Surveillance and Production on Stewart Castle Estate: A GIS-based Analysis of Models of Plantation Spatial Organization

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Chapter 1: Introduction

Archaeologists and historians have traditionally employed one of two basic models to identify and analyze influential factors for spatial organization of plantation sites: first, the centrality of production, based on the minimization of movement of laborers and raw materials for economic efficiency; second, the centrality of control, based on the direct surveillance of slaves and the incorporation of slave housing and slave workspaces into the planters' spatial order. To assess the strength of these two models, a surveyor's map of an 18th century Jamaican sugar plantation known as Stewart Castle is examined. GIS-based cumulative viewshed and anisotropic cost surface analyses are applied using geographical data to determine the degree of visibility and centrality of important elements on the plantation landscape, including the great house, slave quarter, sugar processing works, overseer's house and agricultural fields. This case study will evaluate the two models, as well as determine other potential limiting factors on spatial patterning, such as topography and land-use strategies. In addition, interpretations of the importance of movement and the possibility of slave appropriation of space on plantations are discussed. Finally, the study suggests the implementation of different methodological approaches to analyze the conditions that influenced plantation landscapes.

Previous Theoretical Approaches

Several archaeologists have analyzed the spatial aspects of plantations in the U.S. South and the Caribbean based on historical evidence and archaeological investigation. Two distinct interpretations are evident in their discussions: first, that key features of the plantation, including the great house, agricultural fields, industrial buildings and slave quarter, were organized in order to maximize the profits of the owner; second, that the same features were arranged to create an optimum level of surveillance and control over the enslaved labor force in their daily routines. While this synopsis might suggest that there are only two models of plantation organization, the authors discussed below present their findings as definitive portraits of spatial layout rather than ideal “models.” However, the interpretations are noted as models to investigate their applicability to a wide range of plantations. Specifically, these arguments fail to address other influential factors that shaped plantation landscapes, as well as the potential role of space in slave resistance to plantation hierarchies.

Studies by Kenneth Lewis, Charles E. Orser and Annette Nekola emphasize a planter’s desire to minimize the travel time of slaves and finished goods, thereby instituting a nucleated and centralized settlement plan. Lewis (1985: 37) describes Mt. Vernon to illustrate the ideal placement of the slave houses in neat rows next to the great house, creating a “compact settlement centered around the owner’s residence.” By using this example, Lewis fails to acknowledge the presence of other quarters around the Mt. Vernon property, which significantly limits the applicability of his analysis. Orser and Nekola (1985) take the argument of the importance of production one step further to state that, while racial distinctions separated inhabitants of the plantation landscape, the primary determinant in settlement location was the division of labor. A focus on economic production and power relations establishes an ideal plantation layout that presumes the location of the slave quarter close to the fields and industrial areas to maximize slaves’ time at work. Economic efficiency required a compact arrangement of plantation elements, often necessitating the location of the quarter on land that was marginal for agricultural planting. Following this argument, the spatial organization of plantations of any type can be interpreted as the result of the owner’s need to maximize work time, output and profits.

Other examinations of plantation spaces stress the centrality of surveillance and control over the enslaved population. Terrence Epperson acknowledges the distinction between the planter’s and the slaves’ perception of the same plantation landscape, concluding that the slaves’ landscape was determined by their subordinate status. Epperson (1999: 170) suggests that visibility was a primary motive for planters to design spaces to “make things seeable,” while also producing “spaces of constructed invisibility,” to monitor slaves’ behavior and conceal their presence. Thus, planters sought to legitimize their power and establish discipline through spatial control. James A. Delle’s analysis (1998) of Jamaican coffee plantations also emphasizes the planters’ control over space as an expression of power. Delle argues that Foucault’s theory of surveillance is relevant to the study of the plantation landscape, particularly the importance of visual observation as a form of social control. In addition, Delle discusses the significance of plantation social space and the division of the landscape into areas inhabited and utilized by members of different classes. Maximization of economic production was not the primary organizing principle; the planter class arranged spaces to survey the labor of slaves and control slave movement, thereby establishing their dominance in power and class hierarchies (Delle 1998: 157).

Some authors discuss the potential for both models to explain the spatial layout of plantations in the U.S. and Caribbean. Perhaps a balance was struck between distance and visibility such that the location of the three main components of the plantation, the great house, industrial center and slave village, conformed to the demands of efficient production *and* complete surveillance. Barry Higman, a noted Jamaican plantation historian, argues for the minimization of travel time between slave village, sugar cane fields and the sugar processing complex. The location of each plantation focal point was determined by its proximity to the other foci. For example, Higman (1988: 81) asserts that “the desire to minimize the time involved in movement of labourers meant that the estate village tended to be tied to the works rather than being located at a central site." In addition, the slave village was often placed such that the planter could survey the movement of his workers. In some cases, "the village is seen to be tied to the location of the great house…rather than being a direct response to the economics of movement-minimization" (Higman 1987: 29). Higman's acknowledgement of the two distinct interpretations allows him to account for the Jamaican planters' managerial system that was essential to the success of the island's sugar production. However, although production and visibility were both important, the placement of the works complex was essential to the effective functioning of the agrarian plantation. As Higman states, "the distances between the elements tended to vary in unison…the works and village were closely tied on Jamaican sugar estates, while great houses were satellites orbiting at relatively variable distances" (Higman 1987: 30). Thus, Higman analyzes the quantitative distances between the plantation features, concluding that the association between the village and the works (production) is stronger than that between the great house and the village (surveillance). The strength of Higman's argument is his use of survey maps of historic Jamaican plantations to evaluate his preliminary conclusions about the unprecedented economic efficiency of Jamaican sugar estates in comparison to their British and American counterparts.

Discussion

This brief summary of anthropological and historical approaches to the spatial arrangement of plantations suggests that the two interpretations offered distinct factors that influenced the location of plantation elements. On the one hand, the maximum production of sugar or other cash crops necessitated centralization of slave labor, agricultural fields and processing buildings. This model requires short distances between quarter, works and fields such that no time was lost in the movement of workers or produce. On the other hand, enslaved workers had to be monitored to maintain planter control and reaffirm planter supremacy in the plantation hierarchy. Planters knew that slaves could interrupt the system of production by withholding labor or escaping for brief periods of varying lengths (McDonald 1993: 16). Clear and constant surveillance would hinder these attempts. Placement of the slave quarter close to the great house, as well as positioning the overseer's house near the quarter, would be definite requirements, even if these locations hampered movement-minimization.

One critique of the authors' development of these models discussed above is their applicability to actual plantation landscapes. While authors such as Lewis use standing historic structures to support their arguments, the ideal layout gleaned from these arguments should be relevant to spatial arrangements recovered archaeologically. These arrangements include outlying quarters that Lewis does not include in his analysis of Mt. Vernon. Furthermore, although the incorporation of well-known examples is beneficial, the argument should also address factors that exist in multiple cases so that the plantation archetype is valuable for wide-ranging studies. Similarly, a second critique involves the authors' explanations for their particular interpretation. Most of the analyses include ideals based on a common-sense argument; either the plantation was a kind of agricultural factory that needed to maximize production in order to be profitable, or the planter sought to constantly survey his property to reinforce his position in a strict racial and class hierarchy. While these two evaluations are valid, they reduce the potential for understanding the variety of factors that influenced plantation spatial organization and the balance that planters reached between those factors. These simplistic explanations disregard the local environment, needs of the crop, size of the slave population, and the agency of enslaved laborers. If these models are meant to provide a definitive view of the plantation landscape, then they should acknowledge that the organization of plantation space characterizes the complexities of the relationships between planter, overseer and slaves, and illustrates the constraints of cash crop production.

Essentially, the two arguments described above fail to address a number of questions that a complete analysis of spatial arrangement of buildings, quarters and fields could clarify. These questions involve the environmental limitations on crop planting and processing, access to necessary resources, and provisioning of subsistence goods. For example, Did the cash crop require a constant water source for cultivation and production? How far was the closest source of timber for construction or pasture for livestock? How great was the distance to the farthest agricultural field from the overseer's house, slave quarter and industrial center? An in-depth analysis of a plantation would generate answers to these particular questions and demonstrate the kind of comprehensive explanations that are useful to evaluate models of plantation space.

Furthermore, by looking beyond superficial evaluations of spatial organization, broader hypotheses about the daily life of slaves and the patterns of movement of plantation inhabitants can be formulated. Specifically, issues not present in the current models include: the actual degree of visibility between the great house/overseer's house and the slave quarter, the distances between the works, overseer's house, quarter and fields, and the paths slaves used to reach fields, works and provision grounds. These issues suggest the significance of space to the perpetuation of the plantation system and the potential for slave agency. The analysis that follows considers the surveillance and centralization factors based on their influence on the relationships between distinct plantation elements. In addition, critiques of and alterations to the two interpretations are offered based on the outcomes of the analysis.

Chapter 2: Historical Background

The island of Jamaica is located in the western Caribbean 93 miles south of Cuba. The island was first occupied by the Spanish who eventually built two capitals, Seville and Villa de la Vega (Spanish Town). After the British takeover in 1655 and formal colonization in 1661, elite British investors turned Jamaica into a successful sugar colony similar to its smaller predecessor, Barbados. In the 18th century, British entrepreneurs began the planting and processing of sugar on a large scale, following the example of successful endeavors by other European powers in the Caribbean. By 1783, Jamaica surpassed Barbados as the empire's leading producer and exporter of sugar (McDonald 1993: 2). Jamaica's supremacy would last until 1815 when other rivals within the Caribbean increased their level of production and amount of return. With the profits collected from the sale of sugar, rum and molasses, Jamaica became an attractive settlement location for British elites who could easily establish their social superiority in local communities.

The success of Jamaica's sugar and coffee plantations was dependent upon the labor of enslaved Africans and, later, Afro-Jamaicans. By 1800, Jamaica was a "mature slave society" ruled by a small minority of white planters and supported by thousands of slaves (Higman 2005: 3). The disparity between free and enslaved was much greater in Jamaica than in mainland British colonies and later American states; nine out every ten people was enslaved in Jamaica versus four out of ten people in antebellum South Carolina and Virginia (Higman 2005: 3; Historical Census Browser 2004). Historian Barry Higman estimates that the number of slaves working on sugar plantations in Jamaica c. 1832 was 155,000, about 50% of the total slave population on the island. The average Jamaican plantation operated on a greater scale of both production and slave population than those in the U.S. As Higman (2005: 5) concludes, planters and plantations were prominent in "temperate settler colonies but it was the tropical agrarian system that became definitive."

The intensity and profit of sugar production in Jamaica was in part the result of an extensive internal economy (Higman 2005: 4). This internal system included the distribution of livestock to the coffee and sugar plantations and the supply of fresh produce to the general free population. An integral segment of this internal economy was the provision ground system, which centered on the slaves' planting of crops both to supply their daily meals and to sell at weekly markets. Slaves grew staples such as yams, corn, plantains, bananas and coconuts. Any work the slaves performed in their plots on the provision grounds had to be done after their work in the planter's fields, on a Saturday that they did not have to work, or on Sundays. Slaves also only had Saturday or Sunday to collect their crops, travel to the market and sell their produce. Families with plots often divided the provision ground duties, with men tending to the crops and women going to market. William Beckford in his description of the island of Jamaica noted: "they must go to the mountains early in the morning to search for provisions, that they may be in time to barter or to vend them at the well-known town…although it should be ten, or even a more considerable number of miles from the plantation" (Beckford 1790: 153 (Vol. 1)). The importance of the provision ground system is evident in Beckford's comments about the laws passed in Jamaica to maintain slaves' access to land. He states that the overseer of each plantation was bound by law to provide acreage "for the use of the negroes" for their provisions (Beckford 1790: 164 (Vol. 1)).

In addition, the provision system had implications for the social lives of enslaved laborers. Details about these implications can be discerned in Beckford's *Remarks upon the situation of negroes in Jamaica* in which he describes the difficulties experienced by newly arrived African slaves. Planters did not grant these new slaves the same "independency which the others enjoy" to choose their own space in which to work in the provision grounds. His comment suggests that the slaves themselves considered this land their own to the exclusion of other slaves. Another passage in Beckford further demonstrates this idea, "A plague is not so destructive upon a property as the removal of negroes from their accustomed grounds, from those grounds that have been delivered down from father to son… the consequence will be, declining health, a broken spirit, and an early end" (Beckford 1788: 91-92). Some slaves may have used the provision plot as a form of property to pass on to future generations, one of only a few "possessions" that they managed. Historian Roderick McDonald indicates that planters accepted the slaves' control over this land and "recognized the peril of trespassing upon what the slaves conceived as customary rights, and of breaking what had the effect of a compact" (McDonald 1993: 16). Thus, the provision ground system was not only a necessity for the success of sugar cultivation on a grand scale, but also was an arena in which a limited degree of slave agency was tolerated. Quality of land and access to the main roads are key features of the provision ground system that can be further explored to clarify the daily requirements of slaves to make their plots prosperous.

Historical Evidence

A brief analysis of the evidence of plantation spatial organization from historical sources about Jamaica provides details about contemporary views of an ideal plantation and is useful for comparison to real world examples. The authors of these volumes describe a number of factors that influenced the location of necessary sugar plantation elements such as the works, overseer's house and the slave village. The topography of an estate was also considered by the authors, with recommendations given based on the type of landscape and the availability of water. Finally, the authors note that the area utilized by slaves for their livelihood and profit, the provision grounds, was also ultimately under control of the planter in terms of its location on his property. The sources considered here are three historical works by William Beckford (1788, 1790), a descendant of Jamaican planters, and Thomas Roughley (1823), a successful Jamaican planter.

The elevation of Jamaica varies considerably north to south and east to west; the Blue Mountains rise to more than 2000 meters high in the east, while the southern coastal plains are nearly flat. The interior of the island is a series of hills and valleys that provide relatively fertile agricultural land. William Beckford and Thomas Roughley discussed the qualities of a Jamaican sugar estate in terms of "flat" or "hilly", and made recommendations to other planters based on their experiences with each type of landscape. Roughley argues that hilly land required more attention from the planter given "its various inequalities", while Beckford comments that, for the enslaved laborers, the work on hilly estates was not much more "fatiguing" (Roughley 1823: 257; Beckford 1790: 170 (Vol. 1)). In terms of spatial arrangement, both authors note that planters owning hilly estates had additional considerations for the placement of their fields. Beckford particularly notes that the mode of transport of the cut cane to the works is different for a hilly or flat estate; only mules should be used for transport over hills, while wagons should be used on flat land for easy conveyance (Beckford 1790: 70 (Vol. 2)). Slaves' travel from their village to the cane fields and throughout their daily labor was clearly impacted by the topography of the estate. While planters worried about the logistics of placing fields and buildings on a flat or hilly estate, slaves frequently experienced the "inequalities" of the landscape.

The planting, cutting and processing of sugar was the subject given the greatest amount of consideration by Roughley and Beckford. This fact indicates not only the primacy of the crop to the Jamaican planter, but also the impact that sugar had on every aspect of plantation life, including organization of space. According to Roughley, sugar cane grows best on land with a "gentle" elevation that allows water to drain and reduce the potential for erosion (Roughley

1823: 218). A majority of the coastal plains and inland valleys meet this requirement. The general trend for planting cane was thus to utilize whatever flat land was available. Furthermore, the cane fields and the works would have to be in relative proximity to one another so that the cut cane did not spoil before crushing in the mill. Planters owning large tracts of land often built an additional works complex in order to accommodate cane that was a considerable distance form the original works. Following the ideals of the Enlightenment, Roughley (1823: 235-6) recommends placing sugar cane "into as close an order" and as "contiguous to the works" as the "nature of things" would allow. The works complex should be located in a central area of the estate to minimize distance from the cane fields; this complex should be large enough to accommodate the various buildings of sugar processing (Roughley 1823: 182-83). While Roughley claims that a central location is "most desirable", he does not account for possible variations in topography that may hinder placement of the works in the center. This exclusion plainly indicates that Roughley was suggesting ideal requirements of a Jamaican plantation. Comparison of his suggestions to current data may suggest some of the factors that he did not consider.

Within the works complex itself, the space had to accommodate a number of buildings including the mill, boiling house, curing house, storage buildings and possibly the overseer's house and/or a distillery. In Jamaica, a majority of the mills were operated by water or cattle, with a few steam mills beginning in the first decades of the 19th century and even fewer wind mills. Mills powered by water clearly had to be located near a steady water source, while the cattle mill would require numerous animals during the harvest season to sustain a profitable output. While Beckford notes exact dimensions for the boiling and curing houses, Roughley suggests that the sizes of the works buildings should be proportionate to the estate's output

(Beckford 1790: 30 (Vol. 2); Roughley 1823: 193-4). In addition, all buildings within the works needed to be relatively close to one another to minimize potential spoilage of the cane.

Roughley and Beckford were most specific with the location of the overseer's house. This building had to be located not only close to the works, but also at a higher elevation than the surrounding landscape. Beckford clearly states that the overseer's house had to overlook every possible location of slave employment and habitation, apart from the provision grounds and all agricultural fields (Beckford 1790: 14 (Vol. 2)). Except during the harvest season, the overseer would no doubt accompany the slaves to the fields.

From the planter's perspective, the location of the slave village was as important an element of the plantation landscape as the works and the overseer's house. Beckford notes that the general trend he observed was that a slave had to travel a significant distance to the works but was by no means out of sight of the overseer. Adhering to the ideal of the European elite, the "custom" was to build the slave houses "in strait lines, constructed with some degree of uniformity and strength" (Beckford 1790: 20 (Vol. 2)). Beckford also mentions the picturesque beauty of the village houses among the tree and shrubs, although he later states that the custom is for the quarter to be "totally divested" of vegetation. The latter characteristic was presumably essential to the overseer's surveillance of the slaves (Beckford 1790: 227-28 (Vol. 1), Beckford 1790: 20 (Vol. 2)). Thus, according to historical sources, the village was located relative to the works and overseer's house.

Most of the authors' descriptions of the provision grounds emphasize their distance from the slave village or even the plantation itself. Beckford in particular provides romantic portrayals of the landscape that the slaves would encounter on their journey from the plantation. He notes that some grounds were difficult to access and farm given their location among "majestic trees of an amazing height and thickness" (Beckford 1790: 255 (Vol. 1)). While Beckford admires the beauty of the scenery, he laments the distance which the old and young slaves would have to travel (Beckford 1790: 154 (Vol. 1)). Higman (1988) argues that the similar names for plantations and "mountains" (Mt.) discovered in his examination of Jamaican historical records suggests that provision grounds and ruinate may have been at a considerable distance from the main plantation. In addition, Beckford and Roughley suggest that higher elevations were the most common locations for provision grounds given their "better seasons" and timber resources (Beckford 1790: 169 (Vol. 1)). Therefore, the location of the provision grounds may have presented a particular problem for planters in terms of surveillance and for slaves in terms of travel.

Chapter 3: Stewart Castle Estate

The focus of this analysis is a late 18th century plantation in northwest Jamaica known as Stewart Castle. Located on the coast of the parish of Trelawny, the estate of James Stewart was composed of 1,230 acres, nearly 500 of which were planted with sugar cane (Panning 1995: 172). Most of the information available on the history of Stewart Castle is provided by family documents only located in the National Library of Jamaica in Kingston. One article written by Steven Panning details his survey of the estate in the late 1990s. Panning describes the existing structures and embellishes his account with excerpts from two historical documents written by 'James' and 'John' Stewart. It is unclear if the James Stewart who is credited with writing *Brief account of the Present State of the Negroes in Jamaica* (1792) was also the owner of the plantation recorded on a 1799 plat of the estate. This plat was drafted by Munro, Stevenson and Innes, a surveying firm that recorded a number of plantations between 1796 and 1804, headed by a wealthy Jamaican planter, Thomas Munro (Figure 1; Higman 1988: 34). The final source available on Stewart Castle is a painting by J. B. Kidd detailing the works complex and the Castle in the northwest corner (Figure 2). This image clearly shows the cattle mill that crushed the cane from the surrounding fields, as well as the other sugar processing buildings and the roads that crossed the estate.

Since the following investigation of the general characteristics of plantation spatial organization is based on the 1799 plat, it is necessary to describe the utility of these maps to assess the condition of estates at the time of survey. Historian Barry Higman studied a number of Jamaican plats from the Institute of Jamaica and selected a sample that exemplified the qualities of sugar and coffee plantations, cattle pens and gardens. He also analyzed the maps themselves in terms of the surveyors, measurements, symbolization and accuracy. For the purpose of this analysis, Higman's assessment of the precision of the surveys is useful. A

Figure 1. Plan of Stewart Castle Estate, 10 chains to 1 inch, Munro Stevenson and Innes, 1799. (Courtesy of DAACS)

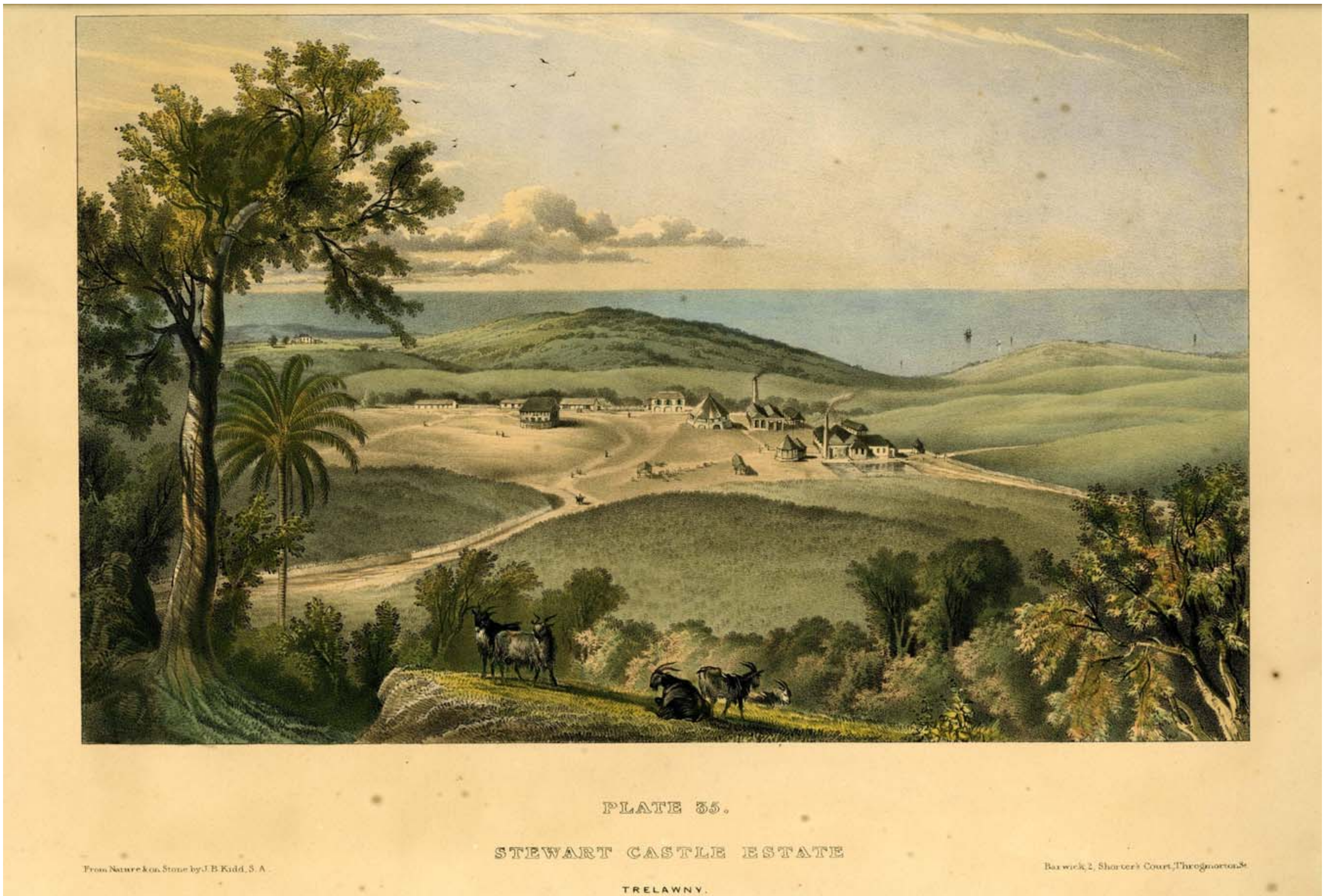


Figure 2. Stewart Castle Estate. (Courtesy of DAACS).

majority of the maps were measured with a scale of ten chains to one inch, with each surveyor's chain equaling 66 feet (Higman 1988: 49). Fields and other areas were mapped, numbered and their acreage recorded in an accompanying table (Figure 3). Higman emphasizes that the maps were primarily utilitarian in that "a premium was placed on accuracy of representation and measurement" in order to provide "reliable data" to planters (Higman 1988: 78). Planters could not afford to have an imprecise calculation of the number of acres of sugar or other crops. The measurement of crop fields impacted the planters' estimates of their yield for the year, the level of productivity they could expect and the costs of planting and harvesting a particular field (Higman 1988: 79). In addition, a plat of numbered fields could be beneficial to the overseer to efficiently monitor the progress of cane within each sector.

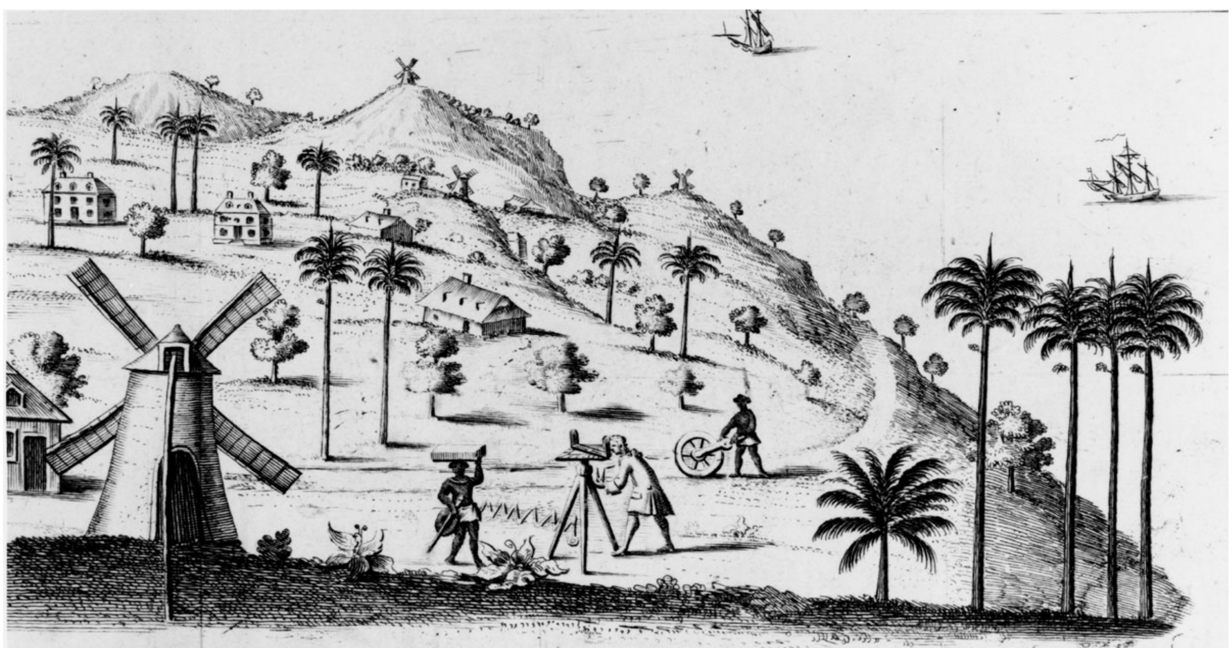


Figure 3. "Slaves Assisting a Surveyor, Barbados." (William Mayo, 1722).

Other parts of the plantation, however, did not require the same amount of precision in surveying. The Stewart plat can attest to this fact since the areas denoted as "Negro Houses" and "Negro Grounds" are not subdivided, and the acreage given is more general. In addition, the works and the Castle of the Stewart estate are more accurately drawn than the slave village houses. Finally, plantation sectors were color-coded according to their particular crop. In the Stewart plat, sugar cane fields were outlined in blue and guinea grass fields in yellow, with other areas simply outlined in black.

A number of different agricultural and industrial areas within the estate are identified on the Stewart plat. These areas were mapped using ArcGIS in order to calculate statistics about each type of region (Figure 4; Chapter 4). According to the 1799 plat, the Stewart Castle estate contained 42 sugar cane fields, totaling approximately 486 acres. The estate also had 60 fields of guinea grass interspersed with the cane and in other areas throughout the property, totaling approximately 150 acres. These fields were necessary to feed the cattle which ran the sugar mill (marked as #64 on the plat). The allotted provision grounds, which likely included the land surrounding the slave village (denoted as “Negro Houses”), totaled approximately 228 acres (#45). This total includes the area where the houses stood, as well as the “Rocky Wood Land”, which was presumably not fit for cane or grass cultivation. Stewart also had a 40 acre field designated “Morass & Pastures” (#69), which likely served as feeding ground for the cattle while the guinea grass was maturing. The estate also contained a works complex that served to process most, if not all, of the sugar cane. A second works complex may have been located almost directly south of the works, although the “Reference” table or key for the plat is unfortunately missing for the areas numbered 62 to 71. Finally, the Castle itself and the compound enclosing it (#68) occupy three acres.

Historic Stewart estate included six main landmarks noted on the 1799 plat which are the focus of the following GIS analysis. First, the slave village, drawn as several rows of small squares on the map, would have been the center of the slave life during off hours. Since the

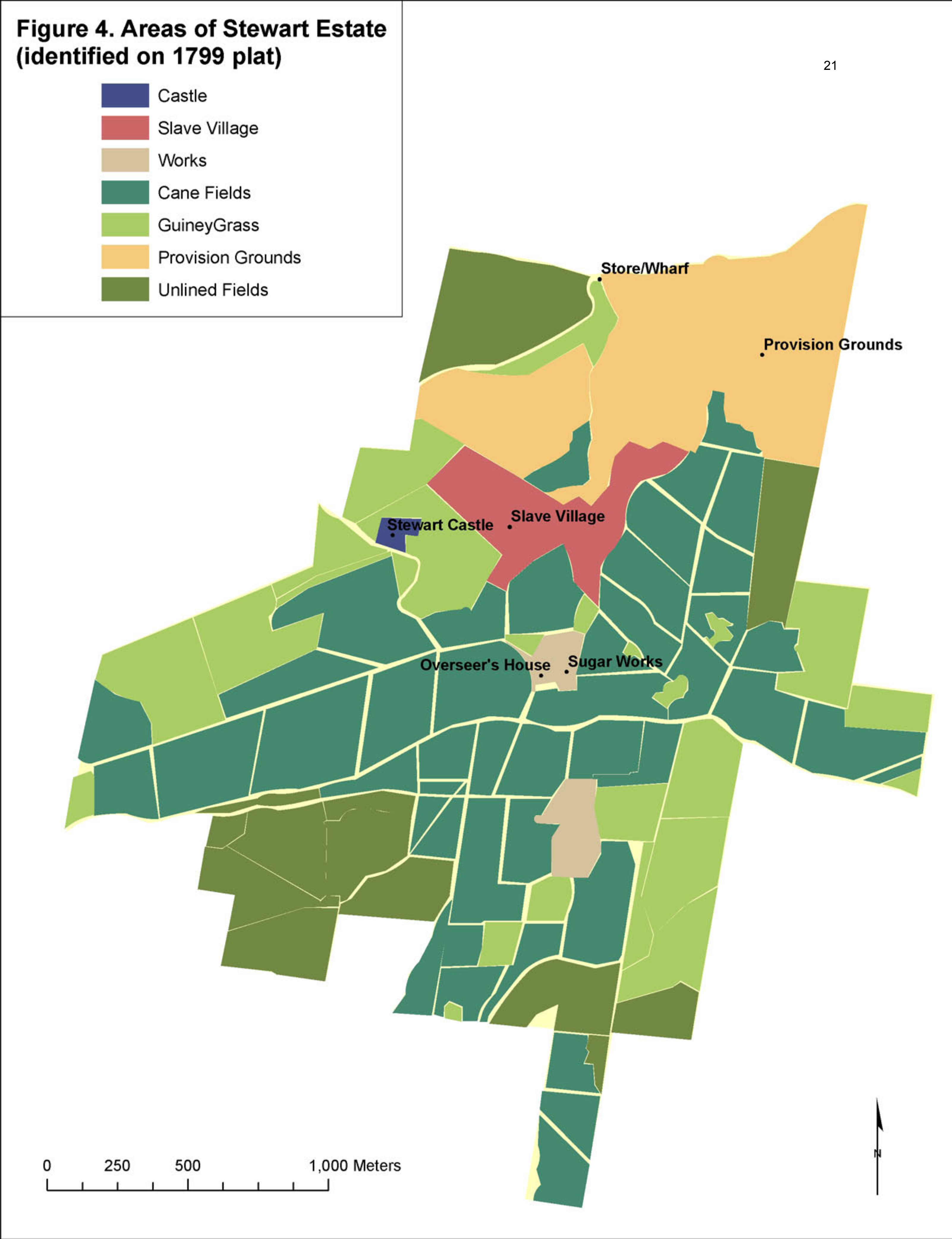


Figure 4. Areas of Stewart Estate
(identified on 1799 plat)
Castle
Slave Village
Works
Cane Fields
GuineyGrass
Provision Grounds
Unlined Fields
Store/Wharf
Provision Grounds
Stewart Castle
Slave Village
Overseer's House
Sugar Works
0
250
500
1,000 Meters
N

surveyor marked that the houses appeared in discernible rows, it is possible that the village fell under the domain of the Stewarts' spatial organization. Second, the provision grounds were located quite close to the village, in comparison to historic accounts of the possible distance that slaves had to travel to their plots. Third, the Stewarts controlled the export of their sugar products through a wharf located on the northern coastline. Enslaved workers would move the manufactured sugar over the northern slopes to the store and, later, onto a ship (Figure 5).

Figure 5. "Shipping Sugar, Antigua, West Indies." (William Clark, 1823).

Fourth, the sugar works, which included the cattle mills, boiling house, curing house and storehouses, was the industrial center of the plantation. Once mature cane was cut from the fields and loaded onto wagons or donkeys, it was taken to the mill where cattle powered the grinders to produce cane juice (Figures 6 and 7). The juice was then boiled in a series of vats

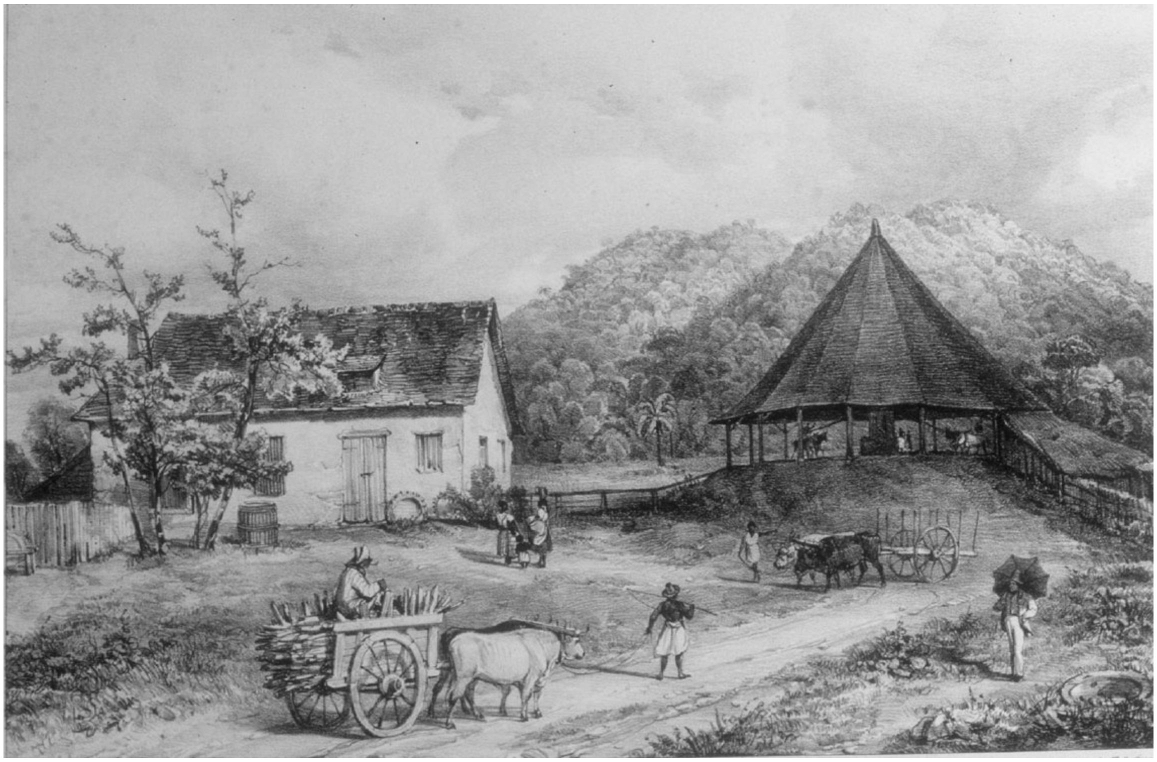
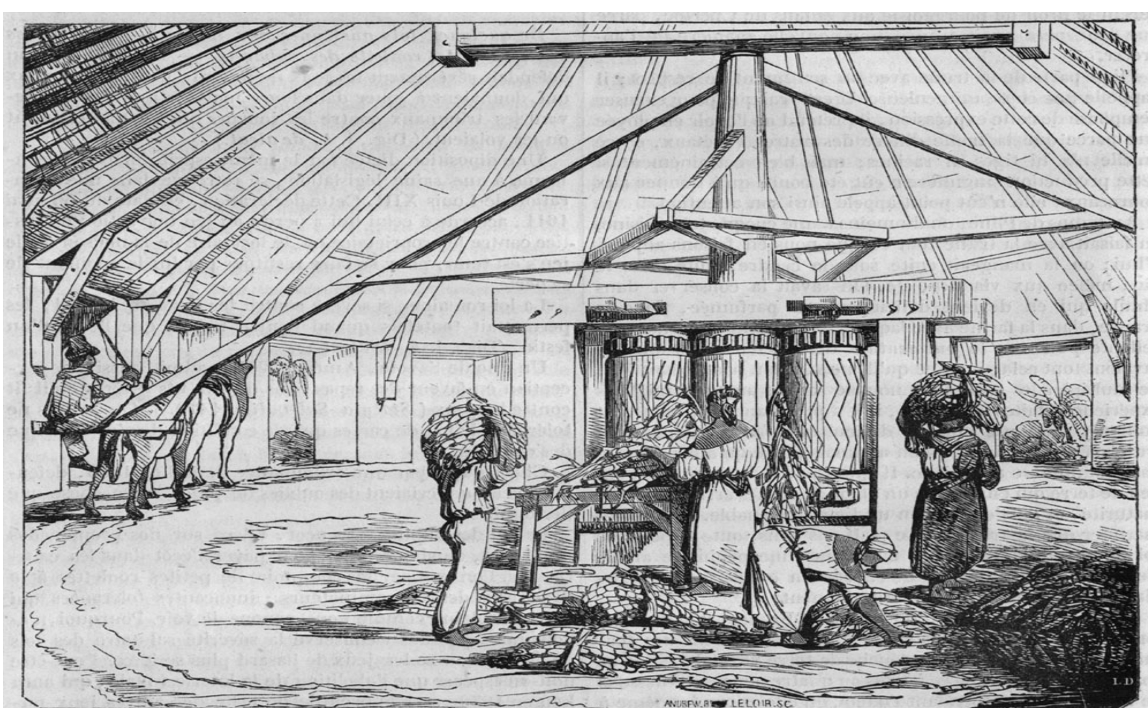


Figure 6. “Sugar Mill and Boiling House, Trinidad.” (Richard Bridgens, 1836).



(Moulin pour exprimer le jus des cannes, à la Martinique.)

Figure 7. “Animal-Powered Sugar Mill, Martinique.” (*Le Magasin Pittoresque* 1835: 68).

and cured for a number of weeks (Figure 8). Fifth, the overseer's house was located in the same numbered field as the works, according to Panning (1995: 174). This house was clearly the focal point for surveillance of enslaved laborers and for managing the daily efficiency of the estate. Although the exact building marking the overseer's house could not be determined, its location within area #64 is fairly certain.

Finally, the Castle itself was a fortified structure surrounded by a masonry wall topped with broken wine bottles. While most Jamaican great houses were open to the island breezes, the Stewarts chose to secure their house from possible raids by maroons or their own slaves. The castle complex includes two defensive towers on the house itself, a cellar and water tank for daily and emergency use, and, in most cases, slits in the high castle walls instead of windows (Panning 1995: 202). These six points are the key elements in plantation spatial organization that comprise the chief components of the GIS analysis.

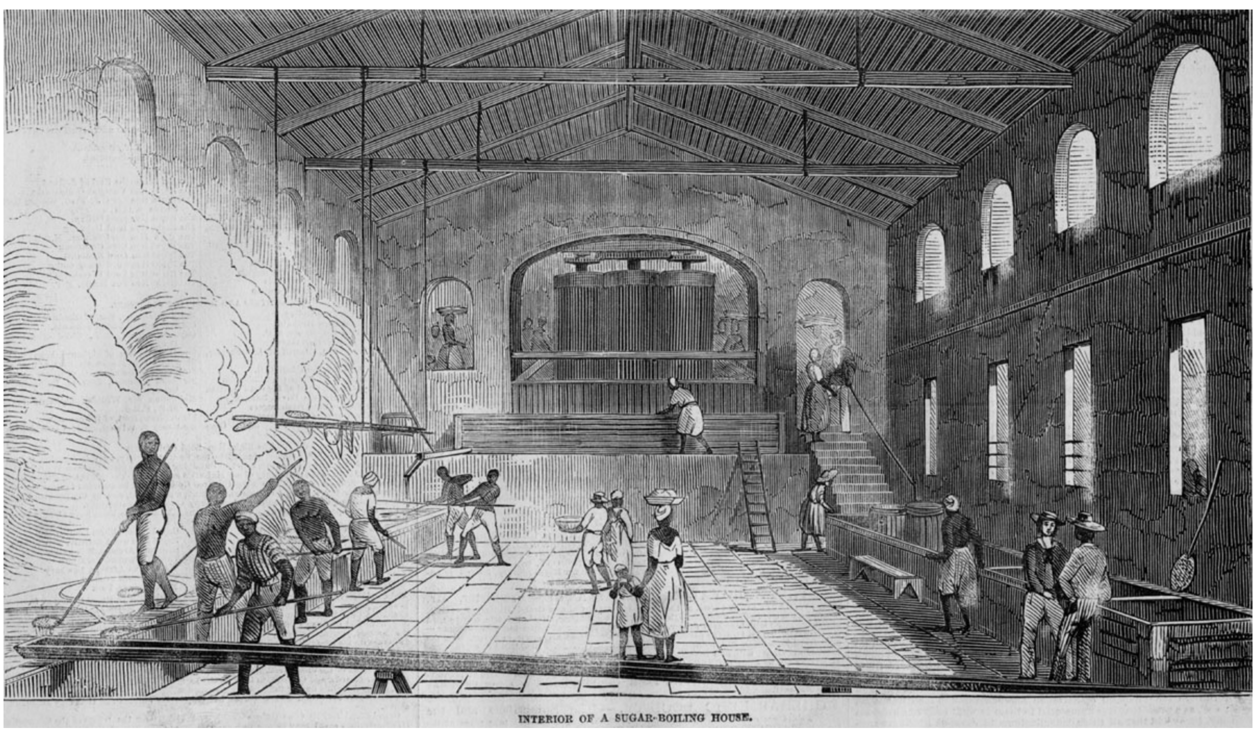


Figure 8. "Sugar Boiling House, Trinidad." (Richard Bridgens, 1836).

Chapter 4: GIS Applications

To geographically assess the impact of surveillance and centralization on plantation layout, certain functions within the GIS suite of programs were utilized. These functions analyze particular geographic data relevant to Stewart Castle, such as the elevation of the terrain within the estate and distances between plantation elements. The elements included in this analysis are the Castle, the slave village, the overseer's house, the sugar works, the wharf (store) and the provision grounds. While some of these features may seem unique to sugar plantations, their general purpose within the historic plantation system can be correlated with similar elements in the U.S. and Caribbean. For example, while the sugar works contained buildings specific to the processing of sugar cane and storage of the products, many plantation landscapes included a works complex to process cash crops, such as tobacco, cotton, rice, coffee and indigo. Furthermore, locations similar to the wharf/store could be the edge of the estate along the road to the market or to the local mill.

In addition to various calculations such as area and slope, the two most applicable functions for this study are viewshed analysis and least cost analysis. As Pieter van Leusen (2002: 6-2) states, "People's choices both structure [their] 'resource landscape' and are structured by it, and we therefore expect archaeological remains to exhibit structuring of this type. Viewshed and cost surface analysis are two ways to reveal such structuring." These functions allow for both theoretical and concrete evaluations of the placement of plantation features. The outcomes of these functions are interpreted to assess the validity of the spatial organization arguments presented above, namely the primacy of surveillance or the primacy of economic efficiency in plantation layout.

In the theoretical case, viewshed and least cost analyses indicate the ideal locations to maximize surveillance and to minimize movement between plantation elements, respectively.

Furthermore, a comparison of the best locations and the actual positions reveals the degree of similarity between the definite and the ideal. In cases where there is notable dissimilarity, other factors can be suggested to account for the observed spatial organization. If surveillance and movement-minimization are not the dominant factors, then planters considered more than their profit margin or their degree of control in the layout of their estates. Thus, the inaccurate predictions of these models can reveal factors not previously addressed. In the actual case, the historic placement of elements is evaluated both by the extent to which the points are intervisible and by the cost of traveling between them. This kind of implementation of viewshed and cost surface analyses appears relatively unique in the field of plantation archaeology. The implications of these new methodological approaches to plantation spatial organization are discussed below (Chapter 7).

Initial GIS Processes

Many functions in the ArcGIS program utilize digital elevation models (DEMs) that store elevation data (z scores) of a given landscape. In the case of Stewart Castle, the DEM was created from a two-dimensional graphics file (DXF): a contour map of a large portion of northwest Trelawny parish. This process was completed by using the "Topo to Raster" function in ArcGIS. Since contour maps often have missing data between the contour lines, the function interpolates information from the input map by using a "drainage enforcement" rule. This rule assumes that water is the primary force that shaped landscapes, with hilltops more common than sinks, and therefore provides nearly accurate representation of streams and ridges (ESRI 2006). Based on this assumption, the interpolation includes an analysis of the morphology of the input landscape and estimates of the elevation at the cell level. The Stewart DEM is the basis for the study of elevation and landscape features discussed below. The original DEM included elevations from the northern coast such that the file had to be adjusted to include only positive (above sea level) values. The DEM was also clipped to only include data for Stewart Castle to ensure that more complicated functions would be limited to the study region. Finally, a hillshade was created for the DEM that estimated the shadows made by the sun's rays to provide a 3-D effect; this image is often the underlying layer of the figures in this analysis (ESRI 2006).

In addition to the production of the DEM, the 1799 plat of Stewart Castle was imported into ArcGIS and aligned with a modern georeferenced image of the particular region. This second step resulted in a new version of the 1799 plat that is calibrated to known geographic locations of landmarks; in this case, several modern roads are in the same locations as historic roads marked on the plat. The newly georeferenced plat is useful for creating data point files of the six plantation elements and for generating polygon shape files necessary for further GIS calculations.

Introduction to Viewshed Analysis

Viewshed analysis is based on the intervisibility of any two points in the study region. This process is based on elevation data from DEMs such as the one created for this analysis. Basic viewsheds reveal what areas of the study region are visible and not visible from a given point. More complex elaborations of this function are discussed below (Chapter 5). The creation of viewsheds is relevant to this paper because it provides an opportunity to assess visibility from one point across the estate and between particular points without data from a direct topographical survey of the current landscape. By utilizing the DEM, the GIS user can create a series of viewsheds that aid in the interpretation of plantation layout, based on an observer's capacity to survey the estate from any given point. In this way, viewshed analysis is a helpful tool to evaluate the validity of the surveillance hypothesis using acquired data from an historic plantation rather than presumed ideal conditions.

Introduction to Cost Surface Analysis

Least cost analysis is an equally useful function in GIS. The process is based on cost surfaces, which model the cost of moving from point A to point B on a given landscape (Conolly 2006: 214). Two different types of cost surfaces exist in GIS analysis: isotropic, which uses an average slope calculation for each cell; and anisotropic, which uses the effective slope that accounts for the direction of travel within each cell. Anisotropic costs were the preferable surfaces used in the following theoretical analysis since the overall slope of the estate is highly variable even on the cell level. As Conolly (2006: 218) states, "Slope that is experienced when traversing a map cell varies from zero to the slope, according to whether the direction of travel is perpendicular to, or parallel with, the aspect, respectively." In this analysis, costs ascribed to slope values are given by Waldo Tobler's hiking function that employs the following equation:

$$V = 6\, e^{-3.5\, |s +. 05|}$$

where "*V* is the walking velocity in km/hr, *e* is the base of natural logarithms, and s is the slope measured in vertical change over horizontal distance" (Kantner 2004: 327). Since the estate is not crossed by any rivers or streams, and no other landscape data is readily available, the Tobler cost is the only cost applied in the analysis. The cost surface output represents accumulated cost experienced by the traveler across the estate and reveals the areas that required the least amount of effort to reach. This function can evaluate the movement-minimization hypothesis since it locates areas for ideal placement of certain plantation elements, such as the overseer's house and the works, according to relatively reduced cost and travel time. In addition, the actual locations of elements can be assessed in terms of the paths between them. Similar to viewshed analysis, least cost analysis can be used to judge the validity of the economic efficiency hypothesis and may offer insight into paths of movement only exploited by slaves.

Critiques

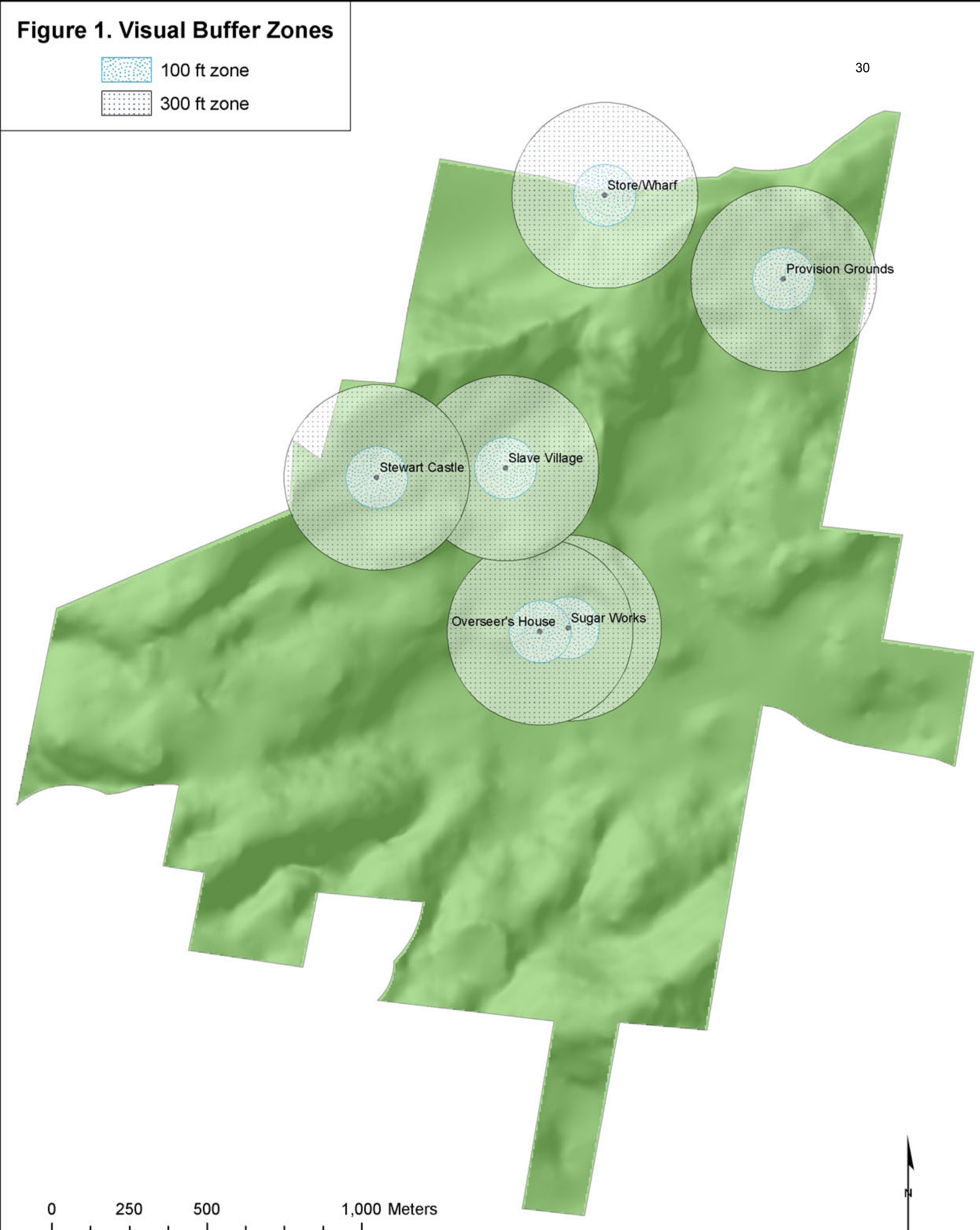
A number of critiques concerning the applicability of these functions to real world data have been raised. A valid critique of the viewshed function relevant to the Stewart Castle case is that it does not take into account the observer's acuity of vision since this factor would require unavailable information (Conolly 2006: 232). While no concrete solution is available, this critique is partly accounted for by visual buffer zones around the six plantation points (Figure 1). According to psychologist Geoffrey Loftus, at 500 feet the average person could see another "person's head but just as one big blur. There is equivalence between size and blurriness. By making something smaller you lose the fine detail" (Schwarz 2005). For the Stewart example, in theory the planter could see the slaves within their village but could not necessarily discern their individual actions. The viewshed analysis below assumes that the observer has a relatively strong acuity of vision.

A legitimate critique of the cost surface function is identified by van Leusen (2002: 6-9), "GIS least cost implementations…only make *local* decisions as to which neighboring cell has the highest or lowest value – they incorporate no *global* knowledge of the landscape at all." As a solution to this shortcoming, van Leusen suggests that the routes created by the cost surface function should be compared to any documented historic roads or paths. This comparison "should then indicate the presence of intermediate goals which can be further investigated." Van Leusen's suggestion is addressed in Chapter 6; the potential absence of roads that follow least cost paths from the village may indicate that slave owners were not concerned with identifying slave paths.

Basic GIS Calculations

ArcGIS performs common statistics on geographical input data such as contour maps and other survey records. One such process is an assessment of slope, in this case applied to the

Figure 1. Visual Buffer Zones



different fields represented in Chapter 3, Figure 4. As noted above, historical authors remarked on the tendency of cane fields to occupy the land with the least change in slope. According to Beckford and Roughley, "flat" land was reserved for sugar cane; other agricultural crops were relegated to poorer quality, "hilly" land. Did the fields of Stewart Castle fall into this general pattern? Did Stewart select the best land to plant with cane? A sequence of figures below addresses these questions. First, a general slope map overlaid with the different types of fields illustrates that the majority of the cane fields occupies the valley (light yellow-green) between the two large hills in the northwest and southeast of the estate (Figure 2). Furthermore, the other agricultural zones (guinea grass, provision grounds and unknown fields) appear to occupy areas of greater variation in slope (bright green and dark blue). This map provides an initial interpretation of the Stewarts' decisions concerning land use.

Figure 3 represents the average slope of cells in each cane field (42 total). The slope values range from 3.83 to 35 degrees, with eight fields in the smallest slope category and nine in the largest slope category. Clearly, the band of fields across the center of the estate represents the best cane fields in terms of minimal variation in elevation. This finding supports Roughley and Beckford's observations about the ideal location of cane fields in well-drained, "flat" areas. As a basis of comparison, slope maps were generated for the guinea grass fields, provision grounds and unknown fields. Figure 4 shows the range of slope values for the guinea grass was 6.3 to 45.2, with six fields having a slope greater than 29 degrees. A peculiar aspect of the guinea fields was the location of several two to three acre fields with minimal slopes interspersed among the cane fields. One explanation for this pattern could be the need for nearby pasture for the cattle driving the cane mill. Since a majority of the guinea grass fields were located along the perimeter of the estate, the Stewarts may have desired to have a closer source of fodder for

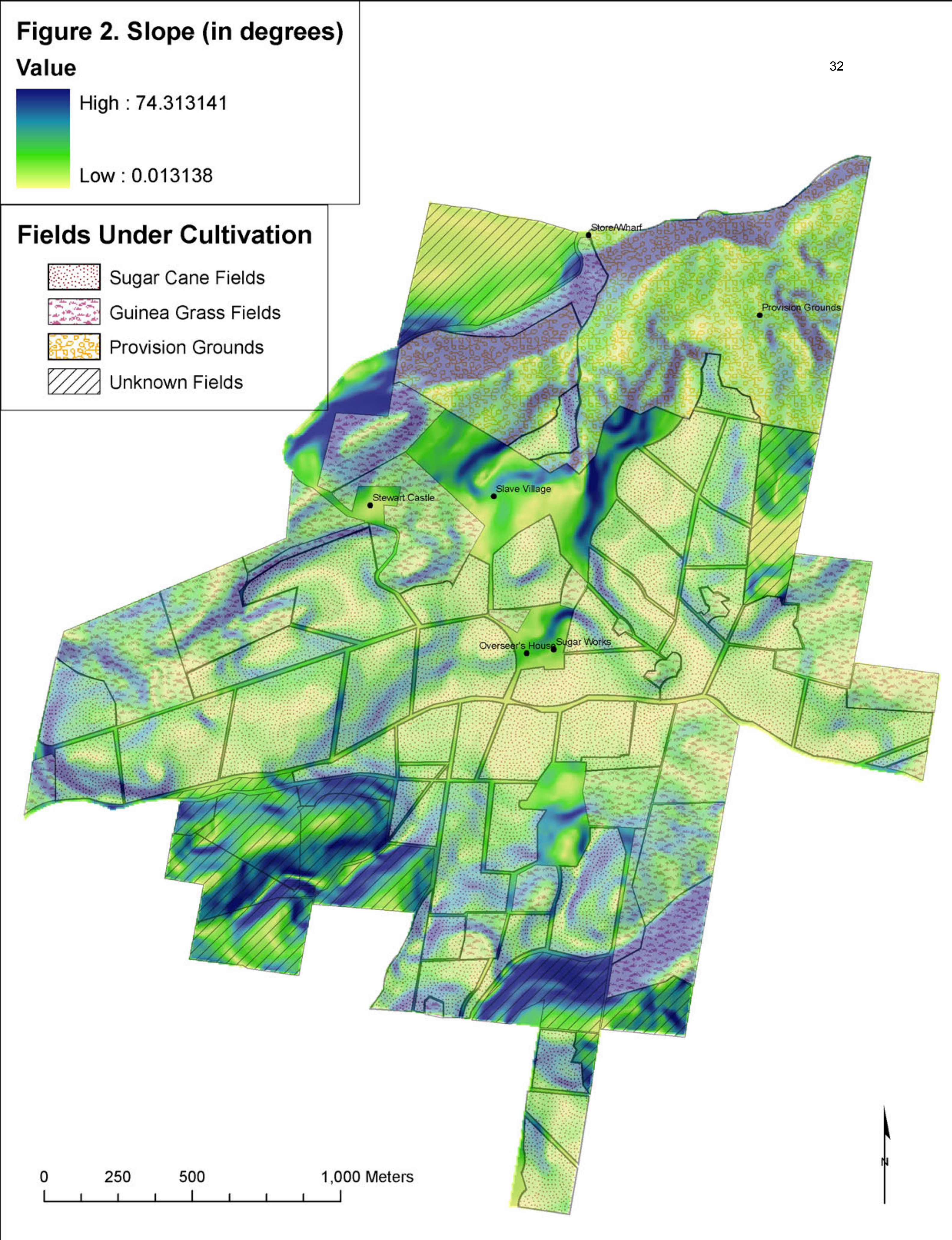


Figure 2. Slope (in degrees)
Value
High : 74.313141
Low : 0.013138
Fields Under Cultivation
Sugar Cane Fields
Guinea Grass Fields
Provision Grounds
Unknown Fields
Store/Wharf
Provision Grounds
Slave Village
Stewart Castle
Overseer's House
Sugar Works
0
250
500
1,000 Meters
N

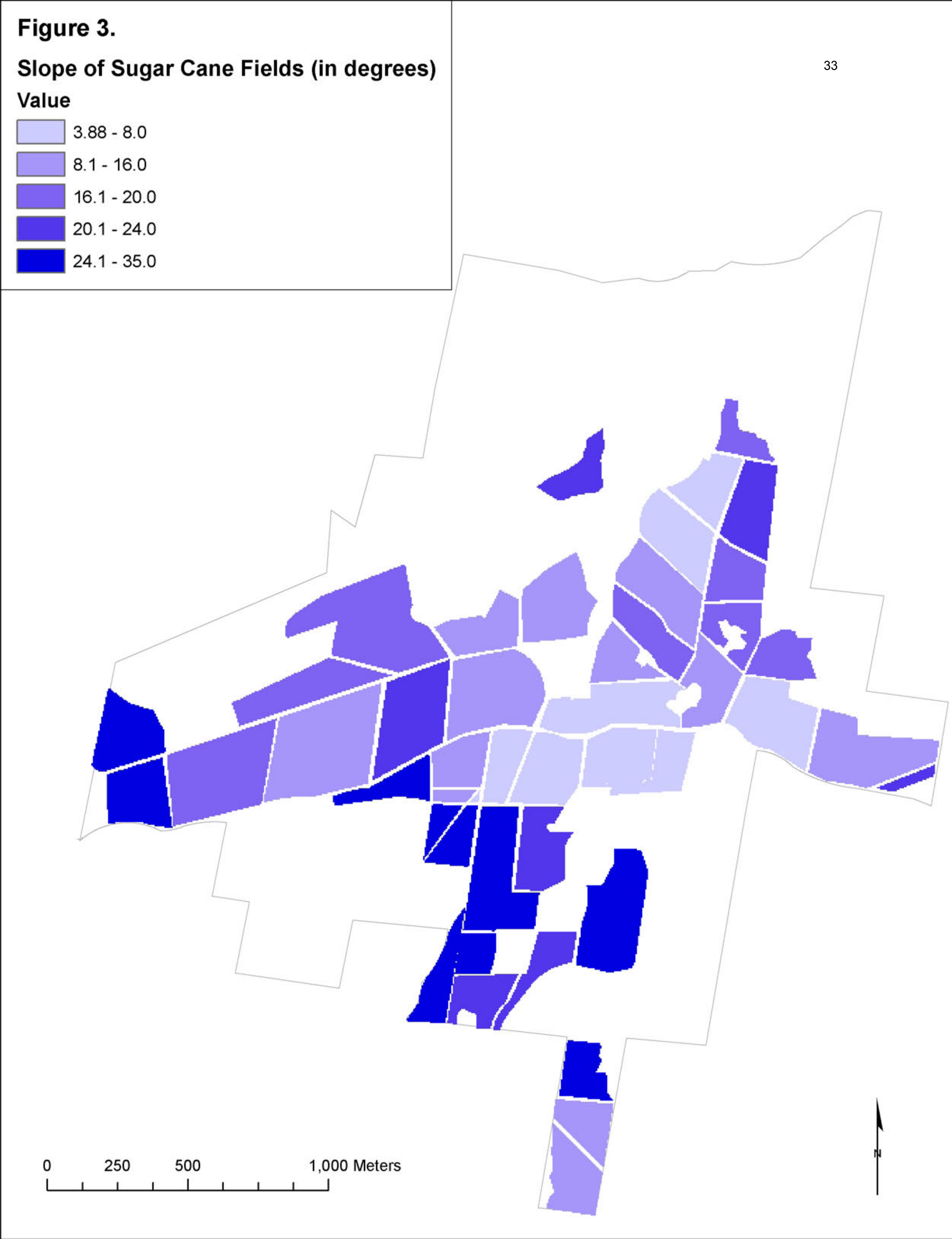


Figure 3.

Slope of Sugar Cane Fields (in degrees)

Figure 4.

Slope of Guinea Grass Fields (in degrees)

the livestock. This hypothesis supports the movement-minimization argument since the influential factor of the observed land use pattern is economic efficiency.

Figures 5 and 6 illustrate the great variation in slope across the plantation. Figure 5 contains only two fields representing the provision ground areas; the slope of these fields is quite high relative to the valley of cane fields. This observation supports the historical accounts of the provision grounds being located in remote areas of the plantation. The two fields are on the northern slope of the mountain and the coastal plain, less than ideal locations for cash crop plots. Figure 6 shows fields of unknown usage; only the northwest corner field was identified as "Morass and Pasture" on the 1799 plat (#69). The larger slopes of the southern fields (> 23º) indicate the propensity to preserve the central valley for cane fields.

Finally, a box plot of the mean slope values further demonstrates the differences in slope between agricultural field types (Figure 7). Given the statistics available through ArcgGIS, the median, first quantile (median of first half of data), mean and third quantile (median of second half of data), were determined by using the mean slope of each field. The box plot of the provision grounds is skewed given the very small sample of two fields; this creates only one value for all four statistics. However, the plot indicates that the provision grounds had the highest slope value out of the four agricultural areas, further signifying the poorer quality of this land for intense cultivation. For the unlined fields, the median slope value was also greater, which suggests that this land was also not ideal. The guinea grass plot illustrates a great degree of variability within the fields and in comparison to the other areas. This result likely reflects the range of positions of the guinea grass fields across the Stewart landscape. Finally, the sugar cane plot followed the expected pattern relative to other fields; the range between the first and third

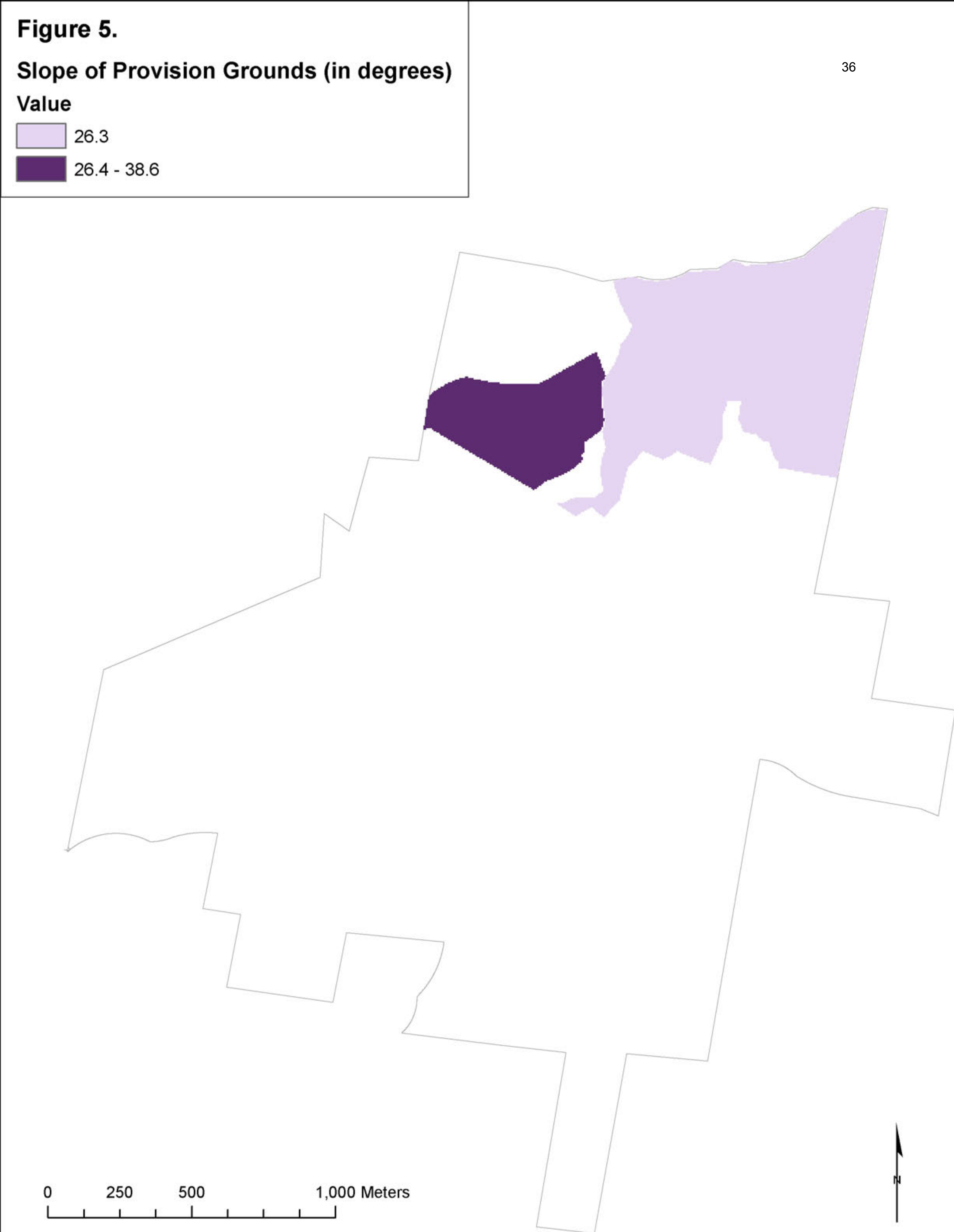


Figure 5.

Slope of Provision Grounds (in degrees)

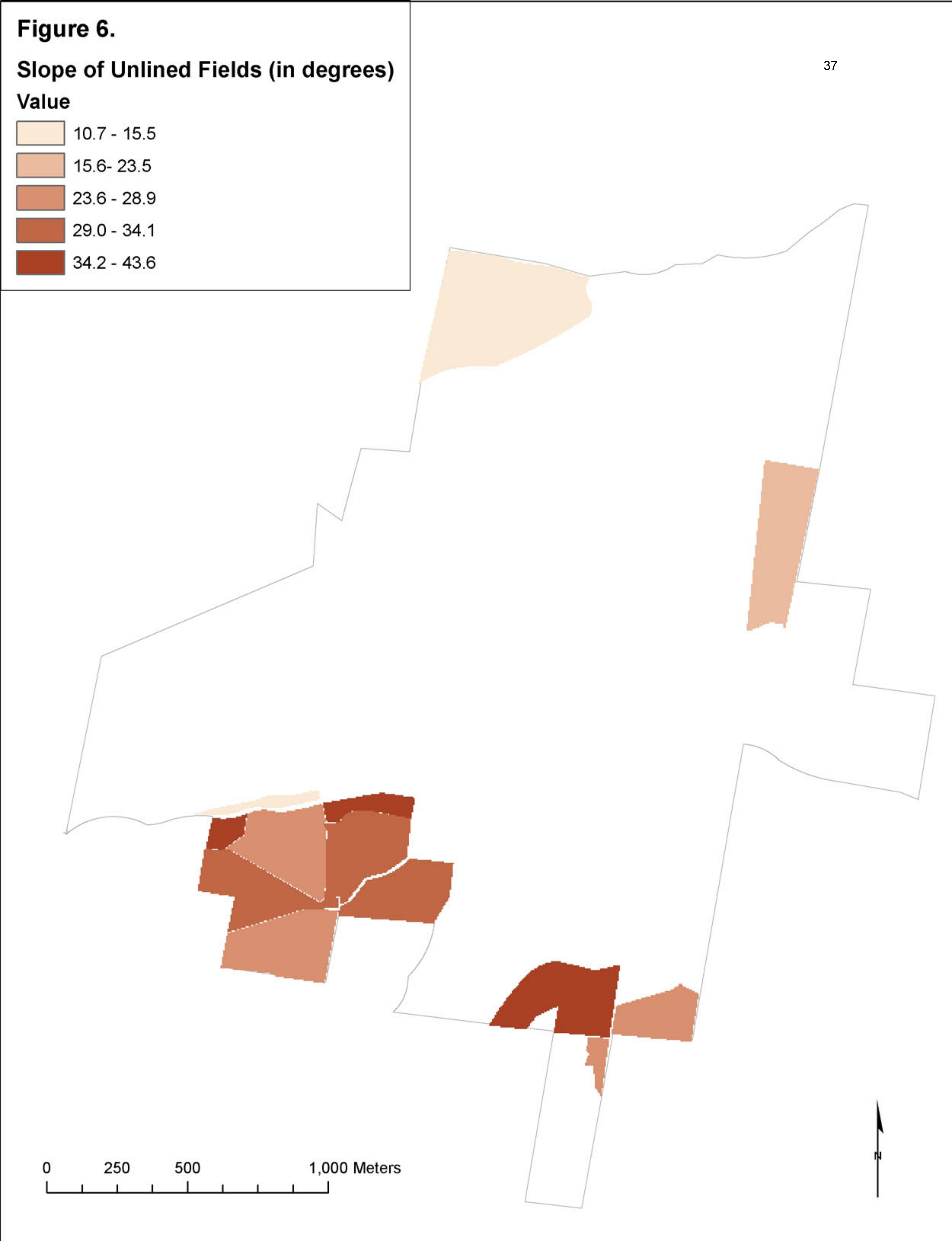
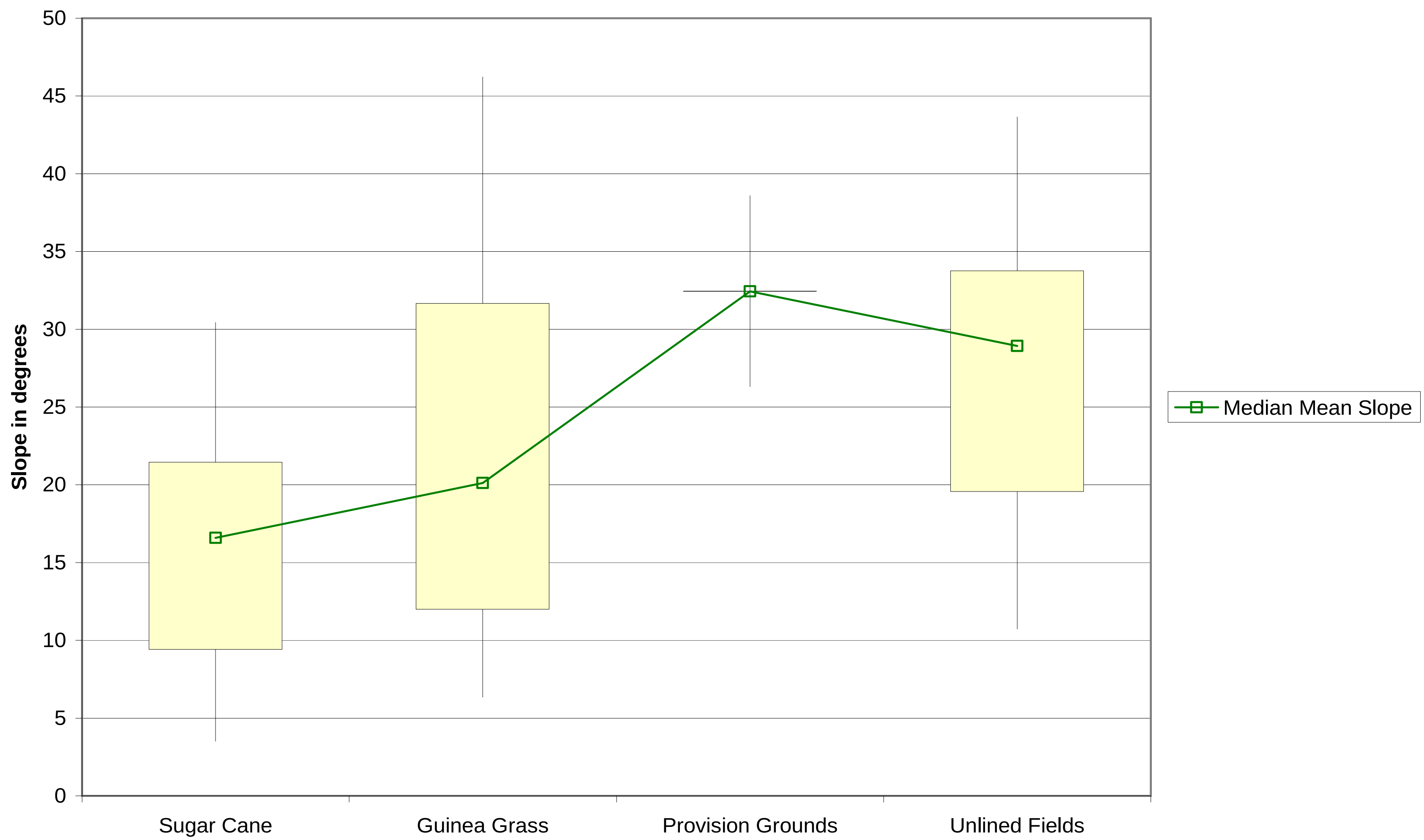


Figure 6.
Slope of Unlined Fields (in degrees)
Value
10.7 - 15.5
15.6- 23.5
23.6 - 28.9
29.0 - 34.1
34.2 - 43.6
0
250
500
1,000 Meters
N

Figure 7. Box Plot of Mean Slope Values



quantiles is smaller and median slope value is the lowest, upholding the hypothesis that the Stewarts chose the proper location to grow cane.

This series of figures exemplifies the kind of land use patterns that developed on coastal Jamaican plantations. On a wider scale, the slope maps reveal the limitations and benefits of topography that planters and their labor force dealt with on a daily basis. First, planters needed to understand their estate's landscape in order to determine appropriate planting times and growth seasons. The locations of non-cash crops like guinea grass had to be practical but not interfere with cane cultivation. Second, slaves presumably had the most experience with the variation in terrain across the estate. With distant pastureland and provision plots, and numerous cane fields, slaves likely gathered knowledge about local topography and sought the best routes to follow (this hypothesis is further explored in Chapter 6). Land use patterns thus provide a significant amount of information about the role of space in the plantation's economic life.

Chapter 5: Viewshed Analysis

Viewshed analysis is a valuable tool within the ArcGIS suite of functions that analyzes cells in the input raster from a particular observer point, and creates an output raster that assigns values to visible and non-visible areas.[1] If there is only one observer point, for instance from the Castle out over the estate, then the viewshed contains only two values: 1, visible, and 0, not visible. More complex viewsheds assess multiple observer points and create a map that assigns each cell a value based on how many points can be seen from a given cell. Finally, many singular viewsheds (from one observer point) can be combined to create a cumulative, rather than a simple Boolean, viewshed. The first and third methods are employed in this analysis to determine the extent to which visibility was an influential factor in establishing the location of key plantation features. According to the surveillance model of spatial organization discussed above, the great house and the overseer's house were positioned to allow the planter or overseer to observe the areas that slaves occupied, such as the cane fields, slave quarter and works complex. This hypothesis is evaluated below using viewshed analysis. In addition to a theoretical assessment of ideal surveillance locations, the intervisibility between plantation elements is assessed based on their actual placement on the estate landscape.

Cumulative Viewshed

To begin a viewshed analysis of the Stewart plat, a grid of points was produced in ArcGIS to create a base set of data points to test visibility across the estate. This grid contains 123 points, approximately 200 meters apart in geographic space over the 1230 acre estate (Figure 1). A viewshed was calculated from each point across the estate. The resulting 123 viewsheds were added together to create a cumulative viewshed. According to David Wheatley (1995), the cumulative viewshed "surface" represents "for each cell within the landscape, the number of

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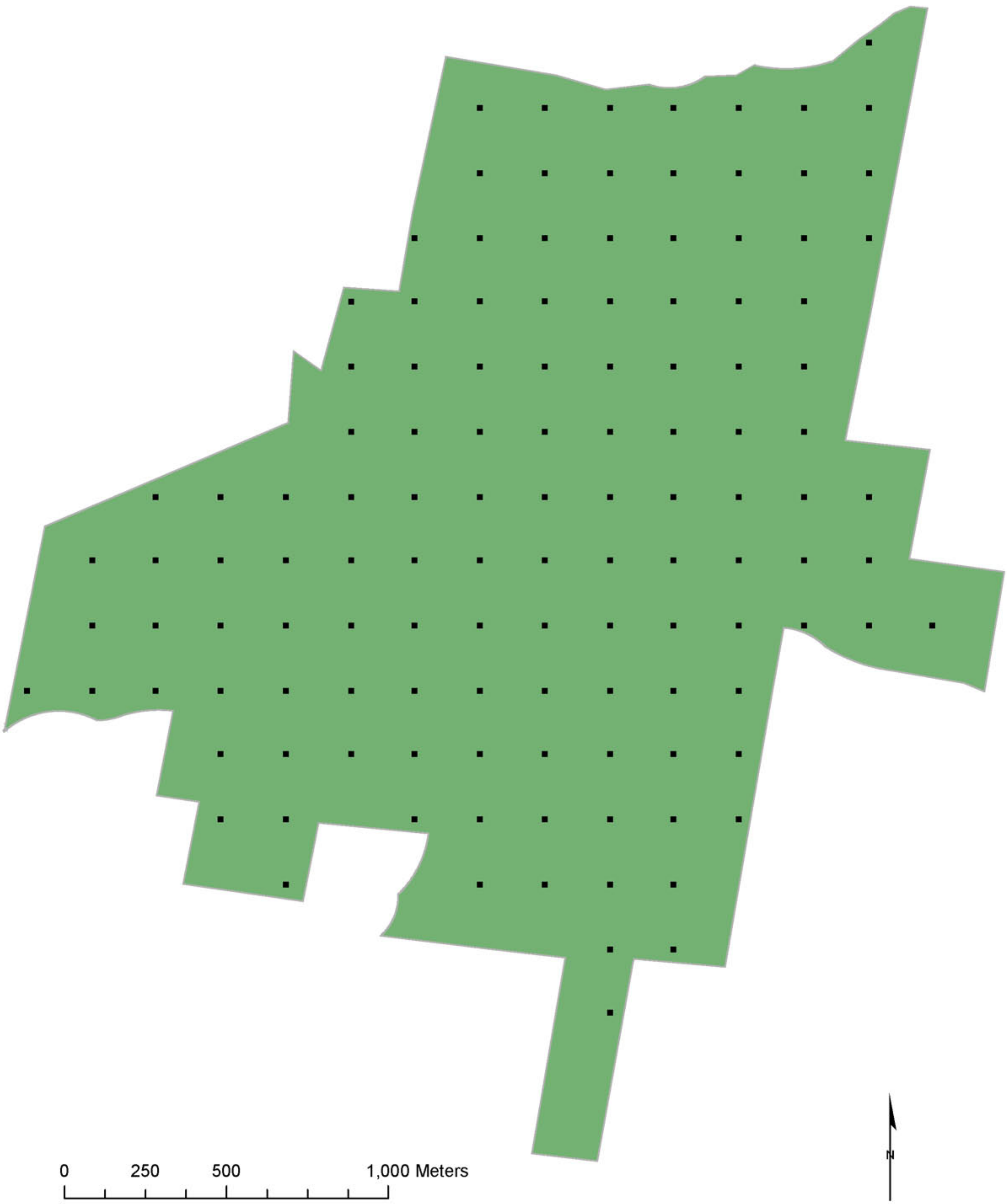
[1] A raster is a "spatial data model that defines space as an array of equally sized cells arranged in rows and columns" (ESRI 2006).

Figure 1. Grid of Test Points.



sites with a line of sight from that cell" (173). Each value generated from the cumulative viewshed for a given cell is determined by the visibility surfaces of the 123 grid points. For example, if one cell of the DEM was visible in 62 of the 123 individual viewsheds, then its cumulative viewshed value is 62. The summed result of the viewsheds thus provides a value for each individual cell from 0 to 123. However, given the large total number of cells, the cumulative viewshed is only a sample of the total area of the estate, and all hypotheses are based on this sample.

The ranked outcome of the cumulative viewshed allows one to pinpoint the areas that are ideal for maximum visibility across the estate. This viewshed is classified in nine categories, ranging from 0 to 80 (Figure 2). The areas shaded according to the highest range (71.1 – 80) represent the cells from which the greatest number of points are visible, as well as the cells that are highly visible from other areas. Since 80 is the greatest value in the scale, rather than 123, then no single data point in the sample provides a view of the entire landscape, and no single point is completely visible from all other points. Figure 2 illustrates that the regions of the highest values are located on the southeast and northwest ridges of the Stewart property. These bands represent areas which would be ideal locations from which to survey the estate. Although the Castle is located on a slope of the northwest ridge, its cumulative viewshed value of 22 places it in the third range of values (17.7 – 26.6), five categories from the ideal range of 71-80. The cell count associated with a value of 22 in the cumulative viewshed is 4084, signifying that 4083 other cells within the figure have the exact same value. The histogram of the number of cells represented in each of the nine visibility categories illustrates that the Castle is located in a more visible location than a majority of the cells (77655), but is not ideal relative to the higher visibility categories (the final six columns in Figure 3).

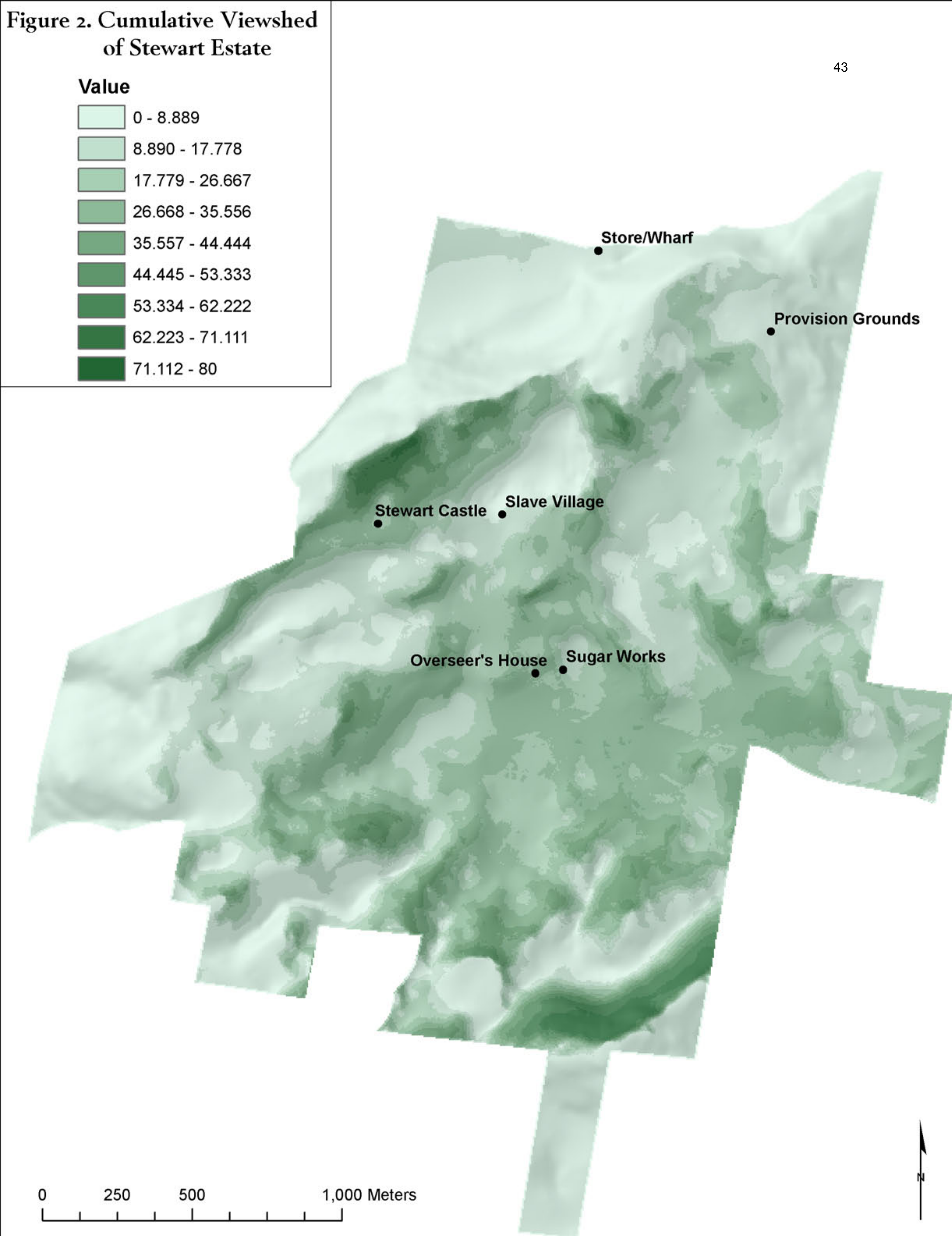


Figure 2. Cumulative Viewshed of Stewart Estate

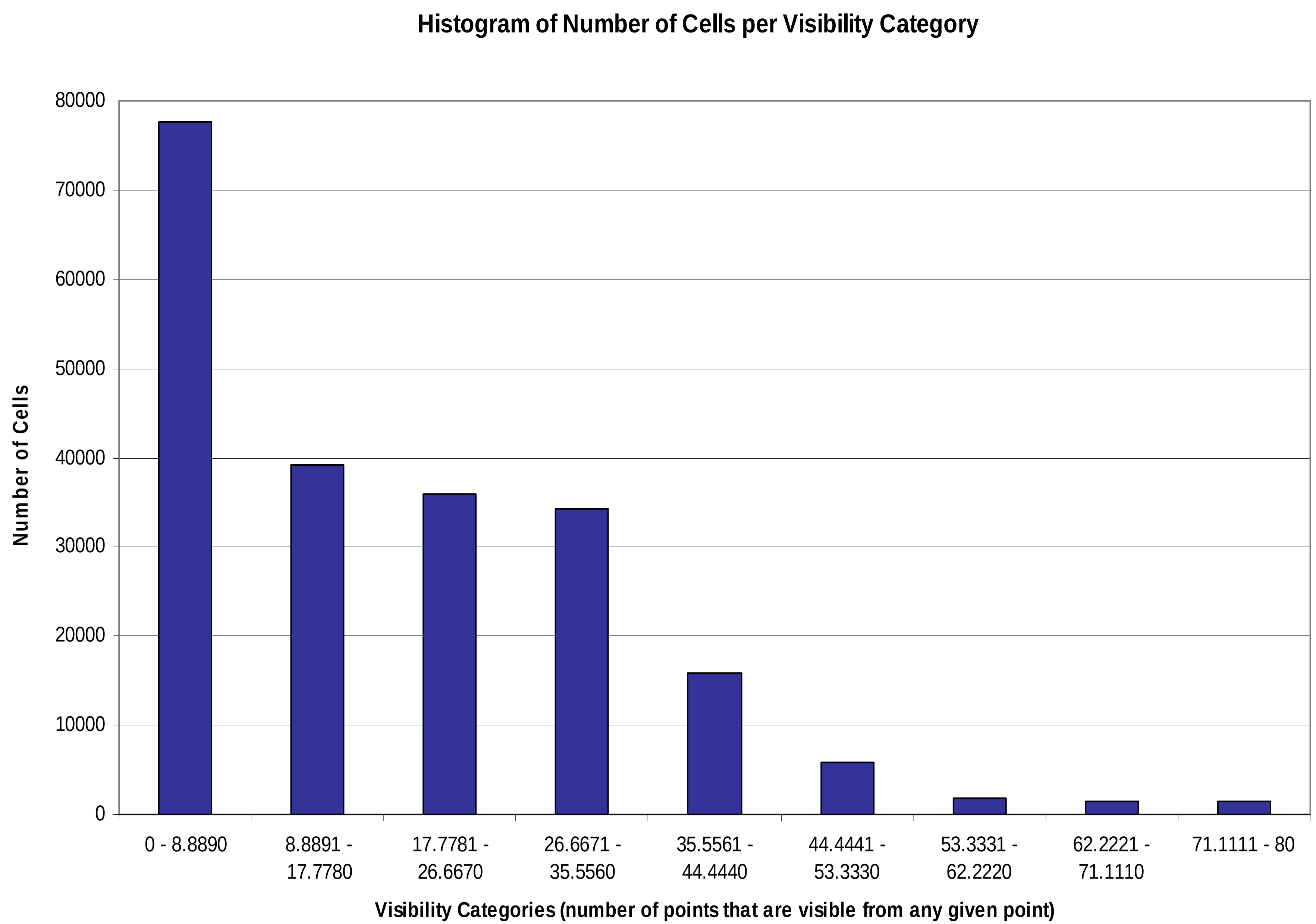


Figure 3. Cumulative Viewshed Histogram

This observation is also supported by Figure 2, since the Castle falls into the third category, rather than the areas of ideal surveillance represented by the highest values (darkest green). Since the Castle's cumulative viewshed value is less than the highest possible value and its value falls into an average range for the entire estate, it is clear that the Castle's placement was not wholly determined by the planter's ability to survey the entire estate. This hypothesis contradicts the surveillance argument, which asserts that plantation elements such as the great house and the overseer's house were located at points from which the planter or overseer could easily observe agricultural production and the slave village. Therefore, on a theoretical level, given the topography of the estate, the placement of Stewart's Castle does not maximize surveillance.

In keeping with the surveillance argument, the overseer's house is the other plantation building that was placed for greater visibility, particularly in proximity of industrial areas. The Stewart Castle overseer's house had a cumulative viewshed value of 27, placing it in the fourth value category, four categories from the ideal range. The count associated with the value of 27 is 4683 out of 80000. Given the histogram of cumulative viewshed values (Figure 3), the overseer's house falls into a common range, although less frequent than the Castle's value of 22. This graph is supported by the cumulative viewshed, since the overseer's house is located in an area of greater visibility than the Castle, but far from an ideal position (represented by the darkest green). Given these inferences, it appears that the overseer's house was also not placed in the best location for surveillance of the estate.

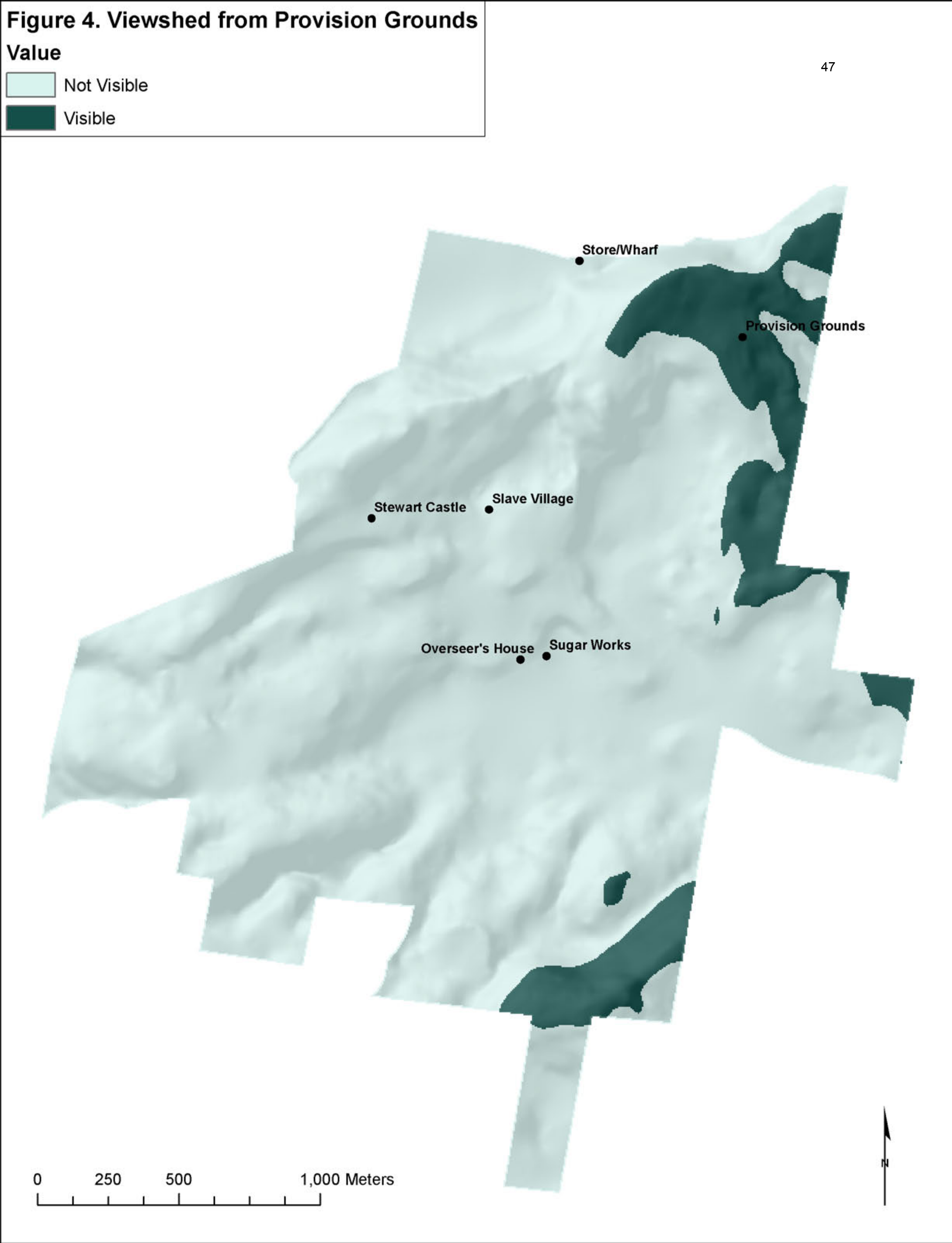
Nonetheless, one may argue that the desire to maximize the proximity of the overseer's house to the slave village and the sugar works was certainly an influential factor in its final location. If surveillance was the dominant aspect of plantation spatial organization, however, as supporters of the surveillance argument claim, then the overseer's house could have been placed approximately 270 feet to the north on a small ridge halfway between the slave village and the works, or on another ridge approximately 320 feet to the east, locations which offer greater visibility. The cumulative viewshed reveals that, while the Castle and the overseer's house had the highest visibility values out of the six primary plantation elements, their positions on the Stewart estate were not ideal for maximum surveillance given the topography of the landscape.

Single Viewsheds

To determine the degree of intervisibility between elements on the landscape, individual viewsheds were created that identify the areas which are visible or not visible from a specific observer point. First, as discussed above, the provision grounds were commonly located in an area of highly variable slope, in this case at a higher elevation than the cane fields and works complex. The provision grounds were in a remote section of the plantation; only local observation was necessary in these areas to protect against theft. For instance, William Beckford, in describing the arrival of new slaves, gives this advice to planters: "Let the same indulgence be allowed him, respecting his ground, let him work it for himself; let it be particularly guarded, and every intrusion upon it for the purpose of theft, if discovered, be severely punished" (Beckford 1788: 21-22). On the Stewart Castle plat, a point was selected in one of the fields marked "Negro Grounds" to represent the provision grounds. The viewshed from this point illustrates that a majority of the estate cannot be seen from the provision grounds (Figure 4). This finding is reasonable given the elevation and slope of the provision ground areas.

Second, the point that represents the store, which housed the processed sugar, and the wharf, from which the sugar was shipped, offered virtually no visibility of the estate (Figure 5). As discussed above, the wharf was located on the shore at the base of the mountain that traverses the estate's northwestern section. Given this location, only areas on the northern side of the

Figure 4. Viewshed from Provision Grounds



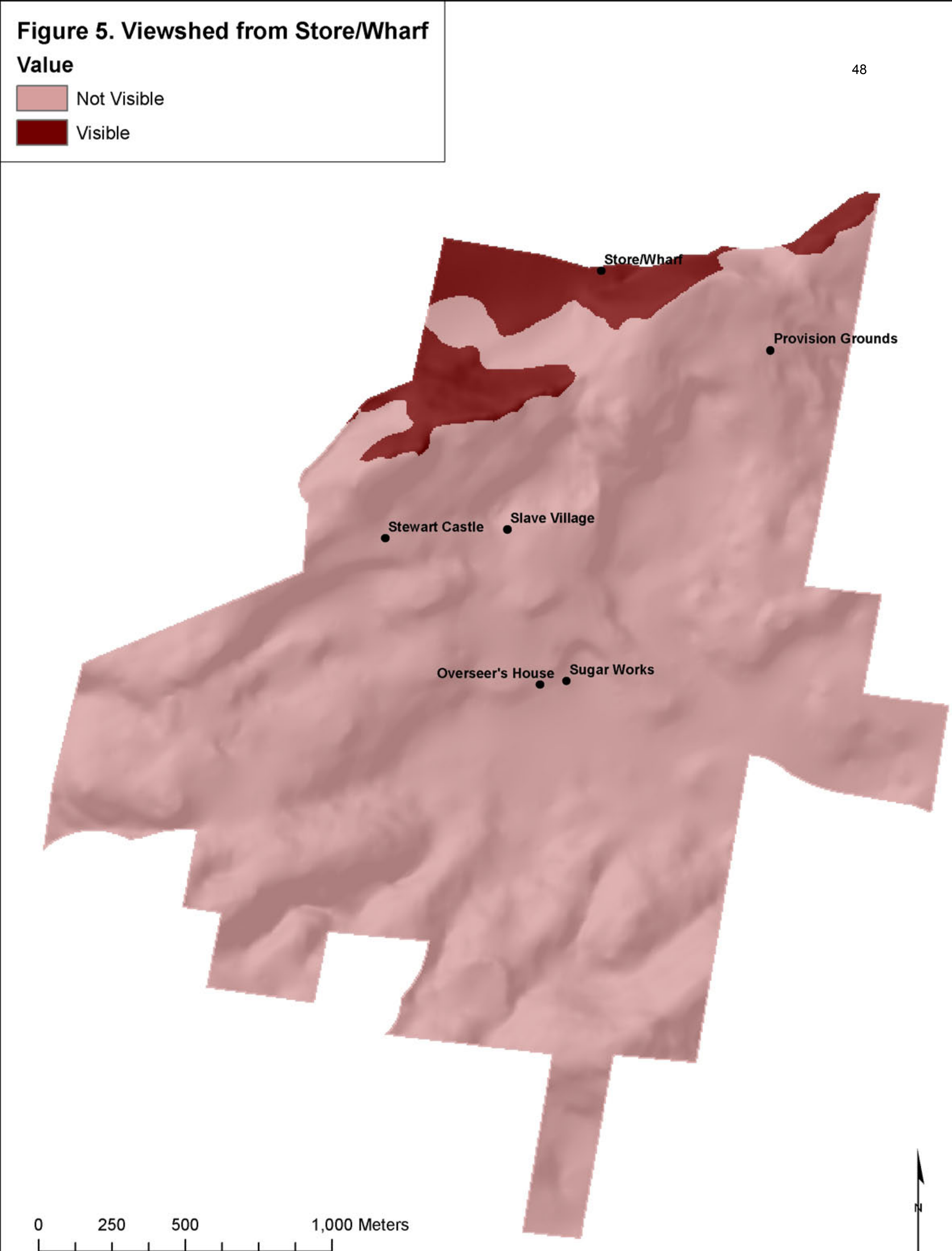


Figure 5. Viewshed from Store/Wharf
Value
Not Visible
Visible
Store/Wharf
Provision Grounds
Stewart Castle
Slave Village
Overseer's House
Sugar Works
0
250
500
1,000 Meters
N

mountain ridge and along the beach can be seen from the wharf. Third the sugar works complex provided a degree of visibility of the southern half of the estate, specifically the valley that contained the sugar cane fields (Figure 6).

The final three points provide the most information about the intervisibility between significant plantation elements. The fourth point is located approximately in the middle of the slave village, marked as “Negro Houses” by the Munro, Stevenson and Innes surveyor (Figure 7). From this point, Stewart Castle is visible, as well as the remainder of the southern slope of the mountain. However, the overseer’s house, the sugar works, and a majority of the sugar cane fields and provision grounds are not visible. This relatively limited visibility of other plantation elements is due to the topography of the slave village, which is located in a small depression. In addition, a series of low ridges to the south of the village blocks any view of the sugar works and cane fields. On a pragmatic level, enslaved laborers traveling to the cane fields, sugar mill or provision plot would not be able to view these areas from their houses. Thus, the importance of well-used and well-known pathways becomes an important feature of the slaves’ plantation landscape. Stewart Castle slaves could not simply locate their destination by sight; acquired knowledge of convenient paths across the estate was required for movement to other plantation elements. This preliminary evaluation of movement is further explored through least cost path analysis discussed below (Chapter 6).

The viewshed from Stewart Castle further reveals the degree of visibility that its location provides (Figure 8). Since the point representing the slave village is approximately in the middle of the rows of houses marked on the 1799 plat, the viewshed indicates that only half of the houses are visible from the Castle. Given this finding, the Castle’s position clearly does not allow maximum surveillance of the slaves’ off-hours activities. Furthermore, neither the sugar

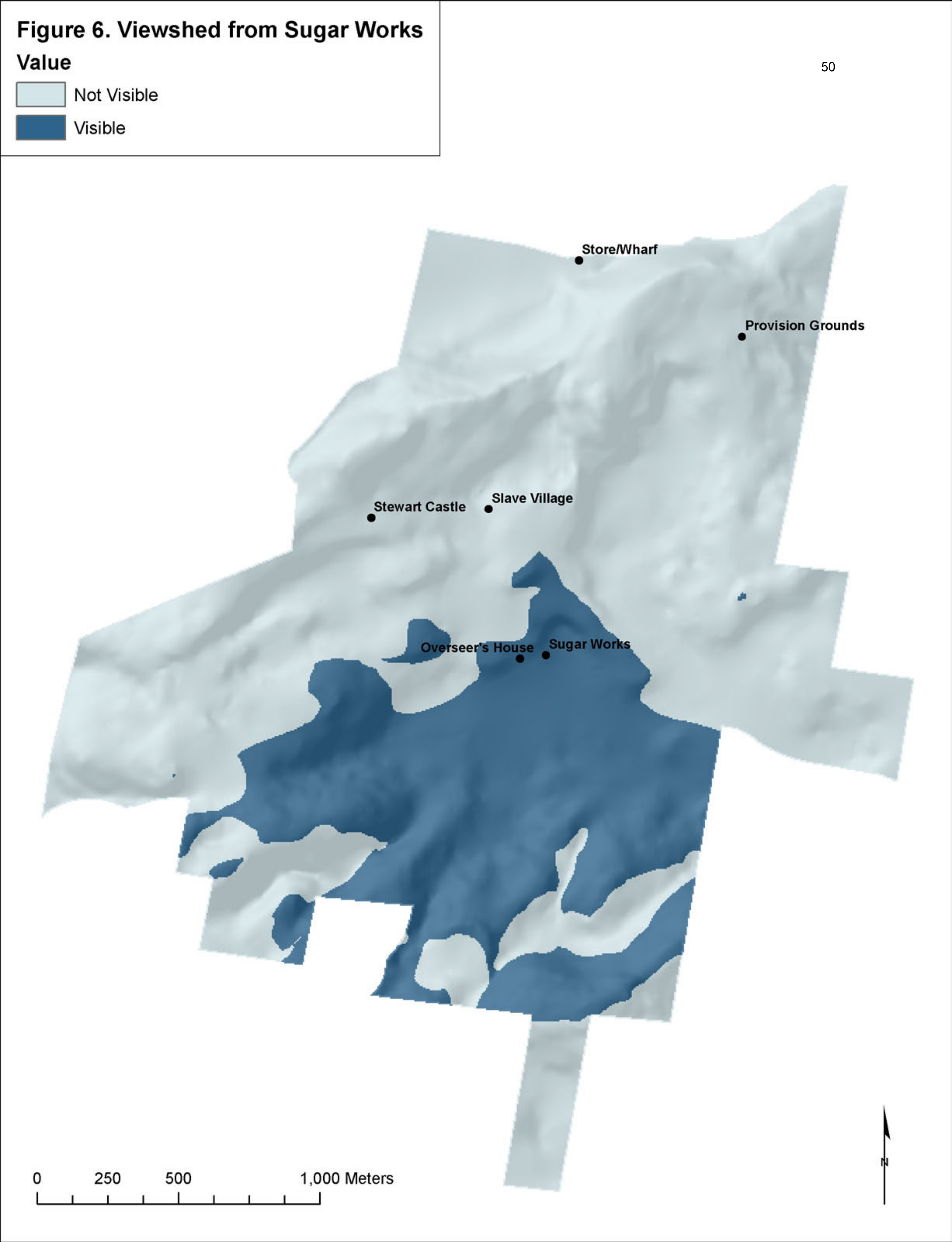
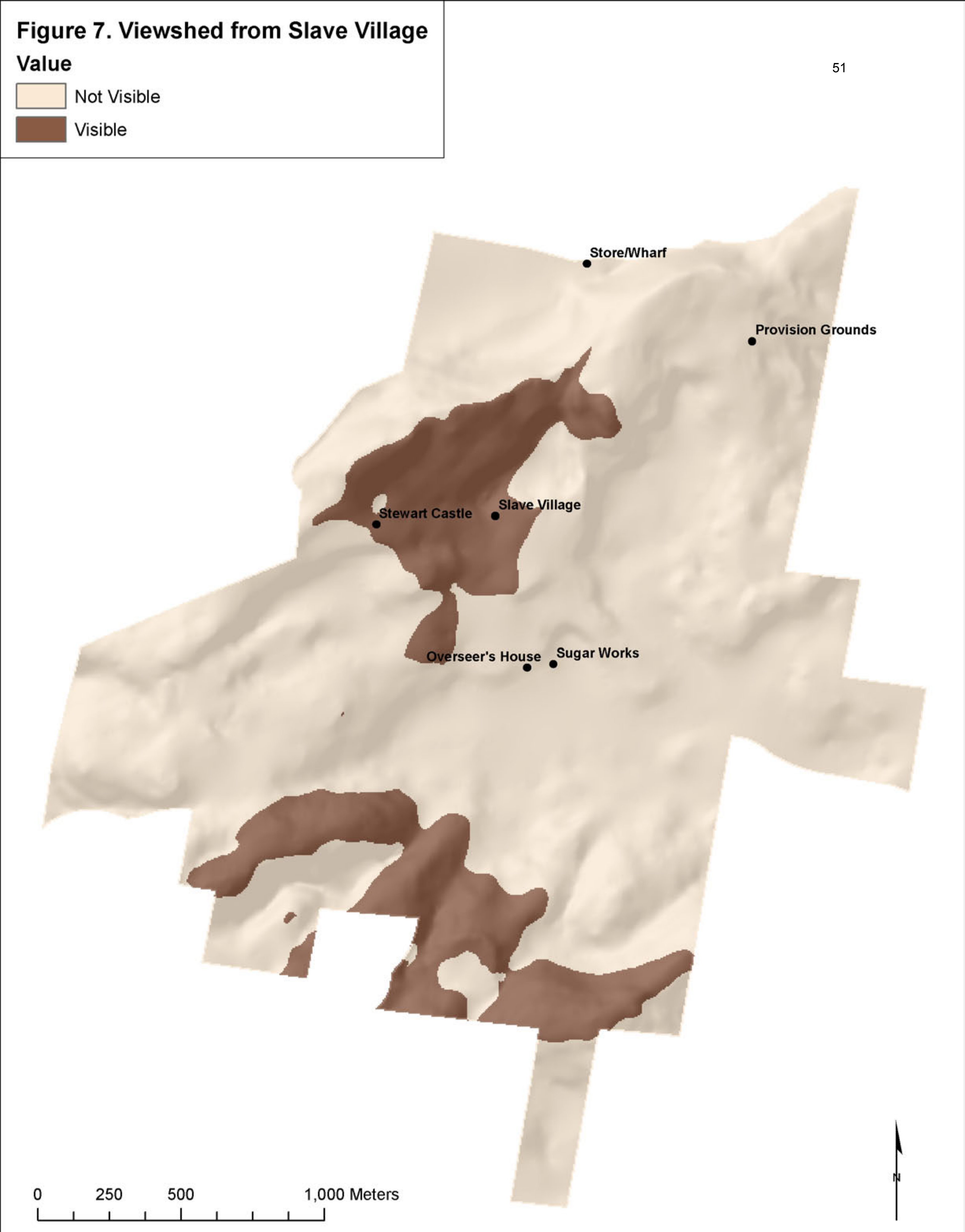


Figure 6. Viewshed from Sugar Works
Value
Not Visible
Visible
Store/Wharf
Provision Grounds
Stewart Castle
Slave Village
Overseer's House
Sugar Works
0
250
500
1,000 Meters
N

Figure 7. Viewshed from Slave Village



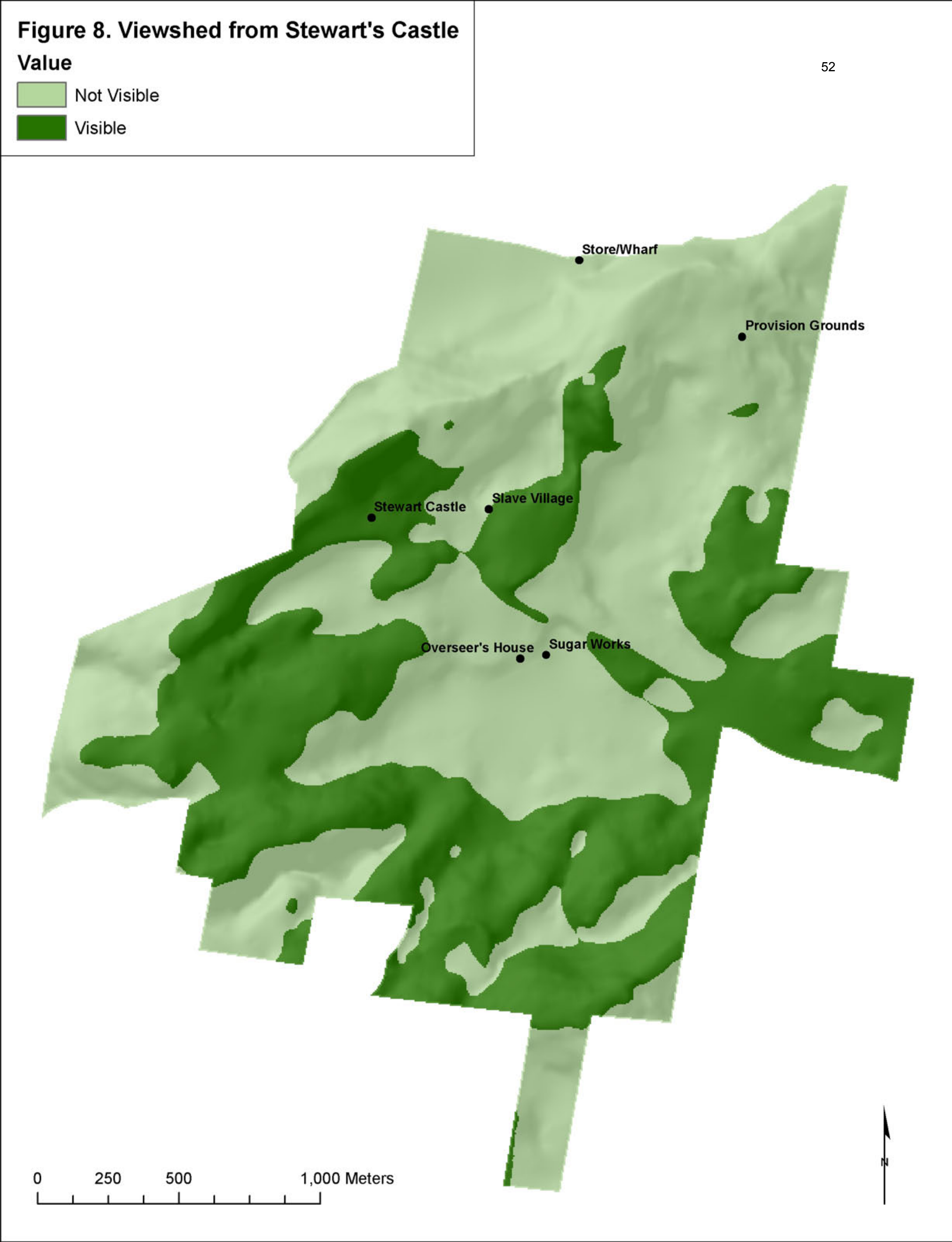


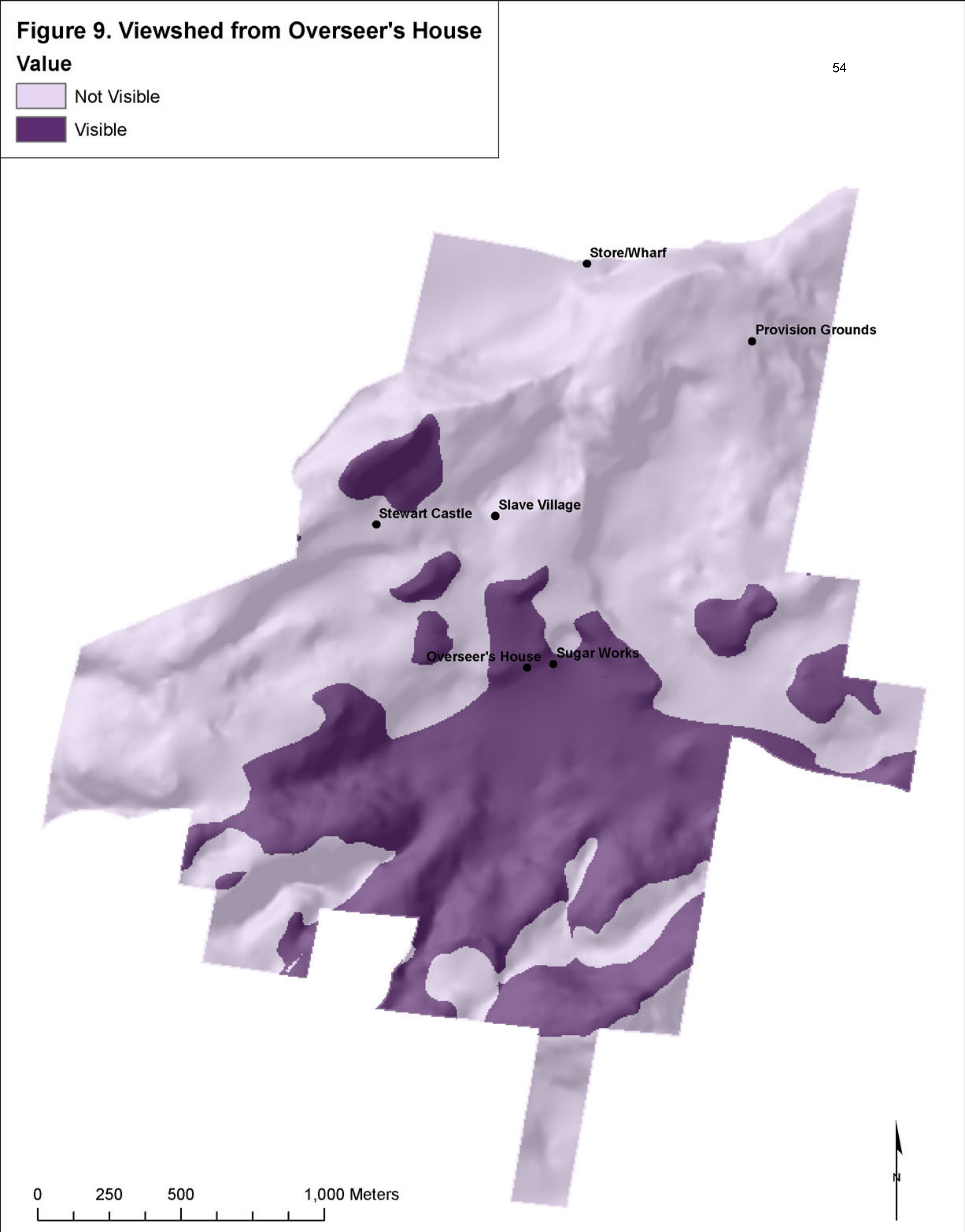
Figure 8. Viewshed from Stewart's Castle
Value
Not Visible
Visible
Store/Wharf
Provision Grounds
Stewart Castle
Slave Village
Overseer's House
Sugar Works
0
250
500
1,000 Meters
N

works nor the overseer's house are visible; once again, low ridges between the Castle and the sugar works block the view. Given this limited visibility, Stewart, as a planter, must have expected his overseer to observe the processing of sugar cane and trusted him to manage it efficiently.

Results from the Castle viewshed support the cumulative viewshed conclusions: the Castle was not located in an ideal location to survey the enslaved labor force or the particular work they completed in the economic heart of the plantation. One possible explanation for this inconsistency with the surveillance argument is the potential vulnerability of the estate. Given the variable slope and elevation of their property, the Stewarts may have chosen a location that provided a prominent view of the surrounding area rather than closer elements. This inference is supported by the bastions and the walled enclosure surrounding the great house; defense and visibility of approaching enemies was obviously a key influence on its position. Figure 8 illustrates that the land immediately surrounding the Castle was visible, as was much of the estate's border. The positioning of the estate suggests that topography may have played a prominent role in the placement of plantation elements, a significant detail that neither the surveillance nor the movement-minimization arguments readily address.

Finally, the viewshed from the overseer's house exemplifies the possibility for oversimplification within the surveillance argument (Figure 9). The overseer could survey the tasks performed within the sugar works and the cane fields directly adjacent to the works complex. Although the total amount of area visible is less than that of the Castle, the overseer could readily observe the slaves in their daily work spaces. The slave village, however, is not visible from the overseer's house, suggesting that, within their own village, slaves could move about more freely without the demands of direct surveillance. This result indicates that the

Figure 9. Viewshed from Overseer's House



surveillance argument can overlook potential levels of visibility by assuming that all plantation elements were visible or obstructed. In the case of Stewart estate, the overseer could manage the manufacturing performance of the works but could not observe the slaves during off hours. The position of the overseer's house can be viewed as a meeting point of the two arguments given that it represents direct surveillance of agricultural productivity.

Discussion

One conclusion suggested by the viewshed analysis is that the Castle was in a position to maximize surveillance; it commanded a broader view of the property rather than direct observation of slave activities. This result contrasts with the surveillance argument, which presumes that the great house and the overseer's house were centers of surveillance designed to maintain plantation hierarchy. The Castle viewshed further demonstrates the house's less than ideal location for observation of slaves in the village and the works. While the Castle's structure offers defense from bands of maroons or its own slave population, its location does not provide for daily observation. Perhaps the Stewarts preferred a grander view of the countryside and assigned their overseer to supervise the slaves. This supposition is complicated by the inability of the overseer to see the slave village from his house near the works. Thus, while surveillance was likely a key component of the daily management of the estate's agricultural production, it was not the organizing principle of plantation space.

In keeping with this hypothesis, the slaves may have experienced a greater degree of latitude in their non-work hours within the village. Without direct surveillance, slaves could make their own choices about division of labor, time management and use of space. In addition, although the slaves would have followed known paths regardless of their ability to see the works and fields, the obstructed view of these features and the absence of marked roads on the 1799 plat suggests that slaves' acquired knowledge of the plantation landscape and created their own routes. The absence of planter and overseer supervision along these routes implies that slaves may have used at least a portion of these spaces independently.   Although the Stewart Castle example may be atypical, the circumstances of its landscape reveal that the current models of spatial organization neglect the importance of topography, the existence of numerous influential factors and the possibility of slave appropriation of space within the plantation.

Chapter 6: Cost Surface Analysis

Single cost surface maps assign values to areas within the study region according to the cost necessary to traverse those areas from a given origin. In similar fashion to viewshed analysis, values from numerous cost surface maps can be interpolated to produce a composite cost surface that signifies many degrees of cost. The accumulated cost surface map is a valuable output since it illustrates the areas of the study region that are easy or difficult to reach based on the input cells (single cost surfaces). This process was performed using an anisotropic approach: both the direction of travel and the slope were taken into account for each cell. As Connolly (2006: 215) states, "the maximum cost of walking across a cell is likely to be incurred when walking uphill in the direction of steepest slope, but this direction is potentially different for every cell in the map." The anisotropic cost surface thus offers a more robust evaluation of the geographic input data. The creation of cost surfaces in ArcGIS is a relevant action for this analysis because it provides a way to identify which locations required the least (or the most) effort to reach from any given cell. Thus, the cumulative cost surface map is implemented to evaluate the movement-minimization hypothesis by determining which elements were centrally located, i.e. had the lowest cost values. A different process was employed to address paths of movement within the estate ('Isotropic Least Cost Paths'section).

Anisotropic Cumulative Cost Surface

To create an anisotropic cost surface in ArcGIS, the pathdistance function must be used; this function requires the DEM, the raster form of a given point within the study region, and a table of cost equivalents (horizontal, vertical or both). Horizontal costs include barriers such as rivers or cliffs and the type of surface being traversed. Vertical costs incorporate movement across steep upward or downward slopes. Unfortunately, no readily available data exists for horizontal factors on the Stewart Castle estate. The vertical cost table was created by using

Tobler's hiking function for a number of slope values. To calculate the cost in hours, the reciprocal of Tobler's function was employed:

Time (hours) to cross 1 cell =
1/(6*(EXP(-3.5*(ABS(TAN(RADIANS(slope_deg))+0.05))))) * 0.005

where 0.005 represents the cell size in kilometers. The reciprocal of Tobler's function is used because the desired calculation is time to cross one cell, rather than the velocity (see Introduction to Cost Surface Analysis, Chapter 4). Tobler's cost was applied in the pathdistance function to create 123 cost surfaces from the grid of 123 points utilized in the viewshed analysis. The average travel cost from each grid point to every cell location was recorded from the individual cost surfaces. These mean costs became the z-values of the 123 points, with geographic x and y coordinates.

The resulting data set was interpolated to the whole estate using the Spatial Analyst kriging function. Kriging assumes that sample points close to one another have more similar values than points that are farther apart (ESRI 2006). Values for non-sampled cells can be estimated from surrounding data inputs. Kriging is a useful technique for interpolating from the grid point data set since it creates a more accurate estimated surface using "statistical relationships among the measured points" (ESRI 2006). The output cost surface from the kriging interpolation identifies the average number of hours required to travel from a given point to every other cell in the study region (Figure 1).[1]

The kriged surface output has a definitive center of minimum number of hours surrounding the overseer's house and the sugar works. This finding shows that the works and the overseer's house were centrally located on the estate; slaves traveling from the village had a short journey if their destination was the overseer's house or the works. Given that the enslaved

[1] The southern, northern and western corners of the estate is not included in Figure 1 since no grid point fell in that location.

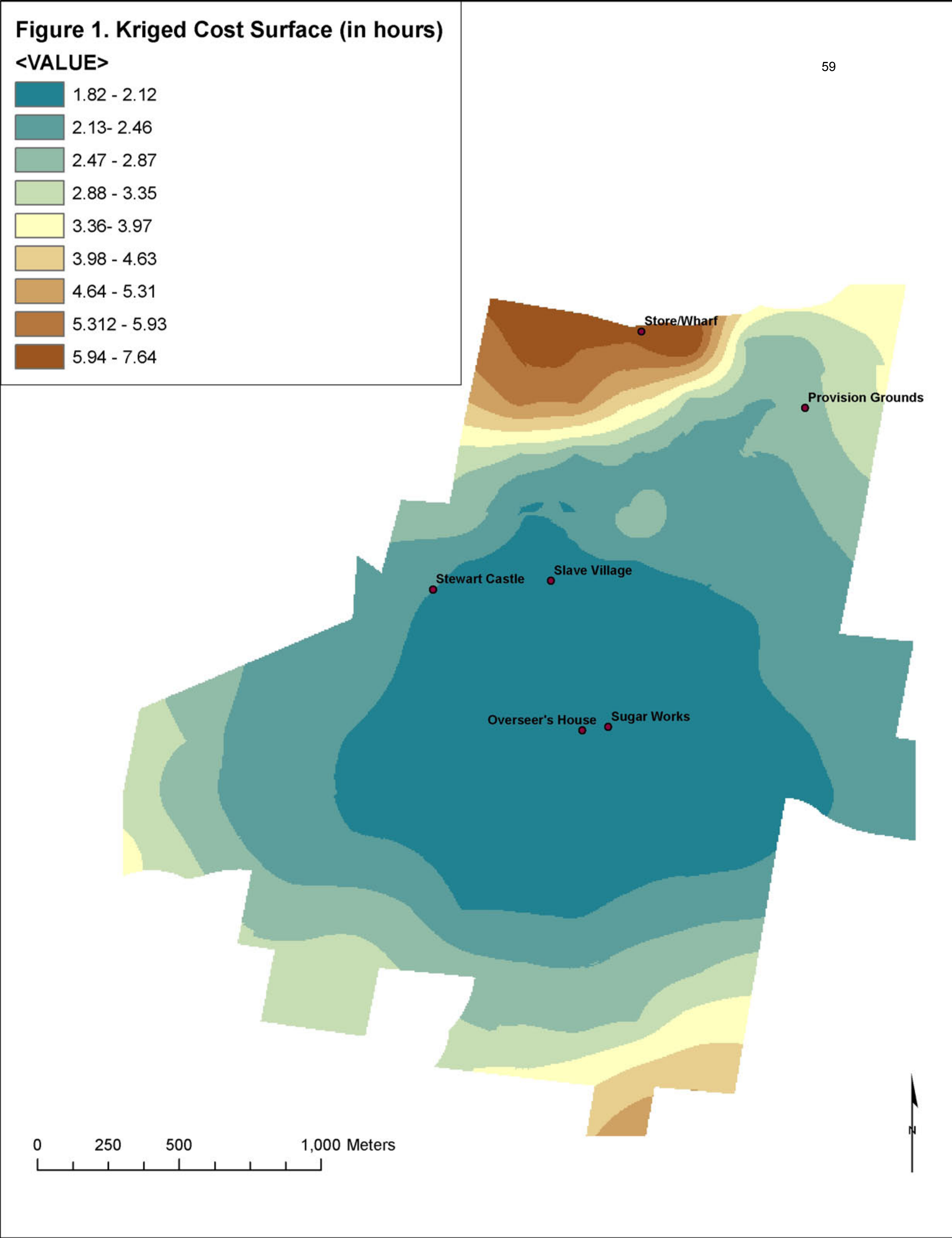


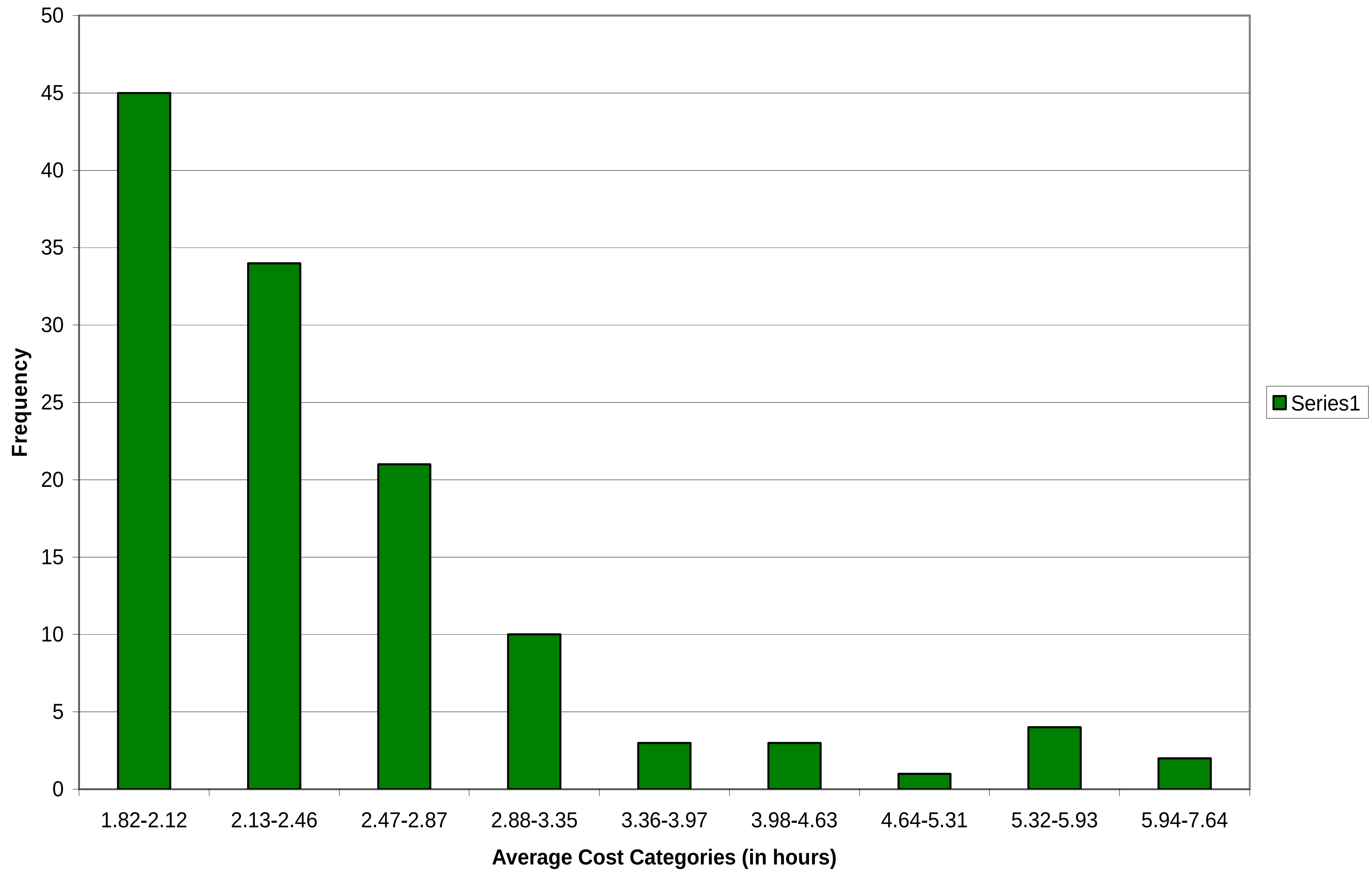
Figure 1. Kriged Cost Surface (in hours)

laborers toiled on a majority of the plantation, the average cost of traveling to the works or overseer's house was lowered by their central position. The overseer's house value of 1.88 hours places it in the first range of values (represented by the darkest blue). The works value of 1.90 places it in the same range. A histogram of the cost surface values supports the previous observations: the overseer's house and the works fall into the most frequent and least cost category (Figure 2). Although this result suggests that the overseer's house could have been placed in a number of other locations, its value is particularly low within the category, indicating it was in a nearly ideal location. These results support the movement-minimization argument that the overseer's house and the works complex should not only be located close to one another, but also should be centrally located relative to the other elements.

Another significant outcome of the cumulative cost surface was the location of the slave village in the first category, with a value of 1.95. This relatively central position of the village suggests that its placement was directly linked to the sugar works and the cane fields. Slaves traveling from the village to the works complex and valley fields experienced a less costly journey in comparison to travel to the provision grounds or the wharf. This result also supports the movement-minimization model since the village was in a cost efficient location.

The remaining three locations exemplify the degree of cost variation across the Stewart landscape. The Castle was on the border between the first and second cost categories. This position indicates that it was in a relatively beneficial location for travel throughout the estate. Compared to the rapid increase in hours along the northwestern and southeastern portions of the estate, the Castle's value of 2.12 hours is quite low. Conversely, the provision grounds and the wharf are clearly the most remote locations out of the six plantation features. A majority of the provision grounds are in the fourth cost category ranging from 2.88 to 3.35 hours, indicating that

Figure 2. Histogram of Average Cost



slaves faced a longer journey to their plots than to the primary cane fields or the works complex. Finally, as evident from the topography, the wharf was very difficult to reach, falling in the highest cost category (darkest brown). While no road information was entered as a horizontal cost, this result indicates that carting the processed sugar over the northeastern ridge was a difficult and time-consuming task.

Isotropic Least Cost Paths

The second part of the cost surface analysis is an evaluation of the potential routes taken by slaves from the village to other plantation elements. An anisotropic cost surface could not be calculated in this instance and consequently the isotropic costs do not account for effective slope (direction of travel and slope). However, as discussed below, the cost distance map is still a relevant output for this study. The surface was created using a cost grid, which signifies the cost of traveling through each cell, and a cost-weighted distance function, which assigns a value to each cell based on the least accumulated cost of getting back to the origin. For this analysis, a cost distance surface was only generated for the slave village point. While it is probable that the planter and overseer only utilized the plantation roads, especially if they were on horseback, slaves could have taken various paths to reach a number of destinations. Specifically, slaves likely devised their own routes to their provision ground plots and possibly to the works complex.

Figure 3 identifies four estimated least cost paths between the village and four other elements given the underlying cost distance surface values. The first road from the village to the wharf clearly remains in each least cost category as far as possible; the other roads follow this same pattern. Overall, the paths indicated by the analysis signify ideal movement-minimization routes since they represent the least amount of effort for the traveler. Significantly, none of these paths exactly match the roads drawn by the surveyor on the 1799 plat. On the one hand, this outcome indicates that movement-minimization may not have been the primary factor in

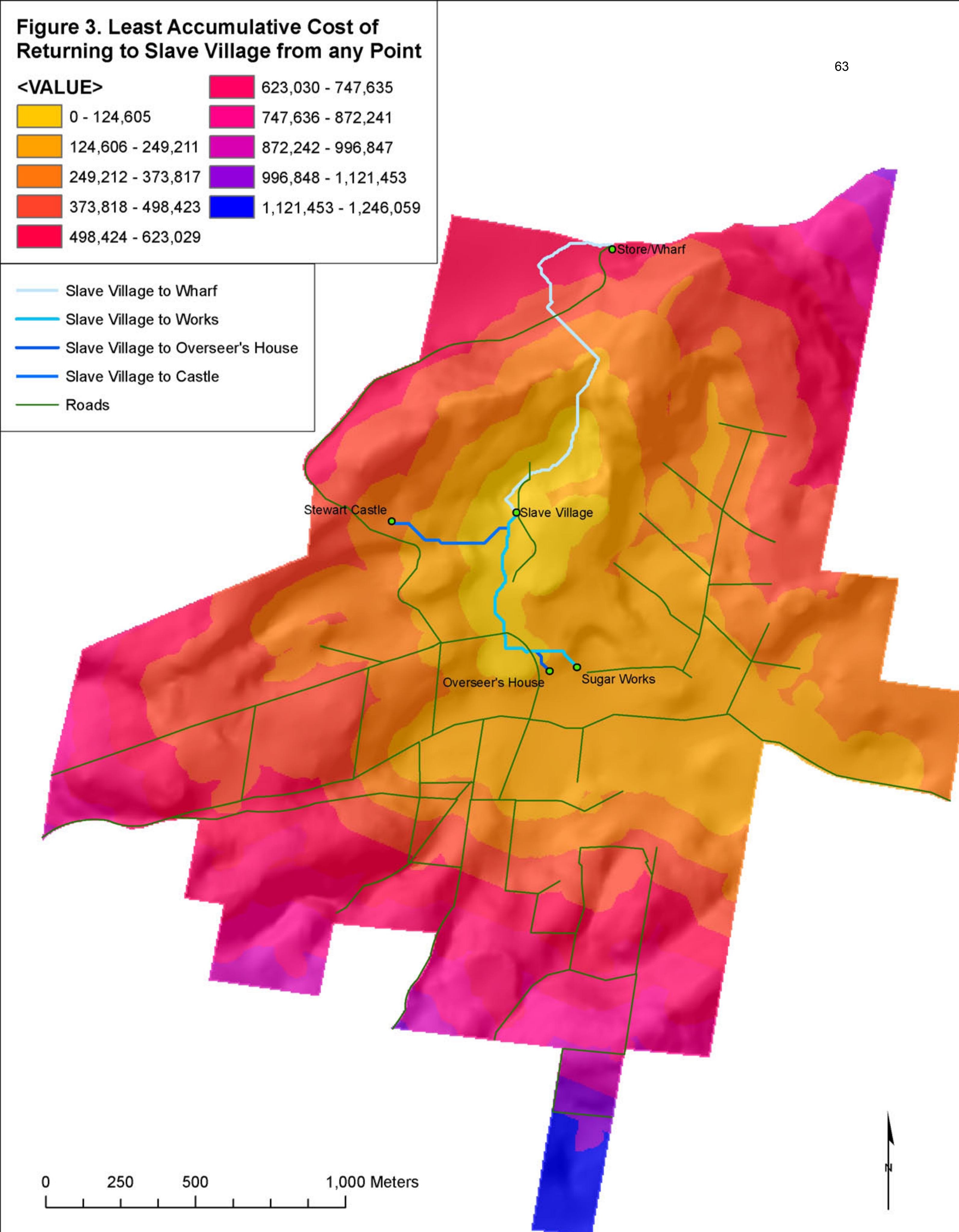


Figure 3. Least Accumulative Cost of Returning to Slave Village from any Point

determining the placement of roads used by the plantation inhabitants. Topography and the need to facilitate travel of all three classes (planter, overseer and slave) across the estate and to nearby towns could have influenced the location of the roads.

On the other hand, the outcome exemplifies Van Leusen's critique of cost path analysis that calls for a comparison of historic roads to least cost paths. Discrepancies between these routes, he argues, may indicate the potential for investigation of "intermediate goals" (Van Leusen 2002: 6-9). In the Stewart Castle example, it is possible that slaves fashioned their own trails similar to those suggested by the cost surface map since these paths required the least amount of effort. Furthermore, the planter may not have taken interest in any footpaths used by slaves and would not have asked the surveyor to map them. A potential exception to this hypothesis is the short road drawn through the middle of the slave village which may represent the slaves' southern path to the overseer/works area.

Nonetheless, comparison of the least cost paths to the actual roads suggests that other factors such as knowledge of the topography, presence of local resources and desire to avoid surveillance may have influenced the slaves' choice of route. This suggestion most certainly applies to the path(s) to the works given the lack of direct planter or overseer surveillance in the areas surrounding the village. It does not, however, apply to the path to the wharf. The presence of a road to the wharf on the 1799 plat likely signifies that this was the only path utilized; considering the steep slopes of the mountain and the difficulty of carting barrels of sugar over this terrain, slaves would choose a clear-cut road with a compact surface.

<u>Discussion</u>

Cost surface analyses provide an evaluation of the movement-minimization argument's two primary assertions: first, that plantation elements were centrally located to maximize efficiency; and second, that elements were located to ease travel by plantation inhabitants. The presence of these characteristics indicates that the planter sought to maximize economic output to the extent that other factors were limited. Given the outcome of the anisotropic cost analysis, the overseer's house, sugar works and slave village were clearly centrally located, satisfying the first contention. However, the isotropic path analysis suggests that the roads within the plantation required a greater amount of cost, contradicting the second contention. In addition, the length of time to reach the wharf/store and the outlying fields likely hindered efficient completion of tasks in those areas. In the Stewart case, the extent of the estate had to be balanced against the desire to minimize movement.

Furthermore, the location of the Castle outside of the least hours category indicates its less than ideal position for travel to the works complex. This finding supports the previous hypothesis concerning the degree of responsibility the Stewarts entrusted to the overseer. Finally, given the absence of mapped routes from the village to other elements, one could argue that the movement-minimization hypothesis does not address the potential for slaves to create their own paths, although this possibility could support the second contention if considered. In fact, appropriation of space by enslaved laborers is not discussed by the proponents of either argument. The least cost analyses thus illustrate a number of shortcomings of the movement-minimization hypothesis, specifically failure to address the size of the estate and the possibility that the best routes were not identified by the planter.

Chapter 7: Conclusions

The viewshed and cost analyses discussed above revealed a number of relevant observations about the relationships between plantation features and the applicability of the spatial organization models. The cumulative viewshed and individual viewsheds described in Chapter 5 do not directly support the hypothesis of the surveillance argument. First, the Castle itself was not located to maximize surveillance of slave work areas or the slave village. Second, the overseer's house was in line with the works but not the slave village; this position can be interpreted as a meeting point of the two arguments since it represents direct observation of agricultural productivity. However, the overall findings suggest that surveillance of the slaves was only a secondary factor in the location of the Castle and overseer's house. In addition, the results indicate that the slaves had some degree of control over their non-work spaces. This outcome illustrates the failure of the surveillance argument to acknowledge the potential ramifications of limited visibility.

The anisotropic cost surface analysis indicates that the slave village, overseer's house and works complex were centrally located. The position of these three features supports the movement-minimization argument: travel costs to work areas were limited. However, the large area of minimum hours lessens the significance of the values of the three locations. A finer grained analysis of the estate surface may provide a greater degree of distinction in terms of centrality. The output also revealed ever-increasing costs to the north and south of the estate which likely hindered travel to remote areas. For example, slaves faced greater costs transporting processed sugar over the northeast ridge to the wharf than journeying to a distant cane field. Thus, while the movement-minimization hypothesis holds true for the industrial center of the estate, the cost surface suggests that costs experienced by plantation inhabitants varied depending on their destination.

The isotropic least cost paths from the village to other plantation elements suggest that slaves may have created their own paths to destinations across the estate rather than merely following plantation roads. These paths also show that the roads marked on the 1799 plat did not directly accommodate slave travel from the village, complicating potential application of the movement-minimization hypothesis. If slaves were fashioning unmarked paths that required the least effort to travel, then movement minimization was not institutionalized by the planter. However, the isotropic paths suggested in Chapter 6 cannot be fully verified given the absence of the effective slope in the calculations.

Historical Evaluation

Given the outcome of the viewshed analysis in Chapter 5, a number of historical statements about Jamaican plantation landscapes can be corroborated or contradicted by evidence from Stewart Castle. First, the provision grounds area was one of the least visible areas on the estate, with a larger slope than other surrounding agricultural areas. This data confirms Beckford and Roughley's descriptions of the remoteness of the provision grounds, indicating that these characteristics were common in Jamaica. Second, Beckford notes that, even if the slaves had to travel a significant distance to the works, they should never be out of sight of the overseer (Beckford 1790: 20 (Vol. 2)). In the case of Stewart Castle, the opposite was true: slaves did not travel far to the works and were not under surveillance for at least part of their journey. This inconsistency with the historic accounts may support the movement-minimization hypothesis if Stewart knowingly chose to locate the village close to the works and sacrifice visibility. Third, the position of the slave village was in part determined by the locations of the works and the overseer's house. Barry Higman affirmed this trend by analyzing distances marked on plats from the late 18th and early 19th centuries. Considering the close proximity of the village to the overseer's house and the works, the Stewart Castle case seems to support this general trend.

When evaluated using the movement-minimization and surveillance arguments, however, the village is not visible from the overseer's house, and no identified roads lead directly from the village to the works. These observations suggest that other factors were involved in the positioning of the village on the landscape.

New Methodological Approach

The evaluations discussed above suggest the importance of employing new methodological approaches such as GIS analysis to the study of plantation spatial organization. Influential factors beyond surveillance and economic efficiency revealed in this analysis include topography, land-use strategies and the specific hierarchies that developed on plantations. The variable terrain of the landscape limited visibility and increased costs, especially to remote sections of the estate such as the outer fields, the provision grounds and the wharf. Similarly, topography played an important role in establishing land-use patterns. Sugar cane was reserved for the valley, while guinea grass was grown at high and low elevations.

Viewshed and least cost data indicate that the relationships between the planter, overseer and slaves could influence spatial organization to a greater degree than current hypotheses acknowledge. In terms of the positioning of key plantation elements such as the Castle and the overseer's house, the Stewarts possibly placed more trust in their overseer to observe slave behavior and located the Castle farther from the village and works. Furthermore, the overseer may have been more concerned with efficient economic production than with direct surveillance of the slaves at all times. As Barry Higman (1987) contends, planters may have sought a balance between distance and visibility to establish efficient production *and* effective surveillance. The data also includes the potential for slaves' appropriation of space within the village, on the provision grounds and along certain routes. These factors and their impacts are not addressed in the arguments for surveillance and movement-minimization.

Studies implementing viewshed and cost surface functions appear relatively unique in the field of plantation archaeology. The implications of new approaches to spatial organization include a focus on quantifiable evidence to support suppositions about discipline and production, as well as in-depth investigations of the local environment. Furthermore, GIS applications can reveal additional factors that influenced plantation layout without direct survey data from the study region. Given the outcomes of this analysis, visibility and least cost functions are clearly useful in an initial assessment of plantation spatial organization for sites that have not been excavated.

WORKS CITED

Beckford, William

1788 *Remarks upon the situation of negroes in Jamaica, impartially made from a local experience of nearly thirteen years in that island, by W. Beckford*. London: printed for T. and J. Egerton. Electronic document, *Eighteenth Century Collections Online*, Gale Group, http://galenet.galegroup.com/servlet/ECCO?locID=viva_uva, accessed February 5, 2007.

1790 *A descriptive account of the island of Jamaica: with remarks upon the cultivation of the sugar-cane, ... also observations and reflections upon what would probably be the consequences of an abolition of the slave-trade, and of the emancipation of the slaves*. 2 vols. London: printed for T. and J. Egerton. Electronic document, *Eighteenth Century Collections Online,* Gale Group, http://galenet.galegroup.com/servlet/ECCO?locID=viva_uva, accessed January 22, 2007.

Connolly, James

2006 *Geographical Information Systems in Archaeology*. Cambridge: Cambridge University Press.

Delle, James A.

1998 *An Archaeology of Social Space: Analyzing Coffee Plantations in Jamaica's Blue Mountains*. New York: Plenum Press.

Epperson, Terrence W.

1999 Constructing difference: the social and spatial order of the Chesapeake plantation. In *"I, Too, Am America": Archaeological Studies of African-American Life*, edited by Theresa A. Singleton, pp. 159-172. Charlottesville: University of Virginia Press.

ESRI (Environmental Systems Research Institute, Inc.)

2006 ArcGIS 9.2 Desktop Help. Electronic document, http://webhelp.esri.com/arcgisdesktop/9.2, accessed January - April 2007.

Higman, Barry W.

1987 The Spatial Economy of Jamaican Sugar Plantations: Cartographic Evidence from the Eighteenth and Nineteenth Centuries. Journal of Historical Geography Vol. 13: pp. 17-39.

1988 *Jamaica Surveyed: Plantation Maps and Plans of the Eighteenth and Nineteenth Centuries*. San Francisco: Institute of Jamaica Publications Ltd.

2005 *Plantation Jamaica, 1750-1850: Capital and Control in a Colonial Economy*. Kingston, Jamaica: University of the West Indies Press.

Kantner, John
2004 Geographical Approaches for Reconstructing Past Human Behavior from Prehistoric Roadways. In *Spatially Integrated Social Science*, edited by Michael F. Goodchild, pp. 323-344. Electronic book, http://site.ebrary.com/lib/uvalib/Top?id=10085303, accessed March 3, 2007.

Lewis, Kenneth E.
1985 Plantation Layout and Function in the South Carolina Low Country. In *The Archaeology of Slavery and Plantation Life*, edited by Theresa A. Singleton, pp. 35-65. Orlando: Academic Press.

Leusen, Pieter Martijn van
2002 Pattern to process: methodological investigations into the formation and interpretation of spatial patterns in archaeological landscapes. Unpublished Ph. D. dissertation, University of Groningen, Netherlands. Chapter 6, pp. 1-23.

McDonald, Roderick A.
1993 *The Economy and Material Culture of Slaves: Goods and Chattels on the Sugar Plantations of Jamaica and Louisiana*. Baton Rouge: Louisiana State University Press.

Orser, Charles E. Jr., and Annette M. Nekola
1985 Plantation Settlement from Slavery to Tenancy: An Example from a Piedmont Plantation in South Carolina. In *The Archaeology of Slavery and Plantation Life*, edited by Theresa A. Singleton, pp. 67-94. Orlando: Academic Press.

Panning, Steven
1995 "Exploring Stewart Castle Estate." Pp. 172-179 (Part 1), 199-205 (Part 2). *Jamaican Historical Journal*. Courtesy of DAACS.

Roughley, Thomas
1823 *The Jamaica planter's guide; or, A system for planting and managing a sugar estate, or other plantations in that island, and throughout the British West Indies in general. Illustrated with interesting anecdotes*. London: printed for Longman, Hurst, Rees, Orme, and Brown. Copy in the Albert and Shirley Small Special Collections Library.

Schawrz, Joel
2005 Witnesses' eyes deceive them when distance is too great. Electronic document, http://64.233.167.104/custom?q=cache:cBMSgJ58A_0J:admin.urel.washington.edu/uweek/archives/issue/uweek_story_small.asp%3Fid%3D2517+loftus+2005&hl=en&ct=clnk&cd=6&gl=us&client=google-coop-np, accessed March 21, 2007.

Singleton, Theresa A. (editor)
1985 *The Archaeology of Slavery and Plantation Life*. Orlando: Academic Press.
1999 *"I, Too, Am America": Archaeological Studies of African-American Life*. Charlottesville: University of Virginia Press.

U.S. Census Bureau
2004 Historical Census Browser. Retrieved January 15, 2007, from the University of Virginia, Geospatial and Statistical Data Center: http://fisher.lib.virginia.edu/collections/stats/histcensus/index.html.

Wheatley, David
1995 Cumulative Viewshed Analysis: a GIS-based method for investigating intervisibility, and its archaeological application. In *Archaeology and Geographical Information Systems: a European Perspective*, edited by G. Lock and Z. Stancic, pp. 171-186. London: Taylor & Francis.

FIGURES

Chapter 3, Figure 3.
Mayo, William. "Slaves Assisting a Surveyor, Barbados, 1722." *A New and Exact Map of . . .Barbadoes . . . according to an actual . . . survey made in the Years 1717 to 1721*. London: 1722. Copy in the John Carter Brown Library at Brown University. Courtesy of *The Atlantic Slave Trade and Slave Life in the Americas: A Visual Record* by Jerome S. Handler and Michael L. Tuite Jr.

Chapter 3, Figure 5.
Clark, William. "Shipping Sugar, Willoughby Bay." *Ten Views In the Island of Antigua, in Which are Represented the Process of Sugar Making.... From Drawings Made by William Clark, During a Residence of Three Years in the West Indies*. London: 1823. Copy in the John Carter Brown Library at Brown University. Courtesy of *The Atlantic Slave Trade and Slave Life in the Americas: A Visual Record* by Jerome S. Handler and Michael L. Tuite Jr.

Chapter 3, Figure 6.
Richard Bridgens. "Carting canes to the mill--sketch taken from the estate of St. Clair farm." *West India Scenery...from sketches taken during a voyage to, and residence of seven years in ... Trinidad*. London: 1836. Plate 10. Copy in Virginia Historical Society, Richmond. Courtesy of *The Atlantic Slave Trade and Slave Life in the Americas: A Visual Record* by Jerome S. Handler and Michael L. Tuite Jr.

Chapter 3, Figure 7.
"Moulin pour exprimer le jus des cannes, ála Martinique. [Animal-Powered Sugar Mill, Martinique, 1835]." *Le Magasin Pittoresque*. Paris: 1835. P. 68. Courtesy of *The Atlantic Slave Trade and Slave Life in the Americas: A Visual Record* by Jerome S. Handler and Michael L. Tuite Jr.

Chapter 3, Figure 8.
"Interior of a Sugar-boiling House." *The Illustrated London News*. 9 June 1849. Vol. 14, p. 388. Copy in the Albert and Shirley Small Special Collections Library, University of Virginia. Courtesy of *The Atlantic Slave Trade and Slave Life in the Americas: A Visual Record* by Jerome S. Handler and Michael L. Tuite Jr.