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Where do standing stones in the North York Moors National Park tend to be placed?

Using ArcGIS Pro to reveal patterns in location placement through
analysis of terrain, viewshed, and intervisibility

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Introduction

This study explores the spatial analysis of three types of standing stones in the North York Moors National Park (NYMNP) in north-west England (Figure 1).

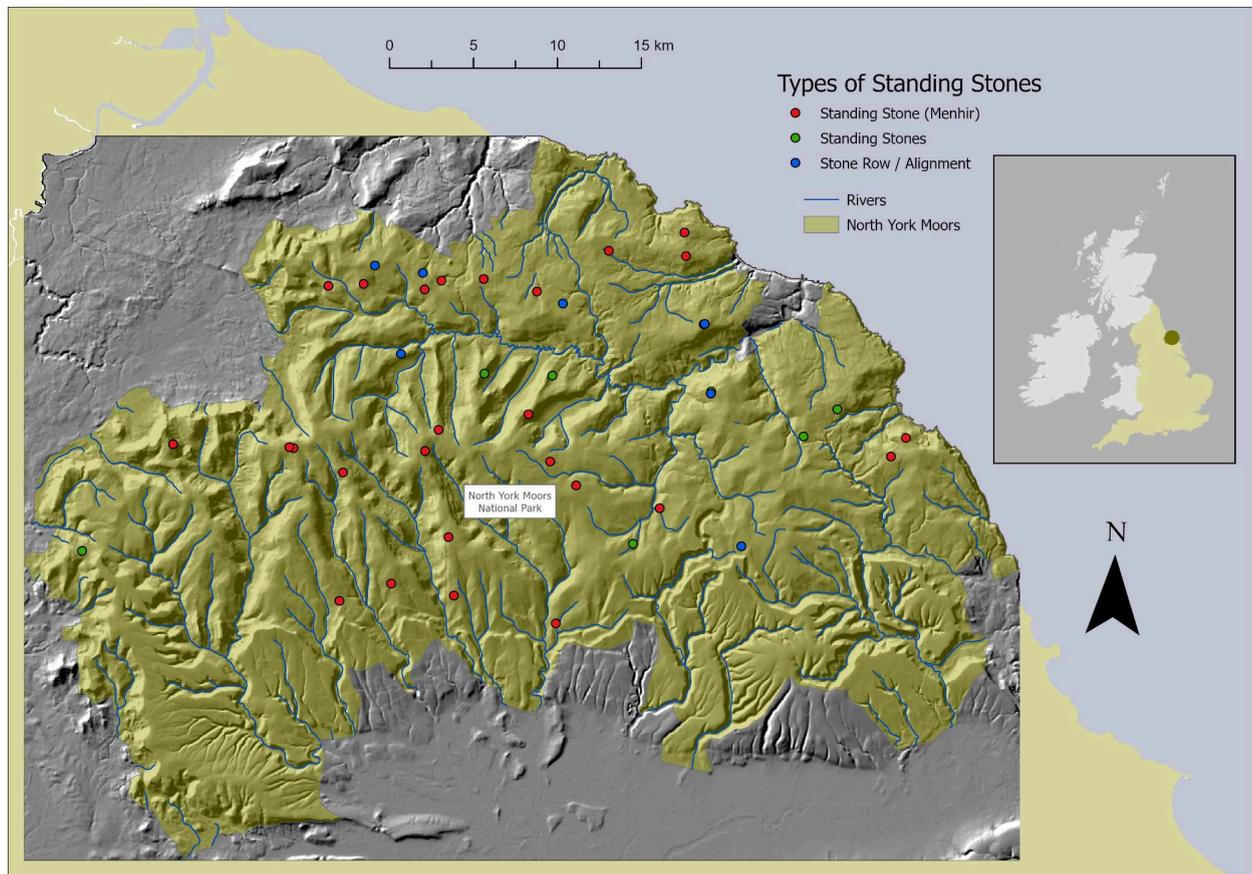


Figure 1: Locational map of the North York Moors National Park in north-east England. Note that the dark green area represents the actual extent of the park, despite a larger area represented by the grey digital terrain model, which failed to clip in ArcGIS Pro despite effort.

These three types are labeled in this paper as 'Standing Stone (Menhir)' (Figure 2), 'Standing Stones' (Figure 3), and 'Stone Row/Alignments' (Figure 4), and collectively referred to as 'stones' or 'standing stones.' All three types are large upright stone pillars of prehistoric origin and often serve territorial, ritual, or astronomical functions (Šaravanja, Oreč and Kopilaš 2022, 82). 'Menhirs' stand alone, 'Standing Stones' are two or more



Figure 2: Champ Dolent Menhir, 2023.

in close proximity, and 'Alignments' are linear groups of more than three (Olaru 2023, 148-149). The individual stones within the categories of Standing Stones and Stone Row/Alignments are grouped together as one collective entity or 'set' because they are meant to be interpreted within the same context. Therefore, it is likely that these types have a greater number of stones than represented in this study so Menhirs can seem to skew data because there is a larger quantity of them.



Figure 3: Penrhos Feilw Standing Stones, 2015.

Figure 4: Menhir Alignments, Carnac, 2014.

The aim of this study is to reveal patterns in the placement of these stones, which could then contribute to future archaeological research on their purpose. To explore this using ArcGIS Pro, three main analyses were conducted: terrain, viewshed (including distance-decay and elevation), and intervisibility between stones.

Research question: "where do standing stones in the North York Moors National Park tend to be placed?"

Hypotheses:

1. The type of landform a stone is placed on influences its placement location.
2. The elevation of an area influences the placement location of a stone.
3. How far into the landscape a stone is (un)able to see influences its placement location.
4. Whether a stone is (un)able to see and be seen by other standing stones in the landscape influences its placement location.

Methods

Data

Underlying data:

- North York Moors National Park Outline (Natural England, 2024)
- Elevation/ Digital Terrain Model (Ordnance Survey, 2025)
- Outline of uk (Office for National Statistics, 2025)

These data sets were obtained from national organisations in an Esri Shapefile format, so were projected to the British National Grid if not already done so. The national park outline and the elevation data were clipped to the extent of the North York Moors.

Archaeological data:

- Map of Standing Stone (Menhir) (The Megalithic Portal, 2025)
- Map of Standing Stones (The Megalithic Portal, 2025)
- Map of Stone Row / Alignment (The Megalithic Portal, 2025)

This data was compiled from a public database, so it is possible that this data is slightly inaccurate or incomplete, but effort was made to clean the data in Microsoft Excel. These three datasets were also combined to form a dataset of forty-one total points. Then, it was added to the map via XY Table to Point and projected to the British National Grid.

Terrain Analysis

Using a Digital Terrain Model of 50m resolution, a Terrain Analysis was conducted using the Geomorphon Landforms tool. Under a search radius of 100 cells, the landscape was categorized into ten categories: flat, peak, ridge, shoulder, spur, slope, hollow, footslope, valley, and pit.

Viewshed Analysis

To begin, elevation data extracted from each stone was input into the Calculate Statistics tool to count the number of stones per 50 meters of elevation between 100-500 meters. Using this data, two types of viewshed analysis were conducted using the Geodesic Viewshed tool: unrestricted and distance-decay, both with a 1.7m observer offset to mimic the average height of a human Jürgens (2004) (as cited in Fischer and Roth 2022, 152) (Figure 5).

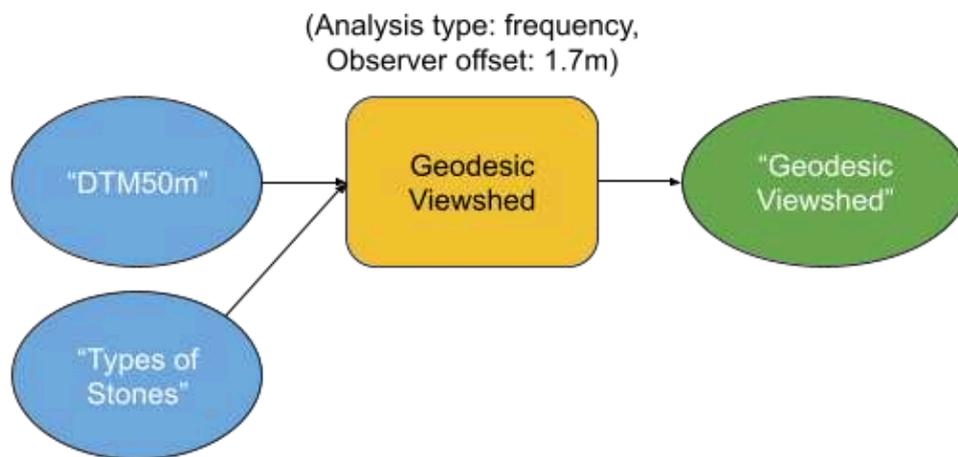


Figure 5: Unrestricted Geodesic Viewshed Workflow Diagram.

Following the methodology of Breuer (2001) (as cited in Fischer and Roth 2022, 151), a distance-decay with an outer radius of 3km was added in an attempt to replicate a more realistic viewshed by accounting for human eyesight that gets weaker as distance increases (Figure 6).

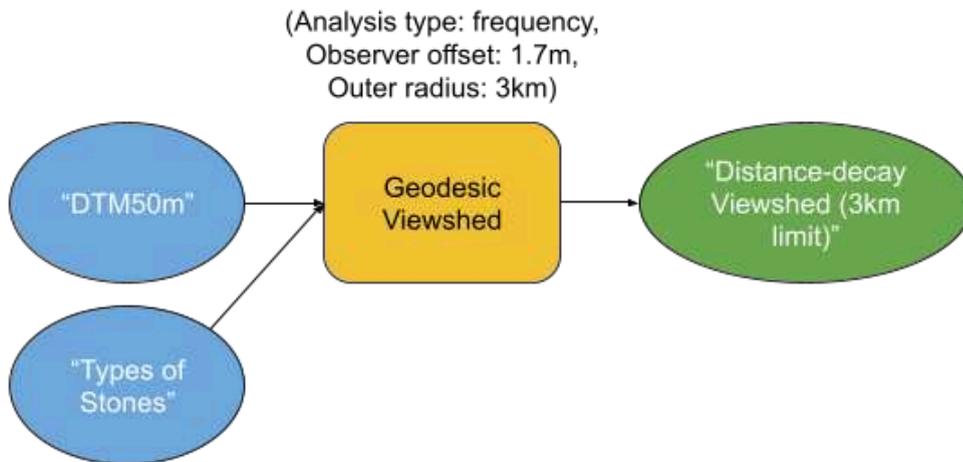


Figure 6: Distance-decay Viewshed Workflow Diagram.

Intervisibility between Stones

An analysis of intervisibility between stones tested which, if any, stones have a reciprocal visual relationship with each other (Figure 7). Four spatial analysis tools were used to output this intervisibility data: Interpolate Shape, Generate Near Table, XY To Line, and Line of Sight.

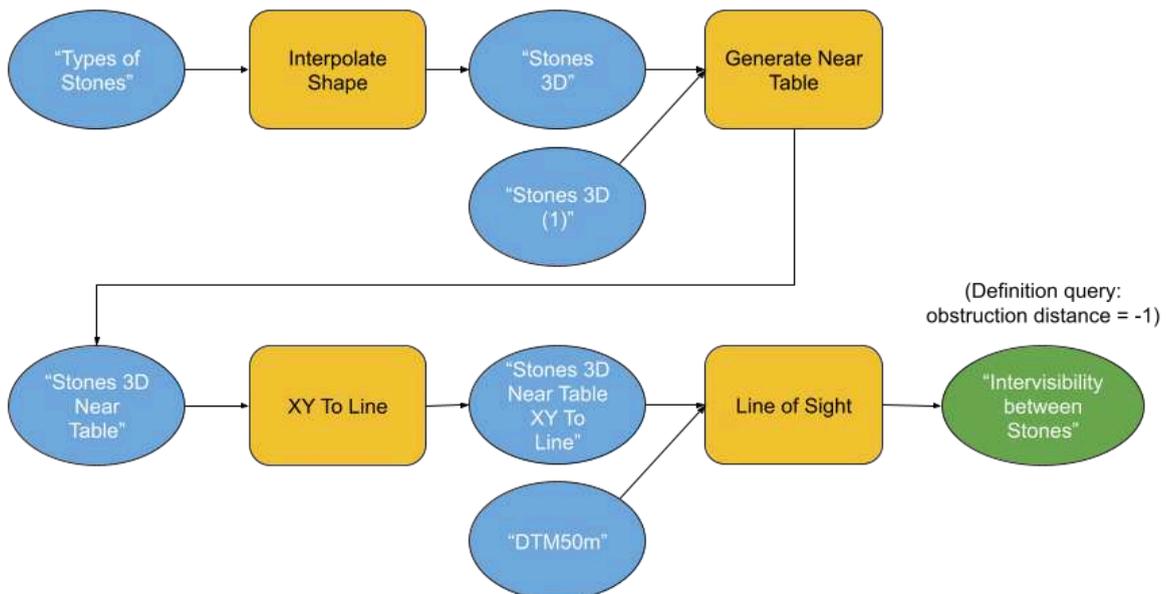


Figure 7: Intervisibility Analysis Workflow Diagram.

Results and Discussion

Terrain Analysis

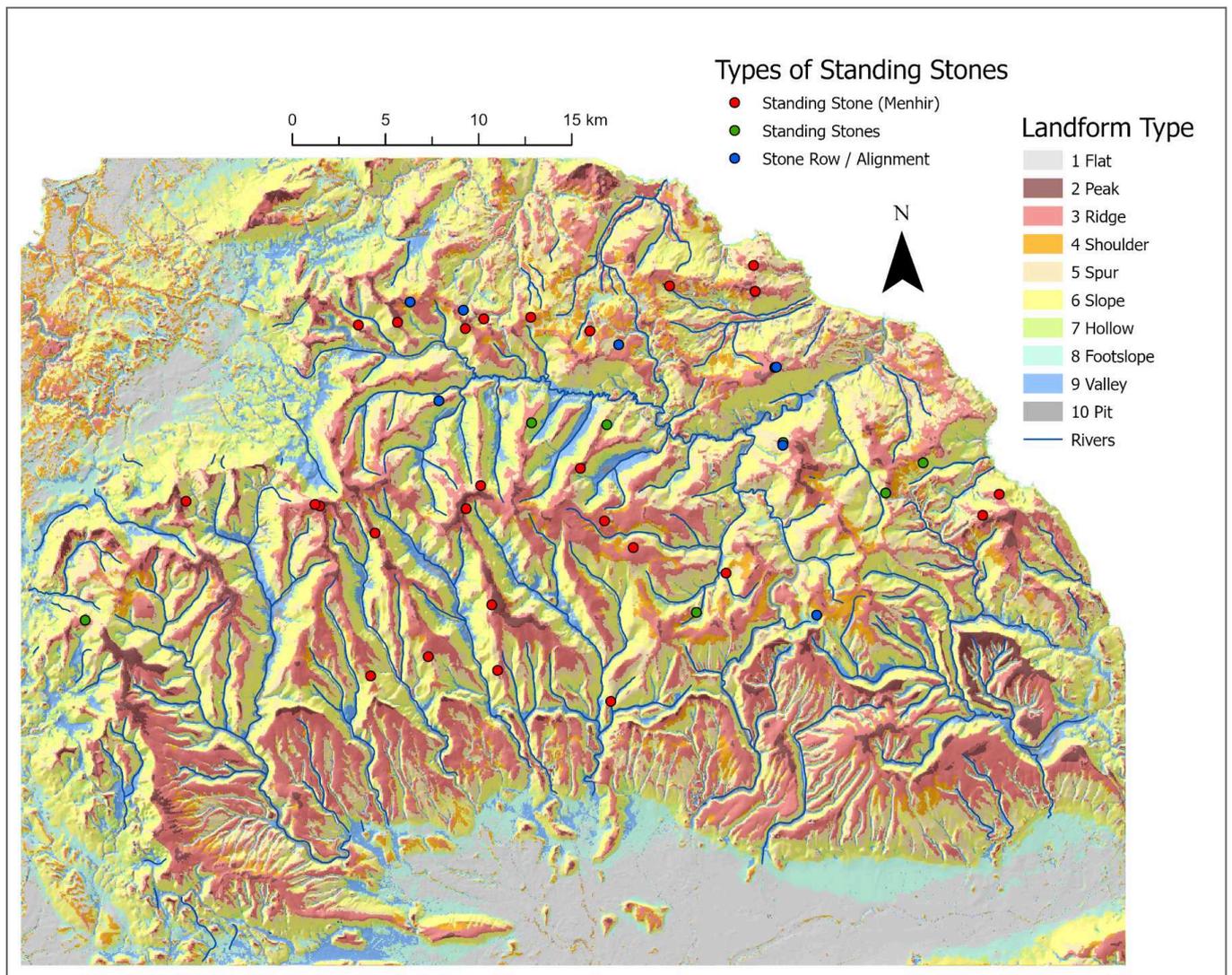


Figure 8: Map of the landform types from Terrain Analysis.

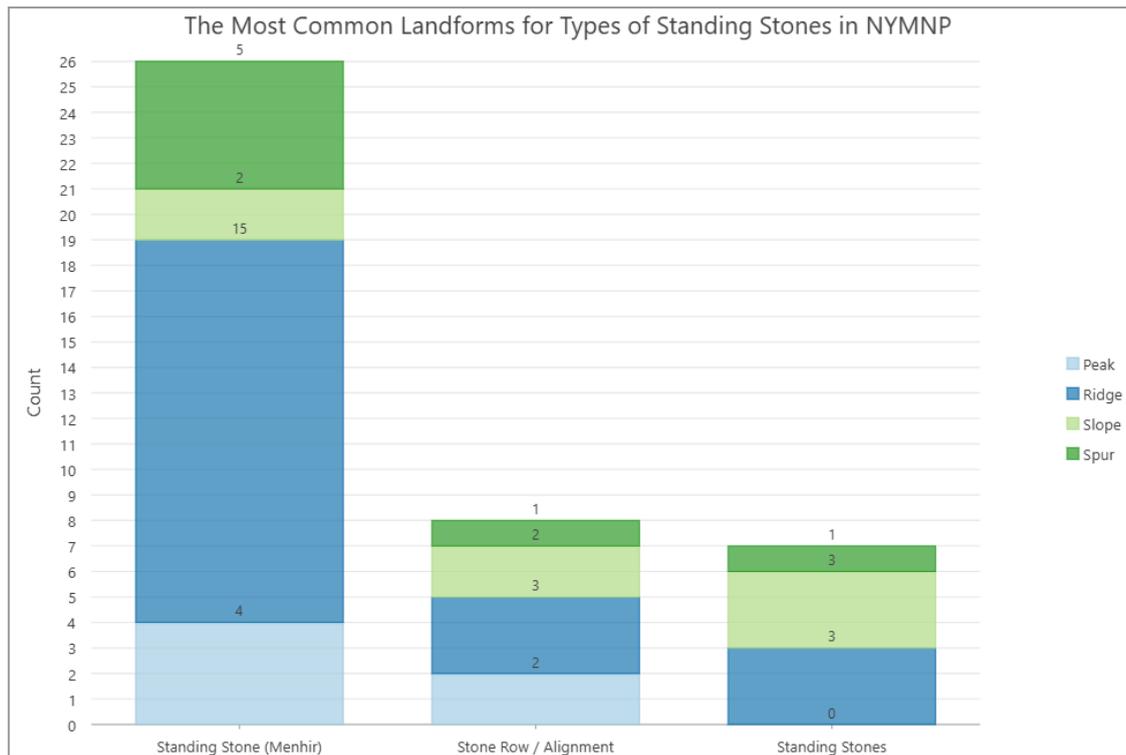


Figure 9: Bar chart displaying the number of stones by type on each landform.

Out of ten landform types, standing stones only appeared on four: peak, ridge, slope, and spur, all types towards the tops of mountains (Figures 8, 9). Each type of stone appears most abundantly on ridges, which sit just below the highest points (peaks) of mountains. For the category of Standing Stones, there is an equal number on both ridges and slopes. An inclination towards ridges suggests taking a defensive position because they provide better sightlines, while the use of four varied landscapes suggest an effort to take advantage of the best sites and resources (Argyriou, Teeuw and Sarris 2017, 4). The hypothesis for this analysis was correct in that the type of landform a stone is placed on influences its placement location.

Viewshed Analysis

Elevation

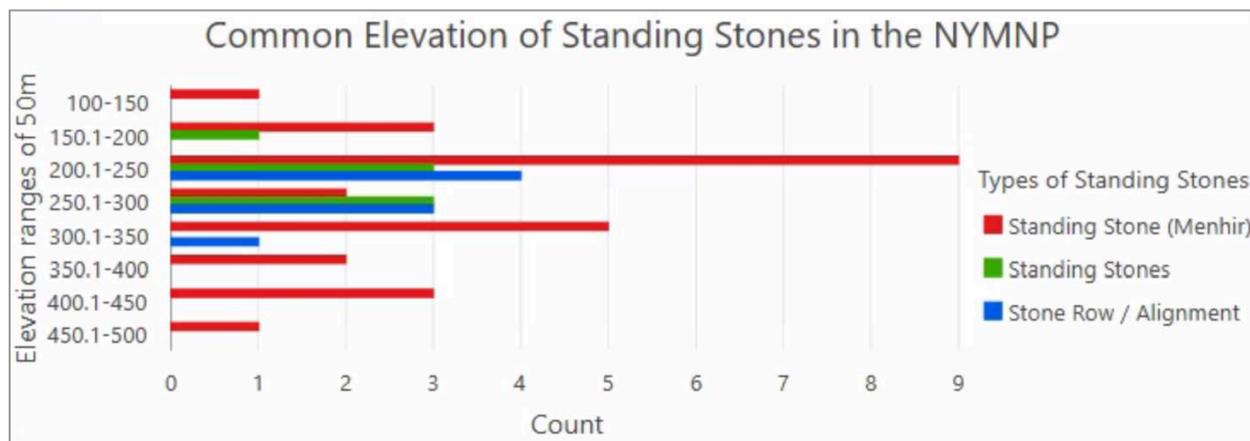


Figure 10: Bar chart displaying the number of stones by type in each range of elevation.

The elevation data revealed a clear preference for the height range of 200.1 to 300 meters (Figure 10). As the large number of Menhirs skewed the data initially towards a smaller range, when broken down by type, it became clear that this is the only range of height where all three types of stones appear. The hypothesis for this analysis was correct in that the elevation of an area influences the placement location of a stone.

Viewshed

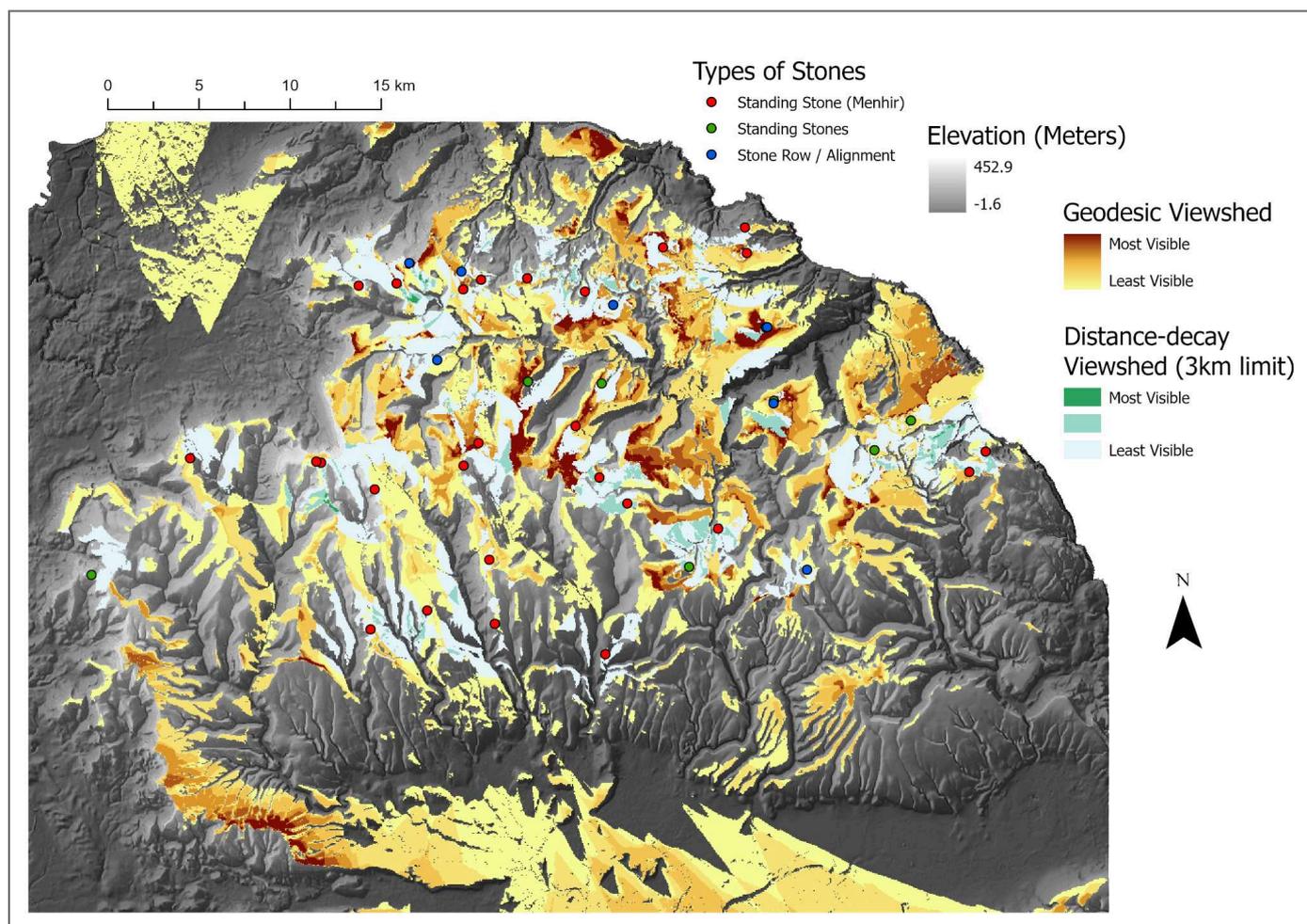


Figure 11: Map of the unrestricted and distance-decay viewsheds.

The unrestricted viewshed revealed that the portions of the landscape that are most visible by all of the stones tend to be concentrated towards the center and north-east areas of the park (Figure 11). The center of the map is very visible because of its high elevation while the areas in the north-east are at a lower elevation and are easier to see from higher vantage points. This area is more visible from other low-elevation areas because of its high concentration of stones, making it more visible simply because there are more observer points nearby. The distance-decay viewshed (Figure 11) shows that in reality, a person standing at these stones would not be able to see much further than the area directly around them, though there is a considerable amount of area that is moderately to highly visible.

Whether a landform or a feature, humans gravitate towards prominence within a landscape (Bernardini et al. 2013, 3946). Further analysis is needed to identify if the

viewshed from this study contains any prominent features, but nonetheless it reveals that viewshed holds important social meaning. Furthermore, if a feature such as a standing stone survives in the same location for multiple generations, its social meanings are exacerbated by group memory (Bernardini et al. 2013, 3953).

Though this data does reveal important information about what observers at these stones would be able to see, the trend is not strong enough to determine whether viewshed was an influential factor in the stones' placement location. Therefore, the result of the hypothesis for these analyses is inconclusive.

Intervisibility between Stones

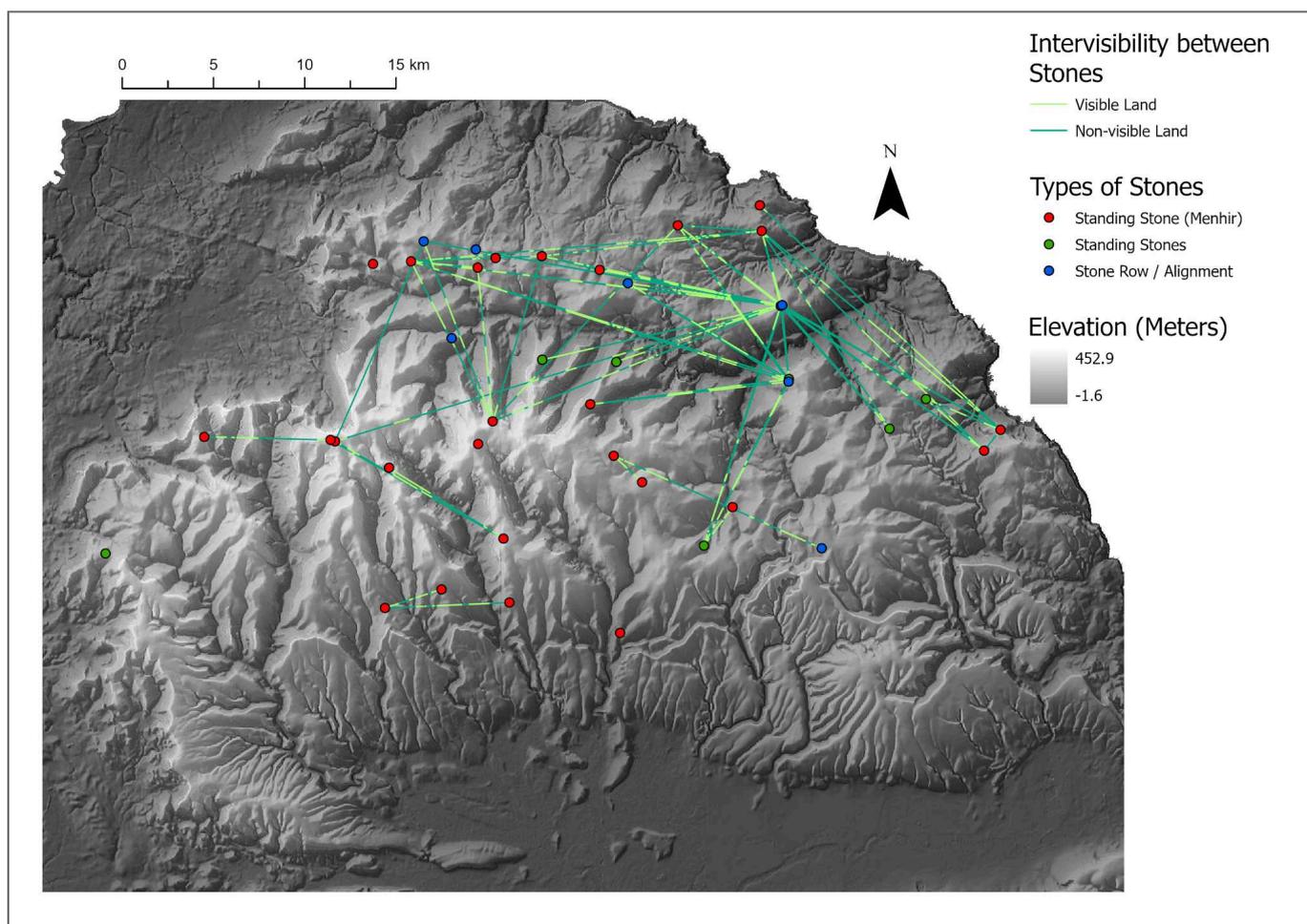


Figure 12: Map of the intervisibility between stones. Note that this map shows only unobstructed sightlines between stones. The non-visible land represented is land that is hidden behind small landforms or in valleys.

The output of this analysis was a straight line that connected each pair of stones to represent their visibility relationship, then separated into two sections, labeled either '1' for visible and '2' for non-visible (Figure 12). Using the Merge editing tool, each section was then combined into one solid line. 99 (12%) out of 820 have completely unobstructed views, meaning they are able to see each other, with the strongest concentration in the north-east region of the park. Unrestricted viewshed and intervisibility both showed a tendency towards the north-east area of the park.

Intervisibility between stones, whether abundant or not, could suggest a purposeful planning of a visual network, possible to control or to overlook natural resources (De Montis and Caschili 2012, 321). An intervisibility network of monuments could even be so important to communities that it influences settlement patterns (Eve and Crema 2014, 267).

The hypothesis for this analysis was correct in that whether a stone is (un)able to see and be seen by other standing stones in the landscape influences its placement location.

Conclusion

Next steps for this project would be to build upon the viewshed analysis. To begin, it would be helpful to normalize the point distribution so it does not overly-concentrate the visibility arrangement in one area. Also, to adjust the distance decay to different outer radii, and present it as a gradual decay rather than a hard boundary. Furthermore, investigating each type of stone separately would clarify data and make it more accurate.

Overall, using ArcGIS Pro to conduct analysis of terrain, viewshed (including distance-decay and elevation), and intervisibility between stones in NYMNP was successful. Out of these five results, the analyses that yielded the strongest results were terrain, elevation, and intervisibility, while both types of viewshed show slighter trends. Hypotheses 1, 2, and 4 were correct, while 3 needs further analysis to be conclusive. The data not only answered the research question of the locational tendencies of the stones, but also achieved the aim of the study which was to reveal factors that influence these tendencies.

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