable indicators of projectile damage; the cases are few (*n* = 13). Exclusion of unifacial and bifacial spin-off scars from the DIF frequencies (*n* = 3) due to their problematic recognition would further emphasise the low occurrence of DIF in the excavated samples.

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Figure 5. LR9 and ME3 DIF examples. (a) Quartzite convergent flake with bending initiated step-terminating DIF. (b) Silcrete serrated point with bending initiated step-terminating DIF. (c) Quartzite convergent flake with single burin scar DIF on left distal margin. (d) Quartzite unifacial point with potential bifacial spin-off scar. (e) Quartzite convergent flake with bending initiated hinge terminating DIF scar and proximal polish.

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Table 6. Distribution of edge damage scars on surface assemblage points.

	Dorsal				Ventral			
Zone	**Proximal**	**left medial**	**Right medial**	**Distal**	**Proximal**	**Left medial**	**Right medial**	**Distal**
LR9 ($n = 105$, 76%)	14	25	19	19	13	14	14	8
LR12 ($n = 68$, 76%)	4	20	15	13	2	14	14	5
ME3 ($n = 36$, 26%)		9	4	10		13		6
ME2 ($n = 34$, 38%)	2	9	14	5		4	2	2

Assessing the excavated sample of points as a single batch ($n = 217$) reveals retouch intensity and morphological variation do not affect the patterning of DIF. There is no significant difference in retouch intensity between points with DIF, and those without (Pearson's chi-squared test: $\chi = 70.716$, $p = 0.379$). The same trend is evident using morphological measures (Supp file A section 3 Table 6). These tests reveal that the patterning of DIF is not affected by overall point morphology, including proximal thinning; and relative thickness at the distal and proximal ends. Proximal retouch is more likely with increasing retouch intensity (Pearson's chi-squared test: $\chi = 0.576$, $p = 0.002$). Most points were retouched on the medial and distal margins only, mirroring the distribution of edge damage scars and pronounced rounding.

Surface sample sites

The DIF frequencies, instances of rejuvenation, possible hafting residues and edge damage distribution for the surface samples, are listed in Tables 4–6.

The LR9 sample included 110 points and 13 convergent flakes, which revealed 12 examples of DIF (Table 4). These included three unifacial spin-off scars, six single burin scars, and three step-terminating bending initiated scars (e.g. Figure 5a). These DIF represent 10% of points and convergent flakes. The proportion of point fragments ($n = 62$) reveals an even distribution of proximal (48%), and distal (44%) fragments were not rejuvenated (Supp. File A section 3 Table 5). Six points displayed superimposition of retouch scars over transverse and marginal breaks, including one burin core. Edge damage scars, in the form of pronounced rounding and chattering, were observed on 105 points (85%), with a strong preference for dorsal medial and distal locations (Table 6).

The LR12 sample included 89 points and 58 convergent flakes, which revealed three DIF and a single case of potential hafting residue. These include a unifacial spin-off and two step-terminating, bending initiated scars. The portion of point fragments discarded ($n = 100$) suggests that distal fragments (62%) are less likely to be rejuvenated (Supp File A section 3 Table 5). Of the 89 points, 5.6% display retouch superimposed over marginal or transverse breaks (Table 6). A preference for use-wear on the medial and distal locations is evident on 68 points (76%) (Table 6).

The Mount Behn surface sites include 27 retouched points and 13 convergent flakes. None retained clear hafting traces, and a single unifacial point retains a DIF scar.

From Mandanari (ME3), 13 points and convergent flakes retained DIF (48%). These included three unifacial and one bifacial spin-off scars, four single burin scars and five bending initiated, stepte-rminating scars. Figure 5b–e illustrates examples of these. Possible resin staining or residue is present on two points. There are no instances of burin core recycling, although one point shows rejuvenation following a marginal break. Edge damage distribution shows a preference for dorsal medial and distal localities (Table 6) and generally mirrors the distribution of retouch.

Of the 39 points and 24 convergent flakes from Wanalirri (ME2), there are 13 instances of DIF. There is a single burin core, recycling a transverse snapped bifacial point. Edge damage distribution shows a preference for dorsal medial and distal localities.

Assessing all the surface sample points as a single batch ($n = 451$) reveals no significant difference in retouch intensity between points with and without DIF (Pearson's chi-squared test: $\chi = 63.819$, $p = 0.893$). Overall, proximal thinning is present on less than 5% of points. The proximal curvature index increases with retouch intensity (Wilcoxon signed-rank test: $Z = –8.271$, $p = 0.001$). Against the range of morphological measures, the patterning of DIF is similarly unaffected by proximal thinning or relative thickness at either the mid or proximal ends (Supp file A section 3 Table 7).

In contrast to the excavated samples, mass, length, elongation, relative distal thickness and marginal angle, all have significant relationships for the batch of points with DIF (Supp file A section 3 Table 7). These variables suggest some of the classic projectile shape assumptions associated with elongation, and tip angle may have been emphasised in the surface collection points with DIF, although other explanations are discussed. Similar to the excavated sites, exclusion of unifacial and bifacial spin-off scars from the DIF frequencies ($n = 8$), due to their problematic recognition, emphasises the low occurrence of DIF. This would reduce DIF frequencies by around half at ME3, for example.

Modelling use distribution on points

While DIF is rare within all point and convergent flake assemblages, pronounced marginal rounding and chattering is prolific (11%–76%). Figure 6 depicts edge damage on the assemblages combined as batches, demonstrating a focus on medial and distal margins. These distributions are not affected by variation in segment perimeter length, as

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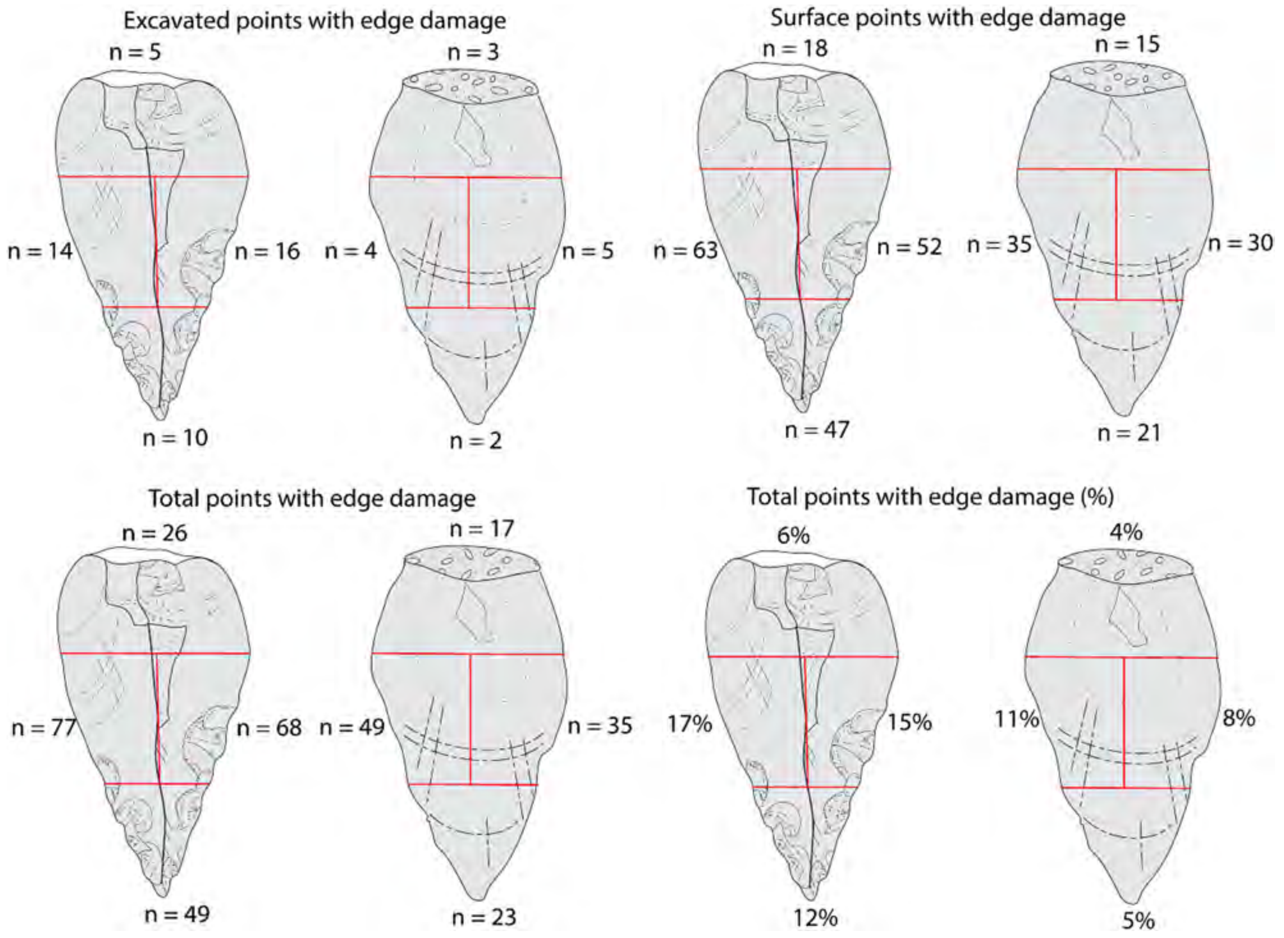
Figure 6. Frequency of edge damage depicted across four zones of each surface for those points with edge damage, within excavated and surface samples. A total and percentage is also given for the collective sample. [Colour figure can be viewed at wileyonlinelibrary.com]



comparing the number of segments with use-wear, against the perimeter length reveals no significant difference, in both the excavated samples (Pearson's chi-squared test: $\chi = 1050$, $p = 0.433$) and surface collections (Pearson's chi-squared test: $\chi = 2916$, $p = 0.228$). These tests suggest the gridded system is reasonably sensitive to use-wear distribution. Distal to medial margins are most affected, regardless of perimeter length; mirroring the distribution of retouch.

It is also possible proximal areas were covered by hafting mastic, which would emphasise the exposed margins as the working edges, although only eight cases with possible hafting residue or polish were identified. While the edge damage distribution might hint at a very slight preference for the right side, comparing left versus right segments with edge damage in both samples reveals no significant difference ($t = 0.377$, $p = 0.706$).

DISCUSSION

The identification of each DIF is interpreted cautiously as probable impact damage, given the absence of experimental data on the local raw material and nuances of DIF formation. The frequency of DIF from the excavated sample is low ($n = 13$), varying between 0.8% and 5.8% of points and convergent flakes from the mid to late Holocene. These frequencies are even lower when considering the exclusion of unifacial and bifacial spin-off fractures, which seem the most problematic to recognise on retouched points. Retouch intensity and point morphology do not affect the likelihood of DIF patterning. Conversely, cases of recycling and rejuvenation vary between 2.4% and 11% of points and evidence for medial and distal marginal use is prolific in all samples. These figures are congruent with the reports of <6.5% DIF and between 50% and 60% marginal use-wear from the Wardaman Country sample of 1536 points (Brindley & Clarkson 2015).

The frequency of DIF from the rock shelter surface sites' points and convergent flakes is comparatively higher ($n = 28$, 10%); varying between 3.4% and 48%. There is some indication that distal point morphology and overall point size, preferences DIF formation in these surface samples. These surface sites may be more liable to taphonomic force loading such as trampling. Alternatively, this DIF patterning could be a result of relatively less rejuvenation and recycling. Instances of this varied between 5.6% and 7.7% of points, less than those from the mid to late Holocene

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excavated samples. Furthermore, the retouch intensity of the excavated points is significantly higher than the surface points (paired sample *t*-test: $t = -2.380$, $p = 0.021$).

Due to a lack of absolute temporal data in the surface collections, it will remain unclear whether these trends are from an increase in point projectile use or a decline in rates of rejuvenation and recycling, in more recent times. Both are discussed below. Elsewhere, claims for a reduced investment into the maintainability of direct percussion points, in favour of the production of pressure flaked bifaces, have been made in relation to the past millennium (Maloney 2015, 2019; Maloney *et al.* 2017a).

If 40–60% of actual stone projectiles retain DIF, as suggested by experimental studies (Fischer *et al.* 1984; Lombard *et al.* 2004; Rots *et al.* 2017); then points in this study identified with DIF could represent around half of the actual projectiles used. This hypothesis would imply excavated points increase to 10% and surface points to 20% – still suggesting occasional projectile use and a possible recent increase. This study suggests that despite an emphasis on recycling and rejuvenation, which undoubtedly removed some evidence of impact damage, the use of points as hafted projectiles was still probably only occasional, with far more regular use in tasks causing marginal abrasion.

Edge damage distribution was predominantly concentrated on dorsal, medial and distal margins of points, mirroring the distribution of retouch. Pronounced edge rounding and chattering on point margins and the converging distal tip suggest these areas are used throughout point reduction, perhaps to cut, abrade, adze and perforate a variety of materials. Overall, the observed distribution of use-wear is far more common (76%) than probable impact fractures (2.8%), or hafting residues (1.7%). It is plausible that this distribution is enhanced by having the medial and distal portions of points projecting from hafts, and the proximal segments within and protected by hafts. This scenario finds support from the single point fragment recovered from CG1 (Maloney *et al.* 2015), where only the distal tip protrudes from the haft. Hafted points are known to have been in recent times as handheld tools (Blundell 1975: 383).

The maintenance of the pointed shape throughout life history does not appear to be a function of projectile use alone; it is more likely to serve in a multiplicity of functional roles. The observation of use-wear, recycling and occasional rejuvenation following probable projectile damage is indicative of a stone tool technology which emphasised maintainability and standardisation.

Standardisation and extendibility of point use-life increase the likelihood that foragers would have an adaptable and ready toolkit to exploit resources (Hiscock 2006: 81; Kuhn 1994; Veth *et al.* 2011: 12) as well as enhance social interconnectedness (Hiscock & Maloney 2017). Standardisation of points provides additional benefits, by facilitating regular blanks, consistent morphologies for hafting and predictable morphological transformations during resharpening (Clarkson 2007: 150–60; Hiscock 1994b: 278).

The relative portion of points with probable projectile evidence from Holocene Australia is notably smaller than those from other regions of the world with stone points (Andrefsky 2008; Lee & Sano 2019; Rots *et al.* 2017). North American studies of hafted bifaces (Ahler 1971; Kay 1996; Truncer 1990) can help rationalise these low numbers within technological organisation models. For example, Andrefsky (2008: 199) suggests that impact damage implies tool makers and users were in situations that allowed them to discard damaged tools and produce fresh ones. He found that hafted bifaces from greater distances to the source, tend to have no impact damage and that near-source bifaces were more likely to have impact damage (Andrefsky 2008: 199). The higher frequency of DIF and the apparent effort to modify the distal portions of points to suit a projectile function in the surface collections of this study could relate to similar provisioning strategies evoked by Andrefsky (2008).

If there was a reduction in pressures to rejuvenate damaged projectiles in more recent times, this could explain why the surface collections retain relatively more DIF and fewer rejuvenation efforts than those recovered from earlier mid to late Holocene contexts. The implication is that retooling or rejuvenating damaged points was more economically crucial during times of higher foraging risk and less so within the last millennium. At this time, toolmakers were already innovating and exploring new techniques of production, which garnered social prestige and consumed comparatively more stone than direct percussion points (Maloney 2015: 265, 2019; Moore 2015).

Site type and bias

Significant bias in this study and most Australian sites is the focus on rock shelter assemblages. All of the assemblages, including the surface sites, are from rock shelters. By nature of geographical proximity to hunting activities, it is plausible that DIF would be more frequent on sites close to hunting activities, such as plains where macropods forage. Villa *et al.* (2009) contend that higher DIF frequencies (>40%) are found at hunting sites, as opposed to residential sites. The single instance of a high proportion of probable DIF, at Mandanari (ME3), was not interpreted as a "kill site" by the original collector or Traditional Owners (Blundell 1975: 198).

The few studies of faunal assemblages in this region where points occur (Maloney *et al.* 2018a; O'Connor 2008) are also from rock shelters. The only substantial faunal subsistence study from the southern Kimberley region (Maloney *et al.* 2018a) identified an overall increase in large macropods during the mid to late Holocene (Maloney *et al.* 2018a: 222), suggesting hunting activities could indeed vary across site type. This hypothesis fits reasonably well with disproportionate frequencies of DIF between site types found elsewhere (Villa *et al.* 2009; Wilkens *et al.* 2012). The contrast of probable projectile damage between site types implies provisioning and transport strategies (e.g. Andrefsky 2008; Villa *et al.* 2009; Wilkens *et al.* 2012). Both Mount Behn and CG3 provided examples of probable

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DIF with superimposed use-scars, suggesting possible recovery after impact damage and return to the site for maintenance and further use.

CONCLUSION

This study has shown that points across the Kimberley, from the mid to late Holocene, were likely only occasionally used as hafted projectiles in range weaponry. Cautious interpretation of the low frequency of DIF from mid to late Holocene contexts suggests occasional project damage and discard within rock shelters. These low figures of probable projectile damage are discussed within technological organisation models, involving high mobility and a need for highly maintainable technology. Marginal edge damage, interpreted as probable use-wear, is prolific on medial and distal point margins – mirroring the distribution of retouch. This form of use-wear, together with recycling and rejuvenation rates, indicates that use and maintenance were concurrent throughout tool use-life.

Retouch maintained the edge and pointed shape, for multipurpose tasks – including but by no means limited to projectile use. Similar to use-wear and residue studies conducted on backed artefacts from eastern Australia (Robertson *et al.* 2009), this study strongly suggests that points were multifunctional. The pointed shape is part of a standardised and highly maintainable technological strategy, which equipped mobile forgers with highly versatile and reliable tools, occasionally used as spearheads.

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