1. Introduction

Mobility is both vital and all-pervasive in the learning and structuring of the world around us (Bender, 2001a, p. 4, 2001b; Gori et al., 2019; Ingold, 2004; Ingold and Vergunst, 2008; Leary, 2014; Sheets-Johnstone, 2011). It affects how people, places and objects become part of the political and social structure of their society (Beaudry, 2015, p. 5; Ingold, 2004; Ingold and Vergunst, 2008; Kador, 2007; Leary, 2014, p. 14; Lelièvre and Marshall, 2015; Tilley, 1994, pp. 20–22). Often viewed through large-scale migrations (Anthony, 1990; Beaudry, 2015, p. 3; Burmeister, 2000; Leary, 2014, p. 3; van Dommelen, 2014) and the patterns of hunter-gatherer groups (Beaudry, 2015, p. 3; Binford, 1980; Kador, 2007; Kelly, 2013, pp. 77–113, 1992, 1983; Kent, 1992; Preston and Kador, 2018), mobility also includes the movements of daily and seasonal life within the landscape, such as the gathering of food and water; the journeying to sacred locations; and the herding of animals (Aldred, 2015; Fowler, 2016; Leary and Kador, 2016; Snead et al., 2009).

These every day actions are no longer seen to occur in a static landscape devoid of social meaning (David and Thomas, 2016; Tilley, 1994). Instead, places and spaces within the landscape are viewed as dynamic participants in human behaviour (Bender, 1993; Branton, 2009; David and Thomas, 2016, pp. 27–43; Gramsch, 1996; Ingold, 1993; Knapp and Ashmore, 1999; Thomas, 2001; Tilley, 1994; Tilley and Bennett, 2004), influencing the social structure in which the identity of its users is defined (Ingold, 2004; Tilley, 1996, 1994, pp. 31, 34, 41). Despite the importance of both place and space, movement in the space between places is rarely discussed outside of phenomenological studies (e.g. (Thomas, 2001, 1996; Tilley, 1994; Tilley and Bennett, 2004), with place given precedence (Aldred, 2014; Anschuetz et al., 2001; Bowser, 2004; Bradley, 2000, 1998; Branton, 2009; Casey, 2016; Frederick, 2014; Gramsch, 1996; Ingold, 1993; Leary, 2014, p. 4; Thomas, 1996, pp. 83–91; Tilley, 1994, p. 18). However, as noted by Tilley (1994, p.27–30), movement through the landscape contains traces of past activities, with paths establishing and maintaining social linkages between individuals, groups and political units. Therefore, by not studying movement in the space between places, the archaeological record is prone to be viewed as static (Aldred, 2014; Leary, 2014; Roughley, 2004), rather than emerging as the perceiver moves within the world (Goetsch and Kakalis, 2018; Ingold, 2011, p. 168).

This emphasis on place over space is particularly present in GIS-based visibility studies, with the landscape often viewed through the perspective of Cartesian-western thought (Bender, 2001a; Llobera, 1996; van Leusen, 2002, chap. 6; Wheatley, 2014; Wheatley and Gillings, 2000). Through this, the observer is situated within the landscape, standing back from the thing observed (Bender, 2001a), and inheriting a privileged god-like view in all directions (Llobera, 1996; Thomas, 1993; Trick, 2004; Wheatley and Gillings, 2000). This is most evident from the prevalence of GIS-based visibility studies that assess the visibility from fixed places within the landscape (Fisher et al., 1997; Kantner and Hobgood, 2016; O'Driscoll, 2017). Although it has been argued that GIS-based visibility studies can be 'humanised' by including phenomenological approaches to understanding landscapes (Gillings, 2015, 2009; Llobera, 2006, 2003, 1996; Llobera et al., 2010; Mlekuž, 2014; Murrieta-Flores, 2012; Roughley, 2004), its application has not focused on how humans visually experienced the landscape whilst *moving* in the space between places (Bell and Lock, 2000; Gearey and Chapman, 2006; Lock and Pouncett, 2010; Murrieta-Flores, 2014). Landscapes continue to be viewed as *containers* for action rather than the *medium* in which human practices and meanings are developed.

This research proposes the GIS-based 'direction-dependent visibility' to overcome the abstraction of landscapes to containers for action. By limiting the potential visibility within the confines of humans' field-of-view when moving in the space between places, the application of GIS for understanding visibility is 'humanised' with the focus being on how people in the past experienced the landscape and its features whilst moving within it, rather than from fixed places beside it. Nonetheless, it should be noted that this approach does not aim to fully replicate the phenomenological experience of visibility whilst moving through the landscape (see (Gaffney and van Leusen, 1995; Wheatley, 1993; Wheatley and Gillings, 2000) for debates), but rather to provide an analytical and reproducible method that allows for a more nuanced understanding of what was visible when moving in the landscape.

Using a prehistoric ridgeway in Cumbria, England as a case study, this paper assesses the mobility of past people when moving through the landscape. In particular, the visibility of Bronze Age cairns when moving along the ridgeway will be examined through the application of direction-dependent visibility. Furthermore, by understanding the way past people moved around and perceived the landscape, the human practices and meanings that may have affected the placement of the cairns can be discussed.

2. Background

2.1 Prehistoric Cumbria

Occupied by humans since ca. 11,000 BC (Barton, 2009; Gale et al., 1985; Pettitt and White, 2012; Salisbury, 1988; Wymer, 1981), Cumbria has yielded archaeological evidence for settlement from the Mesolithic period onwards (Cherry and Cherry, 1995, 1987; Turnbull and Walsh, 1997). However, few Mesolithic sites with human remains in Cumbria have been found, with the majority of evidence coming from lithic scatters (Hodgson and Brennand, 2006; Mitchen, 2009, p. 37) and palaeo-environmental data (Mellars, 1976). The lack of physical evidence for domestic occupation continues in the Neolithic (Cummings, 2017, p. 181; Thomas, 2004), with the period being distinctive for its axe trade and large number of monumental structures (Bradley and Edmonds, 2005; Burl, 1988, 1976; Clare, 2007; Claris et al., 1989; Edmonds, 2005; Waterhouse, 1985). The Bronze Age continues to be typified by monumental structures (Clack and Gosling, 1976), however permanent settlements are now being developed (Richardson, 1982; Young and Simmonds, 1995). Furthermore, woodland clearance increased, with the development of field systems dividing land between social groups (Evans, 2008).

2.2 The Significance of Bronze Age Cairns

Bronze Age cairns in Cumbria are well represented in the archaeological record (Clack and Gosling, 1976; Evans, 2008, p. 149; Hodgson and Brennand, 2006, p. 41; Johnston, 2000). Although reductionist in its description, cairns are piles of stone with the landscape, and were constructed along ridgeways and on the natural routeways between areas of low and high ground (Evans, 2008, p. 162). Often associated with burial practices (Bewley et al., 1992; Walker, 1965; Williams et al., 2004), excavations have also found cairns with no burial remains (Leech, 1983; Yates, 1985). Fleming (1971) suggests that groups of closely spaced cairns (i.e. cairnfields) span multiple periods with some cairns being the product of intentional removal of stone during field clearance. Similarly, it has been noted that the two functions were sometimes interchangeable, with burial mounds providing a suitable place to pile stones during clearance, whilst a clearance cairn provided a ready-made burial monument (Darvill, 2014; Graham, 1956). (Barnatt, 1999) has suggested that the clustering of cairns represented individual ‘family’ groups, with (Johnston, 2001, 2000) arguing that token deposits such as charcoal within cairns implicate the establishing and assertion of rights to land by acting as markers in the landscape.

3. Data and Methods

3.1 Study Area

Cumbria is located on the western coast of North West England and is characterised by mountains, lakes, and valley systems. The study area is situated in the central part of Cumbria and contains the lakes of Ullswater and Haweswater Reservoir (Fig. 1). Running in between the two lakes is the ridgeway best known for being the ‘High Street’ Roman road connecting the Roman forts of Brougham and Ambleside (Hindle, 1998, p. 10). However, its origin as a prehistoric mountain-track has been postulated (The Royal Commission on Historical Monuments of England, 1936). This is made more credible by the ‘High Street’ being identical to a 13^{th} century land-boundary known as the ‘Street of the Britons’ (Hindle, 1998, p. 17; Ragg, 1910), suggesting its historical attribution to the Britons (The Royal Commission on Historical Monuments of England, 1936). Furthermore, the close proximity of multiple Bronze Age cairns to the ridgeway suggests the importance of the area and that at least part of the track were used during this time (Hindle, 1998, p. 9). The location of Bronze Age cairns were received from Historic England and Lake District National Park HER records stored in the Archaeology Data Service digital repository.

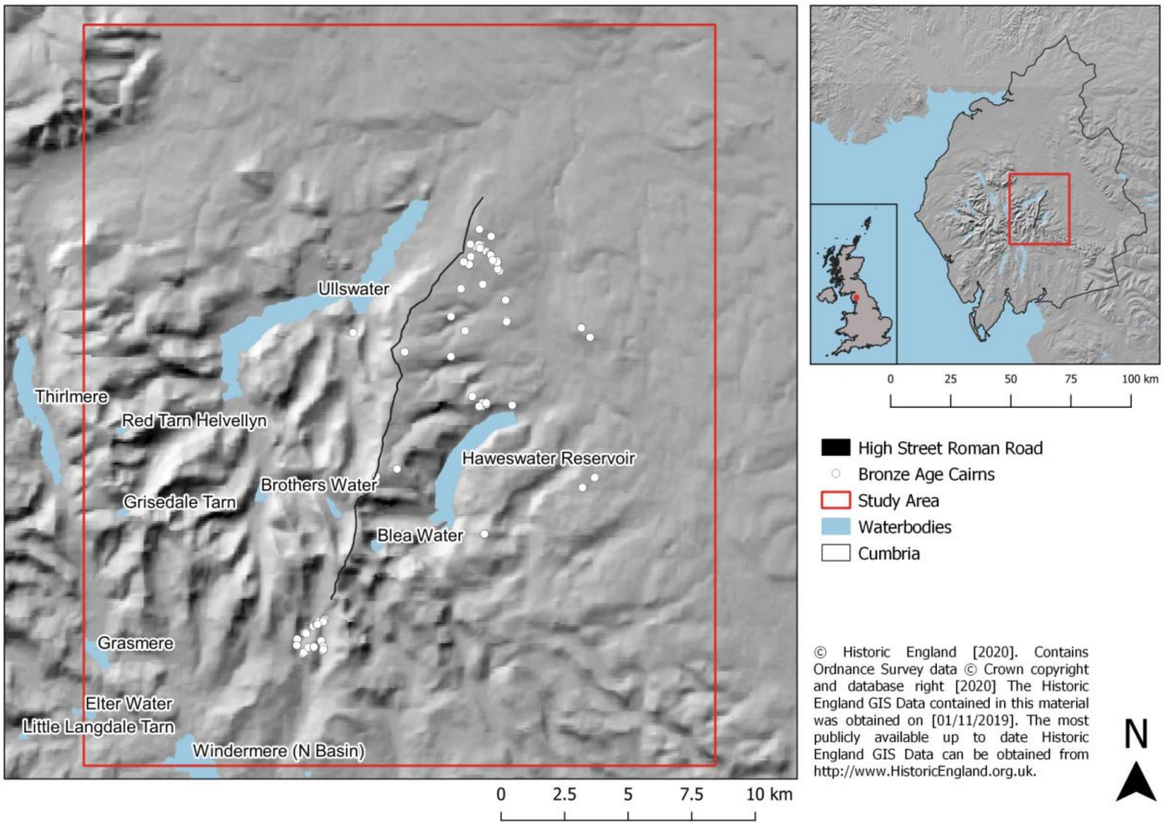

Figure 1. Study Area in Cumbria showing the associated lakes and Bronze Age Cairns

3.2 Identifying Areas of Preferential Movement

Like other prehistoric tracks (Taylor, 1979), the path when moving along the ridgeway lacks physical evidence for its location. Although it has been suggested that ridgeways form natural corridors for movement and facilitate long-distance travel (Bell and Lock, 2000; Bradley, 2007, p. 16; Llobera et al., 2010; Taylor, 1979), the likelihood of movement across the ridgeway in relation to other routes in the landscape has not been assessed.

In order to identify areas of preferential movement within the landscape, the study applied the 'From Everywhere to Everywhere' (FETE) method (White and Barber, 2012). The FETE method aims to convey the likelihood that any given location will be traversed (White and Barber, 2012) by calculating least cost paths between multiple locations within the landscape. Least cost path analysis identifies the path of least resistance by calculating the optimal connection between locations based on distance and the cost needed to cover the distance (Verhagen and Jeneson, 2012). The cost of travelling in a landscape is often based on environmental variables such as slope (Surface-Evans and White, 2012). As the study area is mountainous, slope has been included as a cost. Slope has been derived using ~120m resolution SRTM elevation data (~30m resolution SRTM aggregated to decrease computational time). The SRTM elevation data was retrieved from https://dwtkns.com/srtm30m/. The difficulty of moving across slope has been calculated using the Modified Hiking cost function (Márquez-Pérez et al., 2017), which combines the continuity of Tobler's

Hiking Function (Tobler, 1993) with the precision of MIDE, a method for calculating walking hours for an average hiker (París Roche, 2002). Furthermore, the lake Waterbodies in the study area have been given a conductivity value of 0, ensuring that travel across water is prohibited in the least cost path calculation. The final cost surface, which numerically expresses the difficulty of moving up- and down-slope, whilst prohibiting movement across Waterbodies, was used to calculate a travel cost surface. Using this surface, 227,052 least cost paths were calculated to-and-from a regularly spaced sampling grid of 477 points (Fig. 2).

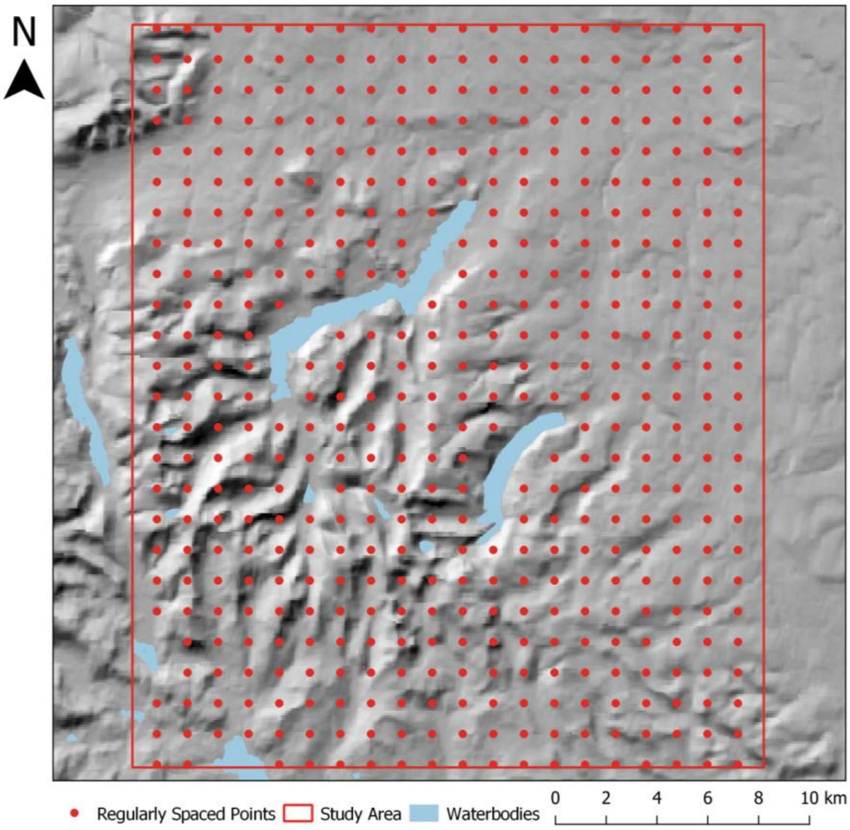

Figure 2. Regularly spaced sampling grid of 477 points within the study area

The rasterised least cost paths were combined and scaled to between 0 and 1. The result is a travel probability surface, whereby a higher value can be associated with an area of preferential movement within the landscape (White and Barber, 2012). In order to better visualise the most accessible corridors in the study area, the density of least cost paths were also accumulated using a kernel of 248m (Murrieta-Flores, 2012; Parcero-Oubiña et al., 2019). 248m is two times the maximum resolution of the least cost path raster, resulting in corridors becoming more pronounced whilst ensuring that density values do not become too smoothed and lose explanatory power (Fig x).

3.3 Reconstructing the Prehistoric Route

In order to calculate direction-dependent visibility, a route of movement along the ridgeway is required. Point centroids were selected within areas of lower elevation north and south of the ridgeway, with the points representing the origin and destination when moving along the ridgeway.

Subsequently, two least cost paths were calculated from the origin-to-destination and destination-to-origin. The least cost paths were calculated using slope derived from the ~30m resolution SRTM and the Modified Hiking cost function (Márquez-Pérez et al., 2017). Furthermore, travel across water was prohibited.

3.4 Direction-dependent Visibility

Visibility is a key factor in determining why a particular site were in a particular place (Wheatley and Gillings, 2002). By assessing whether there is an uninterrupted straight line of sight between two points, areas visible and not visible can be identified (Wheatley, 1995). Although care is taken when defining the height at which visibility is calculated from, visibility is often calculated in all directions around a fixed point (Wheatley and Gillings, 2000). Instead, direction-dependent visibility limits potential visibility to the confines of humans' field-of-view (Fig. 3). The angle of movement from a current location to a location further along the ridgeway was calculated. This angle represents the direction of movement that would be taken when moving along the ridgeway. From this, the potential field-of-view can be calculated. The potential field-of-view is horizontally limited to 62 degrees either side of the direction of movement and represents the visual limit of human visibility (Tilley, 2002). The potential visible areas were limited to 1km from each location along the ridgeway. This reflects the decay in visibility as distance increases (Ogburn, 2006), with 1km being the maximum distance at which clarity of visibility can be considered perfect (Fisher, 1994).

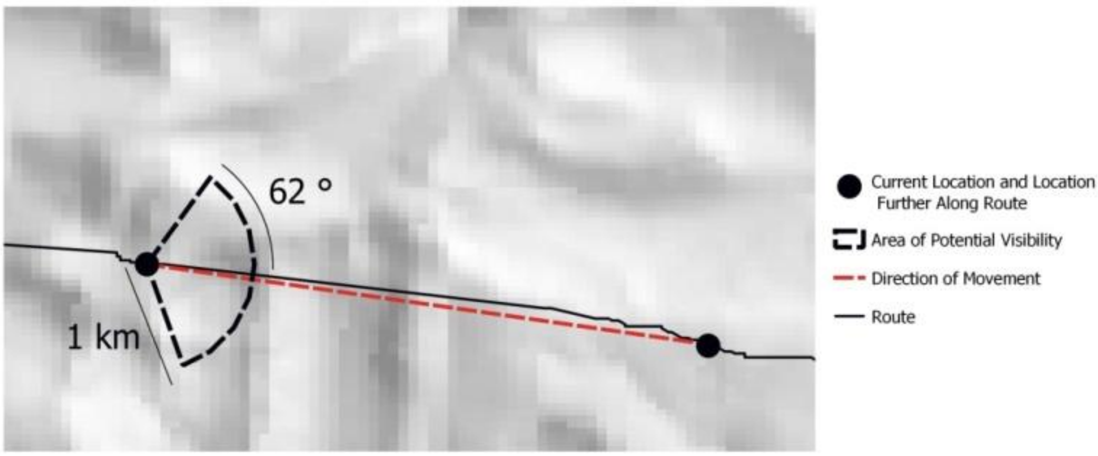

Figure 3. Calculation of Direction-dependent visibility when walking along a route

4. Results

The least cost path density raster has identified multiple routes of preferential movement through the Cumbrian landscape (Fig. 4A), with the least cost path kernel density visually highlighting the most prominent (Fig. 4B). The prohibition of movement across waterbodies has resulted in the routes of preferential movement being channelled parallel to the waterbodies when moving north-east to south-west (Fig. 4B). In particular, the least cost path kernel density has identified the prehistoric ridgeway as a route with high likelihood of traversal when moving north-east to south-west. Furthermore, the least cost path kernel density has resulted in routes orientated north-west to south-east following edges of the waterbodies, as indicated by the lighter areas of highest likelihood for movement (Fig. 4B).

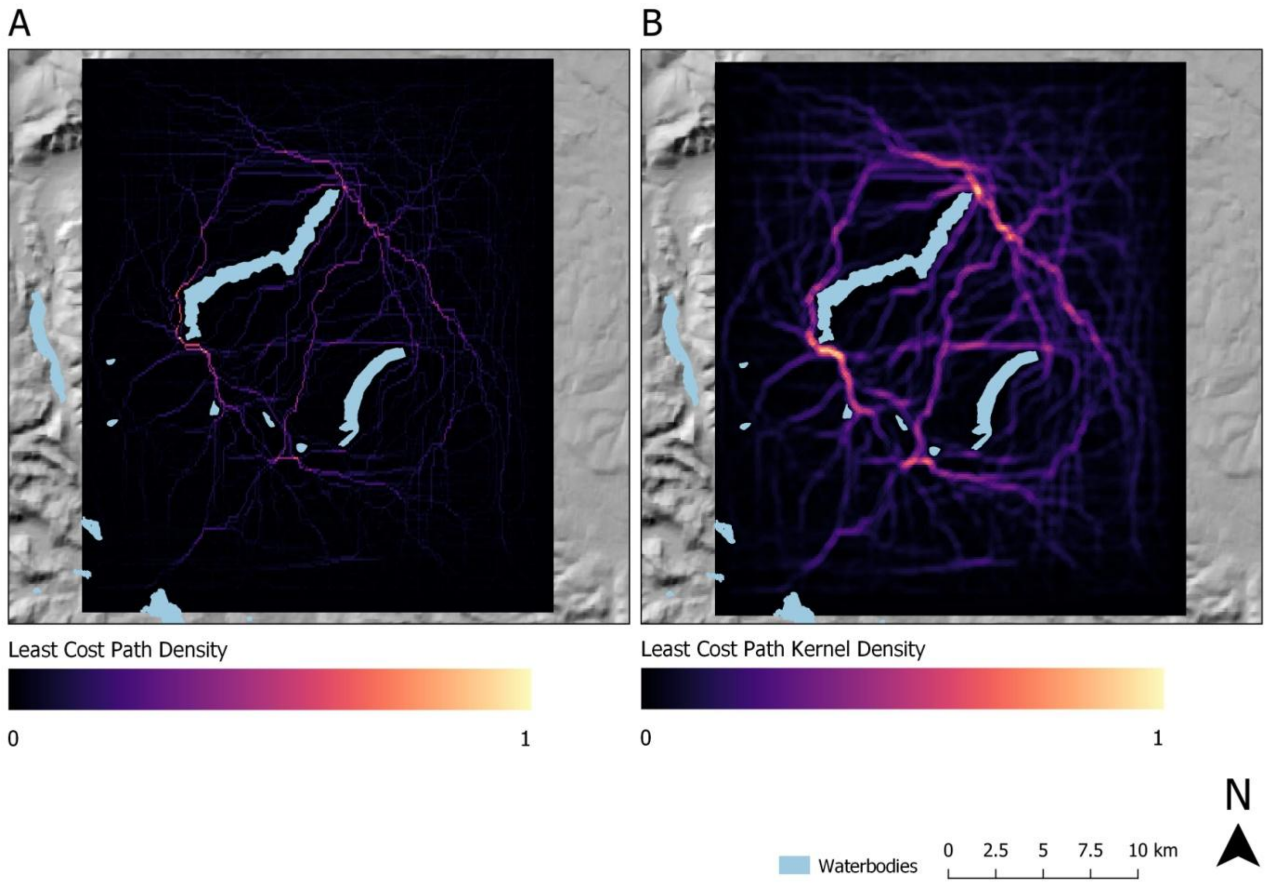

Figure 4. Resultant Least Cost Path Density (A) and Kernel Density Raster (B) using FETE method

The likelihood of the route along the ridgeway is further exemplified by the least cost path computed from the origin and destination points north and south of the ridgeway (Fig. 5A). The difference in the modelled routes of the two least cost paths reflect the anisotropic property of Modified Hiking cost function (Márquez-Pérez et al., 2017), with moving up-hill being more difficult than moving down-hill (Herzog, 2013).

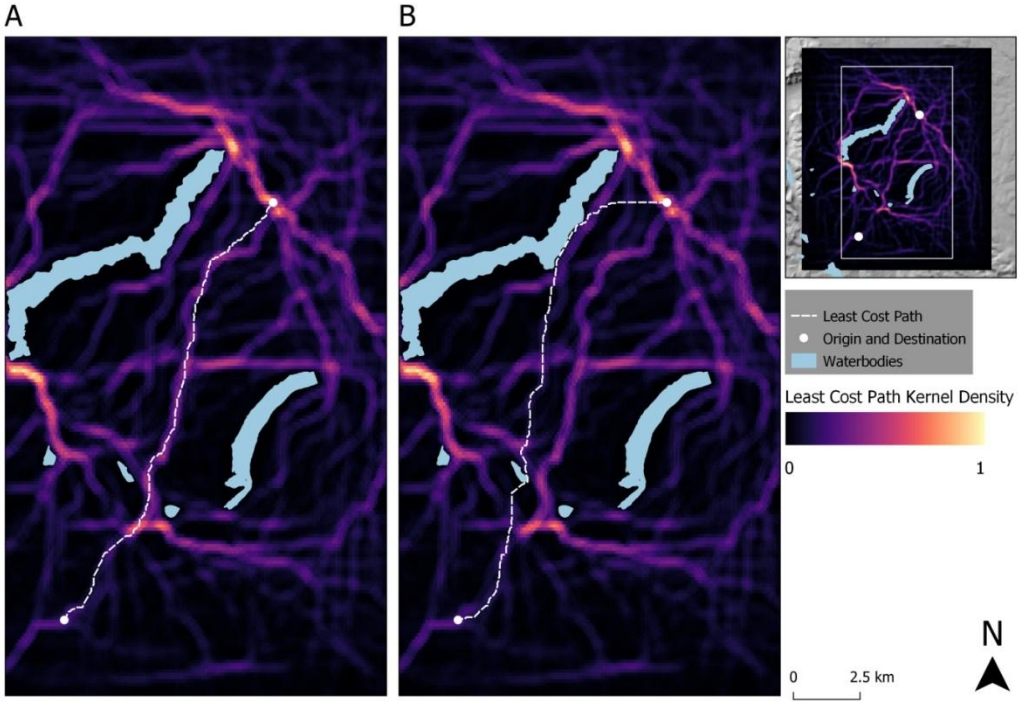

Figure 5. Least Cost Paths from South-to-North (A) and North-to-South (B)

The use of direction-dependent visibility when moving south-to-north and north-to-south along the least cost path that follows the ridgeway has identified that 39 and 32 cairns, respectively, are visible (Fig. 6).

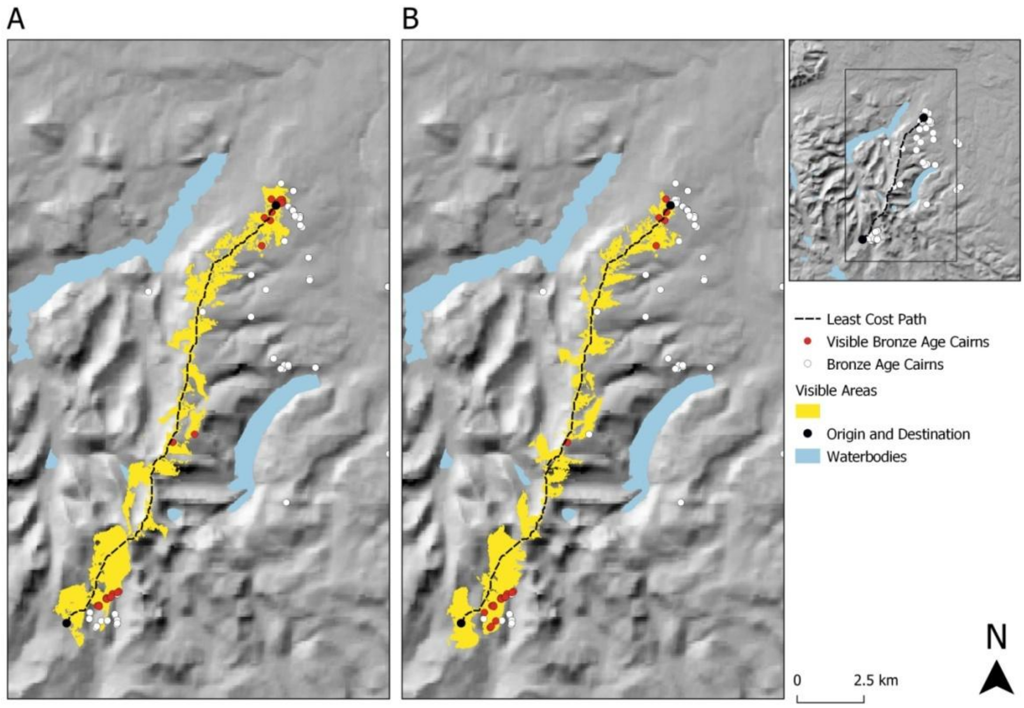

Figure 6. Direction-dependent visibility of Bronze Age Cairns when moving south-to-north (A) and north-to-south (B) along the ridgeway

5. Discussion

Through the identification of the ridgeway as an area of high likelihood of traversal when moving through the landscape, this research supports the postulation of (The Royal Commission on Historical Monuments of England, 1936) that the ridgeway was likely used by Bronze Age people. The different routes predicted when moving south-to-north and north-to-south from areas of lower elevation south and north of the ridgeway may suggest that the route following the Ullswater also acted as a viable route for movement. Movement in Cumbria along rivers is well attested, with Neolithic axe concentrations associated with rivers (Clough and Cummings, 1988; Evans, 2008, p. 78; Fell, 1964; Manby, 1965).

Direction-dependent visibility has identified that a high number of cairns were visible when walking south and north away from the ridgeway, suggesting that the cairns may have been placed within the landscape with the intent of being seen. Through the deliberate construction of monuments, the significance of the lower ground from the ridgeway are inscribed and formalised (Bradley, 1993). In particular, the permanence of the stone cairns prevented the significance of the locations being forgotten and may have maintained social identity and tenurial ties. This process of monument construction within the lower ground can be interpreted as the effects of large scale community fragmentation during Early Bronze Age (Bradley, 1984; Edmonds, 2005), with the cairns marking social groups' attachment to localised tenurial areas (Evans, 2008).

Similarly, the routeway along the ridgeway connecting the two clusters of cairns would have been imbued with new meaning. Through the cairns acting as markers of significance, the journey along the ridgeway may have become encultured through social and physical memory (Tilley, 1994). Stories told would encode information about the ridgeway, the cairns, and the relationship between people and the landscape (Tilley, 1994). Furthermore, memory of the connection between the cairns and the ridgeway would create the natural and cultural framework for experiencing and understanding the world, whilst stabilising and sustaining the histories and traditions of the places in the landscape (Bradley, 2002; Ingold, 1993).

Despite the advantages of direction-dependent visibility in 'humanising' visibility when moving through the landscape, its application in this research has not overcome many of the criticisms of GIS-based visibility analyses. Namely, although direction-dependent visibility was limited to 1km from each location along the ridgeway to ensure perfect visibility, it did not account for the effects of climate and weather on visibility (Wheatley and Gillings, 2000). This is of particular interest as the weather in Cumbria often hinders visibility (Evans, 2008, p. 27). Furthermore, the application of direction-dependent visibility did not incorporate the potential for horizontal movement of the head when moving along the ridgeway. Through its incorporation, the method will better model what people could potentially see from particular locations. Nonetheless, the different number of cairns visible depending on the direction of movement demonstrates the advantages of using direction-dependent visibility over visibility in all directions by acknowledging that visibility is dependent on the direction of the body and humans' physiologically constrained field-of-view.

6. Conclusion

This paper assessed the mobility of past people when moving through the Cumbrian landscape. In particular, the visibility of Bronze Age cairns when moving along the postulated prehistoric trackway was assessed through the application of direction-dependent visibility. The from-everywhere-to-everywhere method identified the trackway as a route of high likelihood for traversal when moving through the Cumbrian landscape and further strengthens the view that the trackway was used during the Bronze Age. Furthermore, direction-dependent visibility identified that a high number of cairns were visible when moving away from the trackway in both north and south directions. This suggests that the cairns were placed within the landscape to formalise the significance of the areas and formalise the attachment of social groups' to tenurial areas. Through this, the ridgeway connecting the cairns would have also created and sustained the natural and cultural framework for understanding the world. This research has found that direction-dependent visibility is a viable method for better understanding the visibility of past people when moving through the landscape and can aid in discussions on how human practices and meanings may have affected the placement of monuments within the landscape.

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Using a prehistoric ridgeway in Cumbria, England as a case study, this paper assesses the mobility of past people when moving through the landscape. In particular, the visibility of Bronze Age cairns when moving along the ridgeway will be examined through the application of direction-dependent visibility. Furthermore, by understanding the way past people moved around and perceived the landscape, the human practices and meanings that may have affected the placement of the cairns can be discussed.