

**MODELLING MOBILITY AND EXCHANGE IN PRE-COLUMBIAN CUBA:
GIS LED APPROACHES TO IDENTIFYING PATHWAYS AND RECONSTRUCTING
JOURNEYS FROM THE ARCHAEOLOGICAL RECORD**

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Abstract

This paper will discuss attempts to model movement and exchange between precolonial sites in Cuba using new archaeological evidence recovered during recent fieldwork. A case study of 102 archaeological sites from a 9,280 km² area in northern Cuba is investigated. Site chronology is discussed with reference to radiocarbon determinations that indicate over 4000 years of pre-Columbian activity in the case study area. GIS applications are used to produce cluster analyses, viewshed analyses, surface cost maps and simulated journey models. These spatial analyses focus on a comparison between water and land based movement between different locales. This provides predictive models of potential pathways through the island landscape based on comparative analysis of journey time and distance data. These potential pathways are then correlated with site distribution patterns at different spatial scales to generate a detailed model of mobility and exchange in pre-Columbian Cuba.

Résumé

Fondée sur des données archéologiques récemment collectées sur le terrain, cette contribution fera état des tentatives de modélisation des mobilités et des échanges entre plusieurs sites précolombiens cubains. Cet article est le résultat de l'étude de 102 sites archéologiques couvrant une surface de 9 280 km² au nord de Cuba. Les datations radiocarbone, effectuées pour ces sites, révèlent une activité continue sur plus de 4 000 ans durant l'époque précolombienne. L'utilisation de SIG a permis de réaliser des analyses par grappes (cluster analysis), de ligne de visée (viewshed analysis) et de coût-surface (cost surface analysis), et de simuler des modèles de trajets. Ces analyses spatiales se concentrent sur la comparaison entre les voyages terrestres et maritimes. Elles permettent d'émettre des hypothèses sur les trajets probables à travers l'île, basées sur l'analyse comparative des temps de parcours et des distances. Ces hypothèses de trajets ont ensuite été corrélées avec la distribution spatiale des sites à différentes échelles, et ce, afin de construire un modèle détaillé de la mobilité et des échanges à Cuba à l'époque précolombienne.

Resumen

Esta artículo expondrá tentativas de crear modelos de movimiento e intercambio entre yacimientos Precolombinos en Cuba usando nueva información arqueológica recogida durante recientes campañas de trabajo de campo. Se presentará un estudio que incluye 102

yacimientos arqueológicos en un área de 9.280 km² en el norte de Cuba. La cronología de los yacimientos es considerada en relación a las dataciones radiocarbono que indican más de 4.000 años de actividad Precolombina en el área del estudio de caso. Aplicaciones SIG son utilizadas para producir análisis de cercanía, cuencas visuales, mapas de costos y modelos de simulación de viajes. Estos análisis espaciales se centran en la comparación de los desplazamientos terrestres y marítimos entre diferentes localidades. Esto proporciona modelos predictivos de posibles rutas a través del paisaje insular basados en análisis comparativos de duración de viaje y distancia recorrida. Estas posibles rutas son correlacionadas con la distribución de los yacimientos a varias escalas espaciales para generar un modelo detallado de movilidad e intercambio en la Cuba Precolombina.

Introduction

This paper discusses the use of spatial analyses using GIS (Witcher 1998; Zubrow 1994) to further investigate the nature of indigenous island interaction in northern Cuba. The archaeological and environmental data gathered from recent fieldwork in the case study area (Figure 1) provide an

opportunity to model interaction using GIS applications.

Interpretation of the archaeological evidence for island interaction in northern Cuba can be enhanced through modelling this evidence with comparative data from wider spatial scales. This can be done using the recently created national Cuban archae-

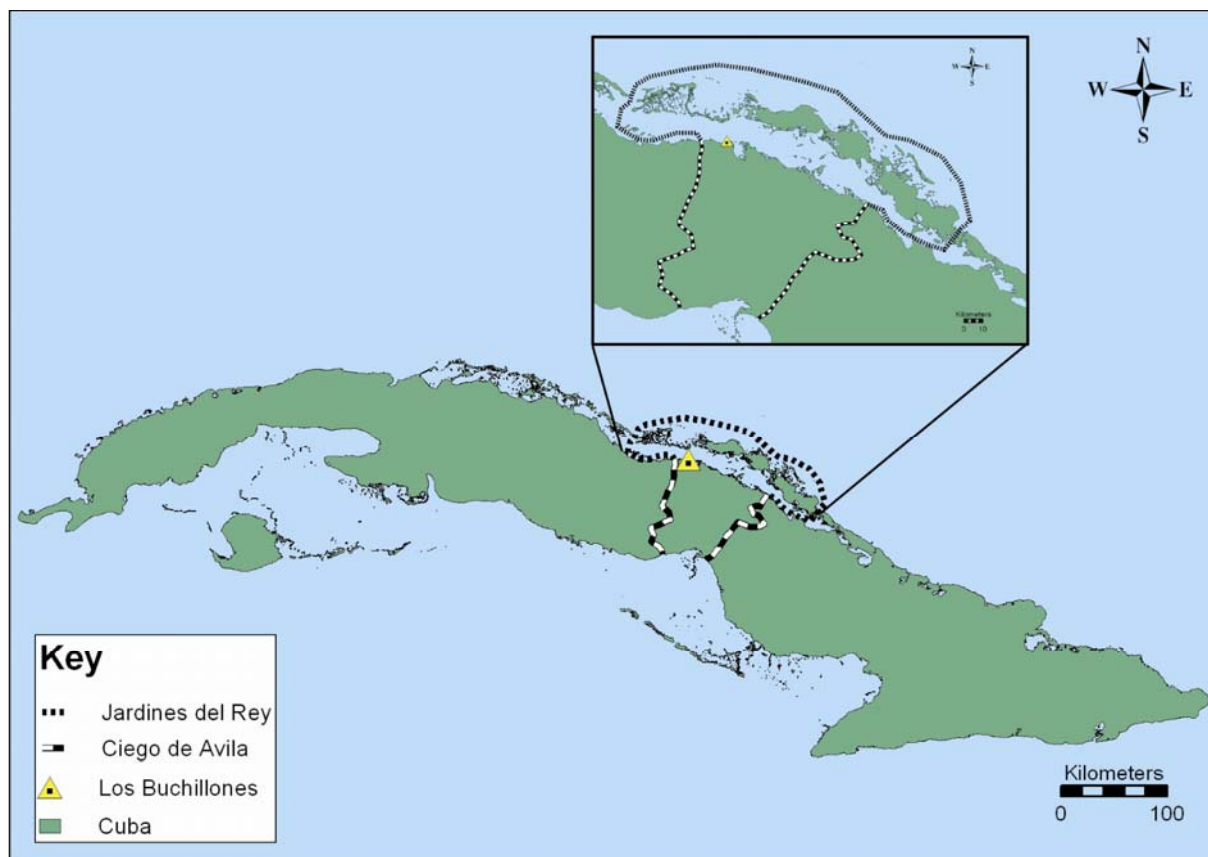


Figure 1. Map of Cuba showing location of Case Study Area in the wider regional area of Ciego de Avila province and the Jardines del Rey archipelago.

ology database, discussed further in previous publications (Cooper 2007, 2010). Therefore spatial analysis and GIS applications were used to model and provide potential interpretations for the nature of island interaction in the case study area and wider surrounding region. This area of north central Cuba, including parts of the Sabana-Camaguey archipelago and the province of Ciego de Avila, has a long standing history of archaeological investigation that provides an excellent dataset with which to develop these spatial analyses (Calvera Rosés and García Lebroc 1994; Cooper et al. in press; Pendergast et al. 2002; Valcárcel Rojas et al. 2006).

Sites in Case Study Area and Wider Region

Site classification is necessary as a means of establishing comparable terms of

reference for the sites within the study area. The common Cuban site classification term of *agroalfarero* is a term used in this paper to indicate pre-Columbian sites with a broad date range of AD 900-1500. The well known site of Los Buchillones, where recent fieldwork has been focused, can be classified as an *agroalfarero* site based on the extensive ceramic collection, including griddles, and the large size of the settlement with evidence of a large sedentary community reliant on agriculture, as well as a number of calibrated radiocarbon dates (Cooper 2008, 2010; Cooper et al. 2006; Valcárcel Rojas et al. 2006). The locations of sites in the surrounding region that have also been classified as *agroalfarero* during recent fieldwork in the area and in the Cuban archaeology database are shown in Figure 2. There are 31 *agroalfarero* sites from the Cuban archaeology database

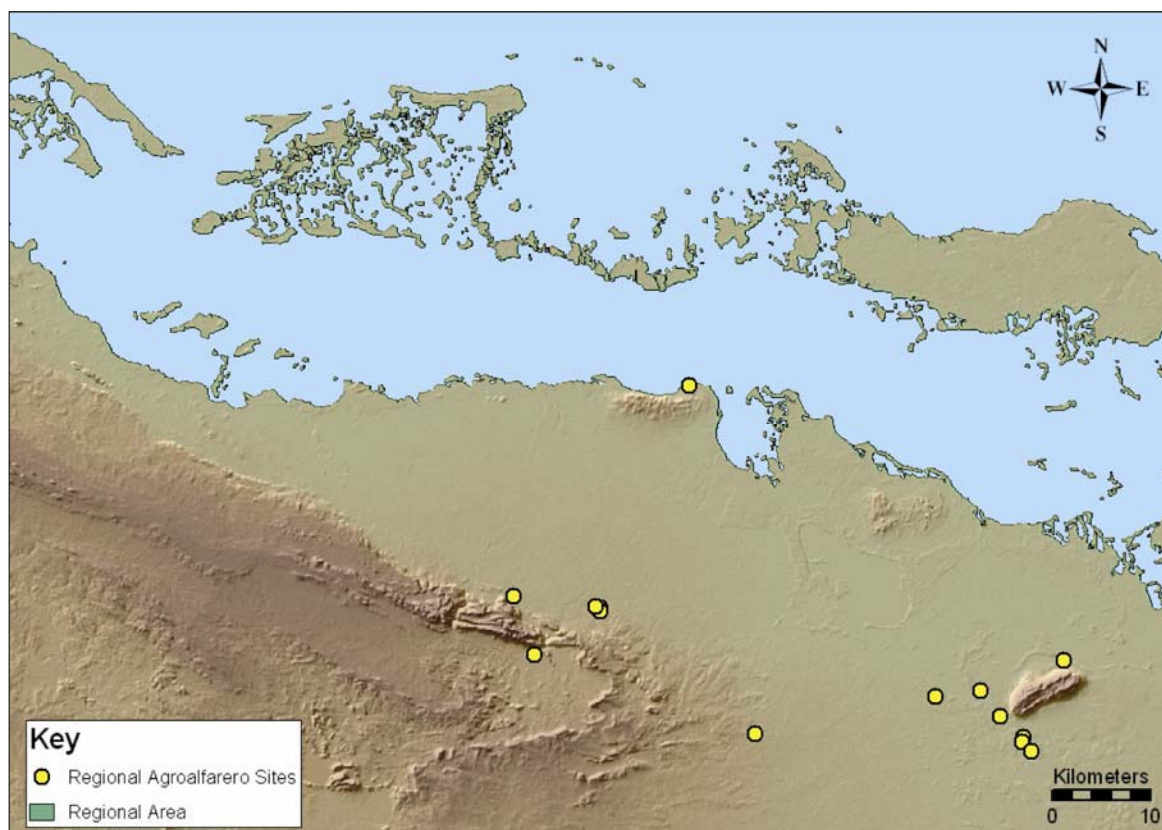


Figure 2. Map showing locations of sites in the regional area that have been identified as *agroalfarero* in the Cuban Archaeology database

within a 50 km radius of Los Buchillones, the nearest being Santa Clarita over 24 km away, with a range of hills in between known as the Lomas de Punta Alegre (Cobo Abréu et al. 1996; Drusini and Luna Calderon 1997; Rivero de la Calle and Trapero Pastor 1997).

The dearth of neighbouring agroalfarero sites has led to Los Buchillones being described as an isolated site: "There are some sites that appear isolated. Such is the case for the site called Los Buchillones" (Calvera Rosés and García Lebroc 1994:1). By contrast other agroalfarero sites in the province are grouped. These groupings of sites have been identified as possible cacicazgos or chiefdoms by Calvera et al. (1996:63). The names allocated by Calvera to these clusters of agroalfarero sites are Falla, Romanillo and La Cunagua, from west to east respectively.

Cluster Analysis and Site Distribution Patterns

As discussed above, there appears to be spatial patterns in the distribution of archaeological sites and groups of agroalfarero sites have been previously been identified as chiefdoms or cacicazgos (Calvera Rosés et al. 1996:63). Therefore cluster analyses were conducted in order to test the spatial characteristics of the distribution of site point data within GIS. The scale at which these analyses are conducted is an important factor in determining the characteristics of spatial patterns. The cluster analyses were carried out at a regional scale that includes all sites within a 50km radius of the case study area. The aim of these analyses is to identify whether site distributions are random, clustered or regular.

There are a number of different spatial analysis methods ranging from the 50 year old nearest-neighbour analysis (Clark and

Evans 1954), that remains a useful method for identifying patterns in point distributions, to the more recent point-density analyses including the k-function method (Lloyd 2007:186). The cluster analysis selected was a kernel density analysis, which is a two-dimensional intensity analysis in ArcGIS. This analysis method was selected as it provides a "*sophisticated density measure.... that produces smoother and more readily interpreted results than simple density techniques*" (Conolly and Lake 2006:175). The parameters for the analysis include kernel shape and bandwidth. A raster is then created using the cumulative densities for each cell based on the overlying density kernels. Input analyses were based on a 10,000 km² regional area using X-Y co-ordinates to generate the site population body.

Cluster Analyses

The kernel density analysis of the agroalfarero sites is illustrated in Figure 3. This analysis identifies a broad pattern of dispersed individual sites on the offshore islands, the coast and the interior of the Cuban mainland as well as three nucleated clusters of sites in the Cuban interior represented by the green and white intensity raster. These clusters include different numbers of sites within close proximity and provide a direct correlation with the groups of sites identified as possible chiefdoms by Calvera and colleagues (Calvera Rosés 1982; Calvera Rosés and García Lebroc 1994) and named, from west to east, Falla (Cluster 1), Romanillo (Cluster 2) and La Cunagua (Cluster 3) (see Table 1).

Discussion of the Cluster Analyses

It should be noted that all analyses are based on the best available data, which are only a sample of a potential 'real' site distribution that includes further, as yet undiscovered, sites. However, the sample of 120

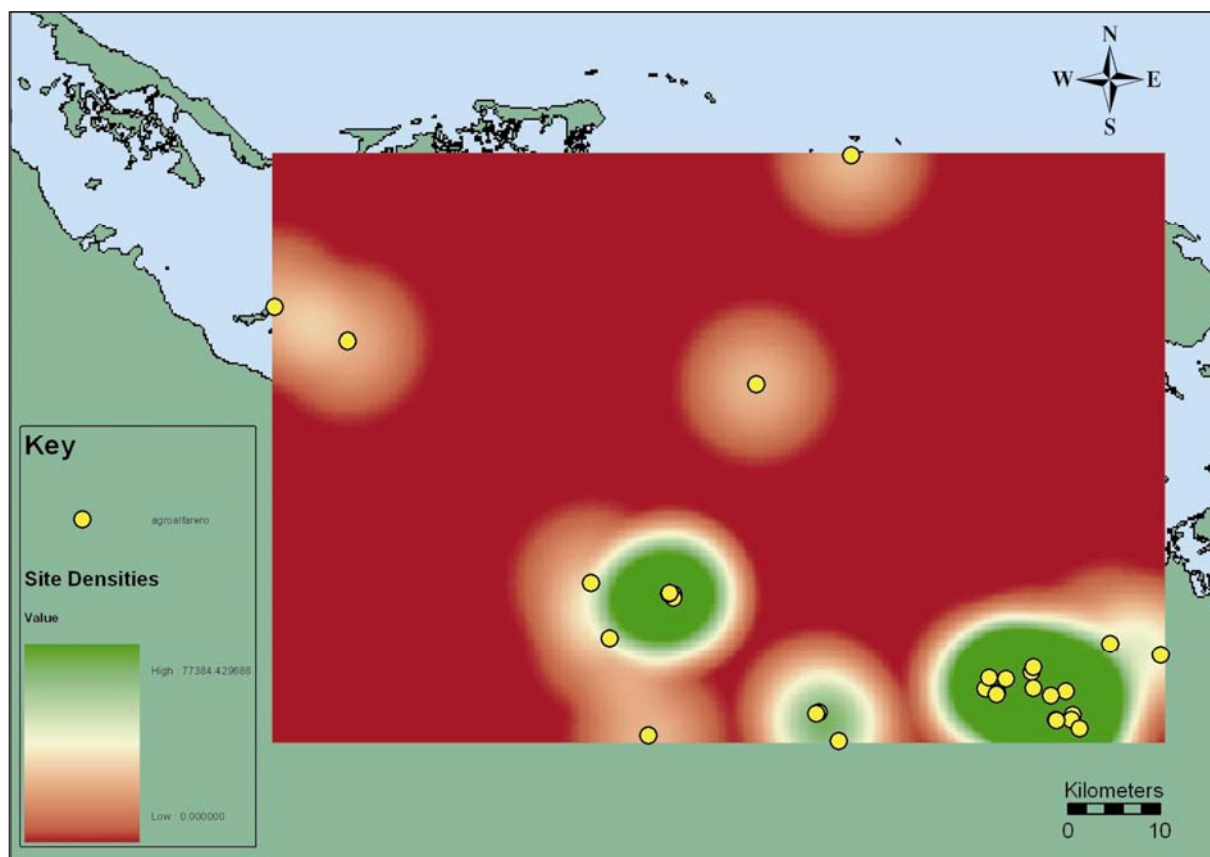


Figure 3. Kernel density analysis of agroalfarero sites that shows three clusters of sites indicated by the green density scale

Cluster 1 (west)	Cluster 2 (south)	Cluster 3 (east)	Cluster 3 (east)
Santa Clarita 1	Guanito	La Rosa	Puente Largo 1
Santa Clarita 2	Romanillo I	La Garita	Cueva el Majo
Santa Clarita 3	Romanillo II	Solapa La Garita	Cayo Largo 1
Santa Clarita 4		San Pedro	Cayo Largo 2
Santa Clarita 5		La Pelona	Cayo Largo 3
Mabuya		Santa Sofia I	Cayo Largo 4
Rio Palma 1		Santa Sofia 2	Las Playuelas
		San Agustin	

Table 1. List of *agroalfarero* sites in the clusters identified in the regional area based on the kernel density analysis.

archaeological sites appears sufficient to make a study of site distribution patterns useful, but there is the potential for non-archaeological bias affecting the spatial patterns. Comparisons were made between

site distribution and a digitised map of modern day settlements and road network in order to identify whether this influenced site distribution patterns. Although some of the sites are close to modern roads there

does not appear to be any evidence that this is affecting site distribution patterns. The concentration of agroalfarero sites near upland areas could be a reflection of the survey strategies and research foci of previous archaeological studies in the province. These potential biases in the data should not be overlooked but nor should their potential limitations preclude the spatial analysis of the sites that are currently available for study.

Summary of Cluster Analyses Data

The available site data appear to indicate three clusters of agroalfarero sites in the Cuban interior with dispersed individual sites on the coast and offshore islands. The survey of the case study area has identified sites on the offshore islands and evidence of agroalfarero period island interaction. These cluster analyses are based on distance and do not take into account the more complex nature of landscape, in which connectivity and the potential for interaction between sites cannot be based on distance alone. Therefore further spatial analyses are required that take into account other factors that affect the potential for interaction, such as topography and visibility. By establishing a more realistic model of the island landscape.

Landscape Topography and Digital Elevation Models

Adding the third dimension of height to two-dimensional maps of archaeological site distributions can help to provide a better context. A Digital Elevation Model (DEM) was created for the whole of Cuba using SRTM data from the NASA Aster satellite with a resolution of less than 3m elevation with 100m² cell sizes. This was used to produce a DEM raster projected in UTM 1984 17N. The site location point data were mapped over the DEM using a semi-transparent hillshade, added to im-

prove the visibility of the data. This analysis indicates a correlation between location of agroalfarero sites in the interior of the Cuban mainland and areas of elevation. There appears to be a link between the agroalfarero site clusters and the three hill ranges of Lomas de Punta Alegre, Loma de Cunagua and Sierra de Jatibonico. All of the sites in the interior of the Cuban mainland are within 7 km of a range of hills. Potential hypotheses to explain this proximity to the upland areas include the regular use of mineral resources or flora and fauna that are only available in these elevated environments (Del Risco Rodríguez 1999:53). Another possibility is that visual relationships between sites and their proximity to areas of elevation produce correspondingly greater visibility. This is discussed in further detail below.

In order to provide a localised picture of topography at each site, a slope map was generated from the DEM, which showed that 27 of the 28 agroalfarero sites in the interior of the Cuban mainland were located on flat land that is always close to or within upland areas (Figures 9.07 and 9.08). Even the sites at high elevations in the Sierra de Jatibonico are on flat highland plains. Hypotheses for explaining the location of agroalfarero sites on flat open areas include the need for flat arable land and the open space to house relatively large concentrations of population.

Inter-site Visibility and Cumulative Viewshed Analyses

Views from sites in the study area and wider province were analysed to identify possible visual connections in the island-landscape. These visual relationships were studied based on both phenomenological data recorded during previous surveys and through GIS based viewshed analyses carried out using Geographic Resources Analysis Support System (GRASS). This

methodology differs to previous studies of viewshed analyses in the Caribbean (Torres and Rodríguez Ramos 2008).

The viewshed analyses were conducted using the cumulative viewshed analysis (r.cva) program (Lake 1998) in GRASS. Six agroalfarero sites were selected for viewshed analyses. From the case study area, Cave 1 Cayo Hijo de Guillermo, Surface Deposit 2 Cayo Contrabando and D2-6, Los Buchillones all had indigenous ceramics and contemporaneous radiocarbon determinations. Three agroalfarero sites were selected from the wider region. These sites have archaeological evidence for substantial settlements with a diverse ceramic assemblage including griddles and vessels with incised and appliqué decoration as well as elaborate lugs that provide further evidence for late prehistoric indigenous activity contemporaneous with selected

sites from the case study area. One site was taken from each of the three clusters identified during the kernel density analyses discussed above: San Clarita 4 from Cluster 1, Guanito from Cluster 2, and La Rosa from Cluster 3.

Example from Cave 1, Cayo Hijo de Guillermo Este

An example of one viewshed is shown in Figure 4. This viewshed from the entrance to Cave 1, Cayo Hijo de Guillermo Este indicates a panoramic view of the surrounding islands. The only portion of the Cuban mainland that is visible from this site is a section of the Lomas de Punta Alegre. The site of Los Buchillones is located in the middle of this range of hills as viewed from Cayo Hijo de Guillermo Este. The island survey of Cayo Hijo de Guillermo Este recorded similar panoramic

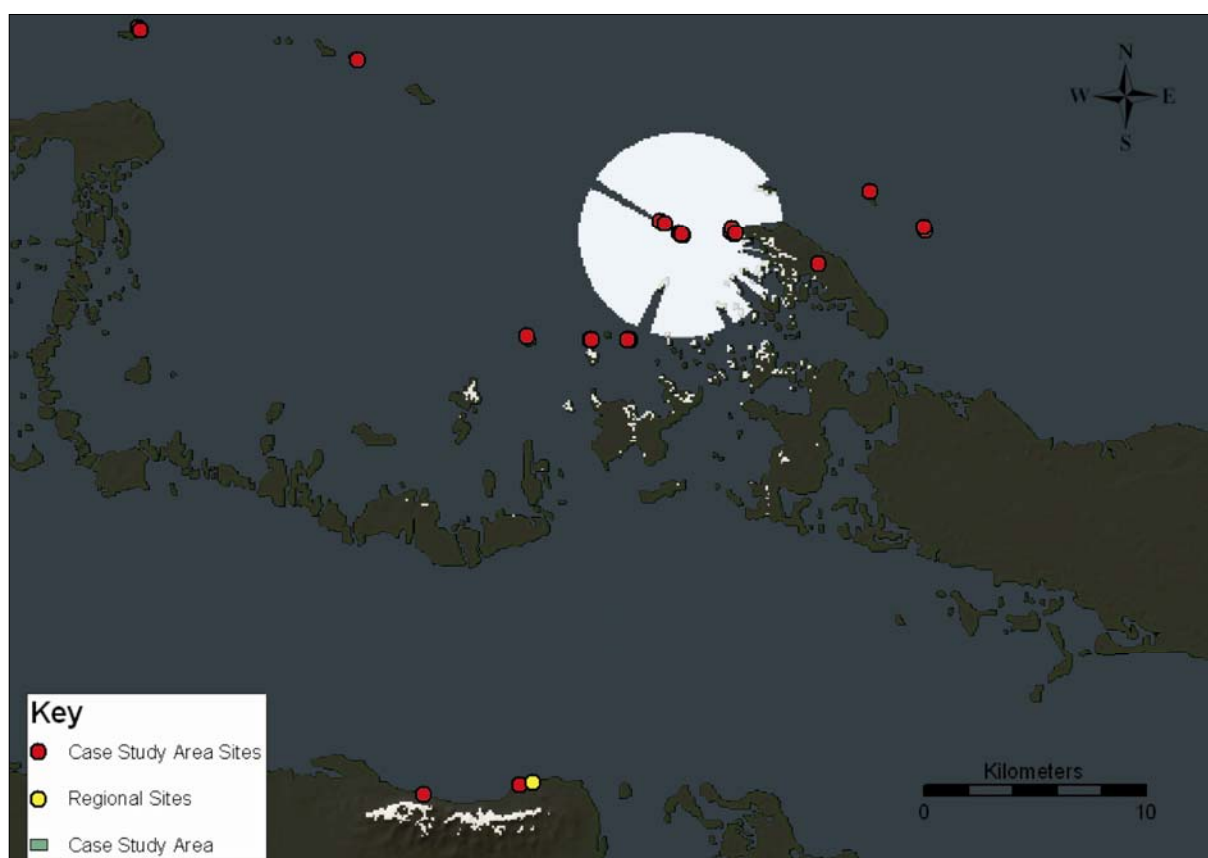


Figure 4. Map showing viewshed from entrance to Cave 1 on Cayo Hijo de Guillermo Este.

views from outside Cave 1 on the island. The humanly recorded views included the Lomas de Punta Alegre as the only portion of the Cuban mainland visible. Therefore the computer-based 'r.cva' viewshed analysis for Cave 1, Cayo Hijo de Guillermo Este was substantiated by the recorded views from the site described and photographed during the survey.

Discussion of Visibility and Viewshed Data

It could appear that these viewshed analyses are just an elaborate model illustrating the simple observation of greater visibility of upland areas. However, the viewshed analyses identify a pattern in the portions of upland area visible and the close proximity of potentially contemporaneous sites. As with any interpretation of patterns in GIS-modelled data, there is the potential that they are the product of patterns of data selection rather than meaningful patterns in the data themselves. It is clear that there are a number of important factors that have not or cannot be taken into account in the cumulative viewshed analyses of the archaeological sites in this region. Not least of which is vegetation cover, which given the ethnohistorical evidence for large forests in Cuba, could have been a major factor. It can be counter argued that settlements could have required large clearances of this vegetation and provided open clear spaces from which long distance views would be possible. In addition there are other factors that would have increased inter-site visibility such as smoke columns or fires from these settlements. However, despite citing some of these factors as important, it would be pure speculation to attempt to model them effectively without detailed evidence for their existence. Therefore all the viewshed analyses have to be considered as speculative models based on the best available data.

Summary of Viewshed Data

The viewshed analyses of six agroalfarero sites in this region indicate that there is a connected visionscape between the sites on the islands and that the clearest topographic feature on the Cuban mainland that is the Lomas de Punta Alegre, the centre of which marks the location of Los Buchillones. In addition, there is a visual connection between some island sites and a visible portion of the Jatibonico mountain range, where the sites of Cluster 1 are located. The views of the Cuban interior from Los Buchillones are limited but there is a panoramic view of the sea stretching out into the Bahía de Buena Vista.

The viewshed analyses from the sites of Cluster 1, 2 and 3 in the Cuban interior indicate that these clusters of sites are all interconnected through site inter-visibility and through the visibility of upland areas close to each cluster. Therefore these viewshed analyses indicate that the agroalfarero sites from the study area and the wider region are linked by visual connections that link the offshore islands, the coast and the Cuban interior. In order to establish whether these connected views are significant for further interpretation of island interaction, it is necessary to turn attention to the nature of the possible connections between these sites and consider the potential pathways of interaction between them.

Pathways through the Islandscape and Surface Cost Analyses

Identifying evidence of past pathways through the landscape is possible through archaeological investigation by discovery of roads, bridges and material evidence of past routes. However, identifying pathways through the sea or bodies of water can prove to be more challenging. There are a number of different methods that can be

used to identify pathways and routes of interaction including archaeological, ethnographic, experimental and surface cost models. The surface cost analyses provide a potential way of analysing past pathways through both the landscape and waterscape that are required when considering island interaction.

This section will focus on the results of surface cost analyses conducted in GRASS using a modified *r.walk* program (Fontanari et al. 2005). The advantage of this program is that it can model possible routes across land and water by creating a cell-based surface friction map of the island. This model factors in topography and variations in travel speeds over land and water to create a surface cost map that calculates the time, distance and energy costs of travelling out from any individual site. Using this surface cost map, it is possible to model potential pathways between sites based on the minimum surface cost path between the two sites. There are clearly limitations to this model, not least of which is the lack of known paleoenvironmental data for the wider regional area as well as the potential importance of tectonic activity and relative sea level change dramatically altering the island in the past (Cooper and Boothroyd in press; Cooper and Peros 2010). Furthermore, it is important to highlight that these models do not take into account the complex social landscape where territorial boundaries may well have played a crucial role in affecting past human mobility in this region. However, these models certainly can help to identify patterns in potential pathways between sites, as well as generate possible travel times and distances for alternative routes. These pathways and their corresponding journey data can then be compared and their interpretative value assessed in light of the archaeological evidence.

Elevation data were taken from the DEM discussed above. The *r.walk* computer model factors in the increasing and decreasing speeds created by increasing and decreasing angles of inclination in the landscape (Fontanari et al. 2005). This allows the creation of topographically sensitive landscape surface cost maps. One of the key findings of recent fieldwork has been evidence for water-based journeys in the case study area. This evidence for water based travelling highlighted the need to modify the *r.walk* program to include water-based travel speeds. Canoes are thought to be the most common form of waterbased transportation among indigenous groups in the Caribbean (Glazier 1991:49; Robiou Lamarche 1992:69), and there is evidence for indigenous canoes at the site of Los Buchillones (Cooper 2004). The surface cost analyses for waterbased travel were inputted using data from an experimental canoe trip between Cayo Hijo de Guillermo Este and Los Buchillones and comparative ethnographic and experimental data (Callaghan 2001, 2003a, 2003b, Callaghan 2006; Callaghan and Bray 2007).

Excavations at Los Buchillones highlight the permeable nature of the coastline in the prehistoric period with people living on the liminal edge blurring the boundary between land and water. There are a number of navigable lagoons and lakes in the region that allow water based travel into the interior. Interviews conducted with fisherman in Punta Alegre and Maximo Gomez revealed that many of the rivers in the region were navigable and regularly travelled up and down by small boats, canoes and punts. These bodies of water, including lagoons, lakes and large rivers that were potentially navigable by canoe, were digitised to create a map of the navigable waterscape in the region, using a combination of the DEM, satellite imagery, and local Cuban maps georeferenced in ArcGIS.

R.walk analyses were then conducted to generate surface cost maps for the six sites discussed above. Once these surface cost maps had been created, it was possible to start analysing potential pathways. This was done by rasterising the site point for the start of the pathway and then creating an anisotropic terrain cost flow analysis in GRASS back to the original site. All of the sites had both landscape models, where

only walking across land was possible, and islandscape models, where walking across land and canoeing along navigable waterways was possible, created for comparative analysis.

Following these analyses in GRASS, the surface cost analyses were exported into ArcGIS for projection and comparative analysis. These surface cost pathway analyses produced a model of travel times and

Base Site	Travel Site	Surface Cost Map	Distance	Time
Buchillones	Guanito	Landscape	40.9 km	8 hrs 50 min
Buchillones	Guanito	Islandscape	50.8 km	5 hrs 56 min
Buchillones	Santa Clarita 4	Landscape	25.2 km	5 hrs 39 min
Buchillones	Santa Clarita 4	Islandscape	31.3 km	3 hrs 18 min
Buchillones	Rio Palma	Landscape	29.8 km	7 hrs 28 min
Buchillones	Rio Palma	Islandscape	39.8 km	5 hrs 11 min
Buchillones	La Rosa	Landscape	40.9 km	10 hrs 32 min
Buchillones	La Rosa	Islandscape	45.2 km	5 hrs 12 min
Buchillones	La Garita	Landscape	43.2 km	12 hrs 8 min
Buchillones	La Garita	Islandscape	49.4 km	5 hrs 30 min
Buchillones	Rosa de los Chinos	Landscape	53.2 km	12 hrs 41 min
Buchillones	Rosa de los Chinos	Islandscape	67.3 km	6 hrs 59 min
La Rosa	Santa Clarita 4	Landscape	36.6 km	7 hrs 52 min
La Rosa	Santa Clarita 4	Islandscape	48.3 km	7 hrs 19 min
Buchillones	C1 geste	Islandscape	26.4 km	2 hrs 31 min
Buchillones	Contrabando	Islandscape	20.9 km	1 hr 55 min
Buchillones	Oeste	Islandscape	27.1 km	2 hrs 33 min
Buchillones	Guillermo	Islandscape	27.3 km	2 hrs 40 min

Table 2: List of surface cost pathways, travel times and distances between *agroalfarero* sites in the region.

distances between sites that were useful for direct relative comparison and for reconstructing potentially informative inter-site travel times, distances and routes. The surface cost pathways generated for a sample of agroalfarero sites throughout the region and these are listed in Table 2.

The inclusion of the waterscape when modelling island interaction changes the perspective of the islandscape and provides a different perspective of relative distance and connectivity between sites in the region. This can be visually represented by the islandscape surface cost map from Los Buchillones that is banded at 30 min travel times from the site (Figure 5).

This map provides an example of how the interactive space within the islandscape can be displayed visually to present alternative understandings of distance. This surface

cost map illustrates how travelling along the coast and up the navigable rivers changes the way in which archaeological evidence for interaction at different sites can be interpreted. The coastal waters become a connected route for interaction running east-west along the north of Cuba with navigable rivers forming subsidiary paths up to sites and settlement clusters in the interior.

Discussion of Surface Cost Pathway Data

The rivers and navigable watercourses are based on modern river systems and lake sizes that may, or indeed surely have, changed over time. Obstructions such as past bridges or dams have not been taken into account. In addition, the rivers are not precisely mapped as they were digitised using remote sensing satellite imagery and photocopied maps. Therefore not all of the

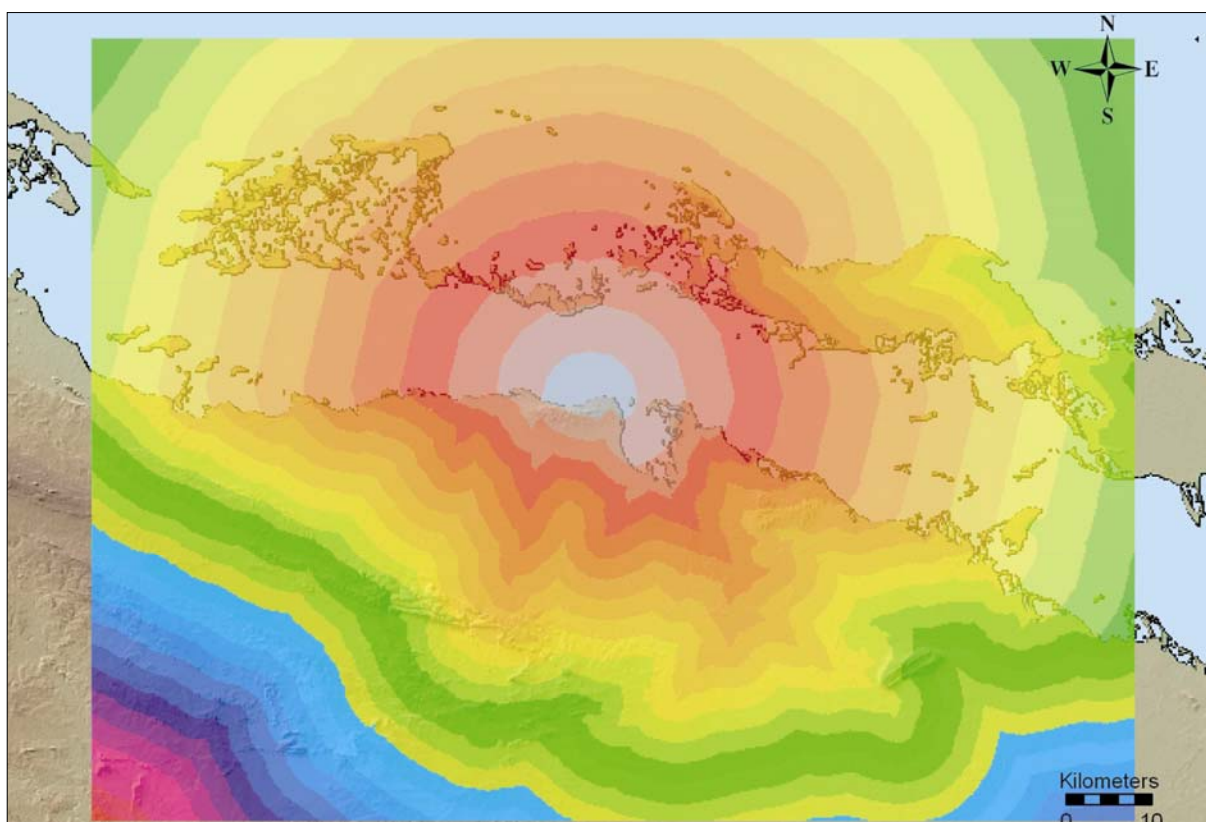


Figure 5. Map showing travel times from Los Buchillones banded at 30 minute intervals based on walking across the landscape and canoeing across navigable bodies of water.

river systems have been individually surveyed and confirmed as currently navigable by canoe. However, the possibility of obstructions on these rivers in the past raises an issue for discussion and highlights an advantage in the use of the canoe as opposed to other forms of transport (Johnstone 2001). Not only does the canoe have a very shallow draft that allows it to be paddled through shallow waters, it is also one of few watercraft that can be easily portaged around any obstacles or obstructions in a river. This is a significant advantage of the canoe as a means of transport as it can travel through a diverse range of different bodies of water including seas, lakes, wetlands and rivers. This is in contrast to the often deeper drafted and heavier masted, keeled, finned or outrigger vessels commonly found in other island theatres around the world (Gosden and Pavlides 1994; Horden and Purcell 2000; Rainbird 2004; Robiou Lamarche 1992).

Summary of Surface Cost Pathway Data

All of the archaeological sites on the offshore islands in the case study area, with evidence of contemporaneous island interaction with Los Buchillones, have return travel times of less than 5 hr 30 min. All of the archaeological sites in the wider province, where there is evidence for permanent occupation, are within less than 5 hr 30 min of Los Buchillones and as they are permanent settlements there is the potential to stay overnight.

Water has the potential to reduce the travelling times between sites, even if distances are increased. The archaeological evidence indicates regular journeys between sites in the case study area over a distance of at least 27 km one way, or round trips of 54 km, over water. Evidence suggests a one-way travel time of 2 hr 31 min from Los Buchillones to Cave 1, Cayo Hijo de Guillermo Este, and given the ar-

chaeological evidence at this site for travel further away from this island and out to the reef, it is likely that these travel times were greater.

The initial models for travel times to the interior sites based on walking through the landscape are time consuming and the majority could not be completed in the daylight hours of one day. This has contributed to previous interpretations of isolated sites and limited interaction between sites in the interior, sites on the coast and sites on the offshore islands.

When all of the water in the region that is navigable by canoe is taken into account, the travel times between these sites can be re-modelled. The water-based journeys to all of the sites in the interior can be completed within the daylight hours of one day. Many of these journeys are up to 30% longer and sometimes take routes that go in the opposite direction from the destination site. The routes between Los Buchillones and each of the site clusters do not pass close to any known intermediate sites that could be used to break up the journey or stay overnight. Therefore models based on the evidence from the case study area for regular water based island interaction can help to illuminate alternative routes and pathways along which interaction could occur.

Conclusions

There is substantive evidence for marine based transport and interaction with the offshore islands and marine environments in the case study area. Where evidence is available at Los Buchillones marine resources are an important component for both subsistence and as a raw material for artefact production. It can therefore be hypothesised that inter-island and marine environment interaction in the case study area was direct and regular.

Shallow berth canoes allow navigation up shallow rivers and also enable portage around any potential barriers such as waterfalls. Examples of canoes have been found at Los Buchillones and there is archaeological and ethnographic evidence for their use by indigenous peoples throughout Cuba and the wider Caribbean. Anyone who spends time working with the sea knows that before any trip can be attempted one needs to observe the sea and draw on experience to plan for potential meteorological conditions. An important observation of the viewshed analyses is that none of the interior sites from Cluster 1, 2 or 3 have views of the sea. This contributes to arguments against direct access to the marine environments from the sites in the interior and supports the hypothesis of a coastal centre, such as Los Buchillones, from where marine resources were distributed to sites in the interior.

The distribution of marine sourced materials at archaeological sites in Cuba reveals the extent to which marine materials were moving into the interior of the island. Movement of materials into the interior also raises the question of means of transport. In the case study area, Los Buchillones is 'blocked' from the interior by the Lomas de Punta Alegre. It is time consuming to walk over this range of hills. However, excavations of stilted houses in the wetland environment suggest that water based transport was common at Los Buchillones. Surface cost models of possible journeys highlighted the likelihood that navigable rivers were used to transport materials to the clusters of sites in the interior. Marine resources from the island archipelago and terrestrial resources from upland areas in the Sierra de Jatibonico and Cuna-gua hills could have been the basis for trade and exchange between coastal and inland sites. Certainly the quantities of shell at inland sites, some of which are

over 100 km from the marine habitats from which the shell came suggests interaction with communities, such as Los Buchillones, that are closer to the source of the resources.

Given the archaeological evidence from the case study area for the use of marine resources being transported between sites, the question is raised concerning the degree to which coastal interaction occurred east-west along the north coast of Cuba. The movement between the sea and the interior indicates a potential element for investigation using sites in the Cuban archaeology database. The spatial scale at which observations of patterns of interaction can be observed needs to be co-ordinated with the confidence in interpretation (Orton 2000). However, one could argue that Los Buchillones functions as a port or centre for trade and exchange. This idea of coastal ports for interaction has been raised in Puerto Rico by Reniel Rodríguez Ramos (Rodríguez Ramos 2002:19). Therefore further evidence for interaction can be extrapolated for all of Cuba during future research that using data from the national archaeology database.

In addition to providing information on interaction, the foregoing analyses have questioned the use of concepts, such as 'communal' and 'remote'. Previous associations have identified site groups as bounded, particularly by distance, but my studies have shown that travel times are not directly correlated to distance. Sites in the case study area have been located within a regional network of interaction through archaeological evidence and landscape data including inter site visibility, topography and pathways. Although my research is only an initial attempt to model island interaction, it provides a testable model to explain the nature and extent of island interaction in northern Cuba.

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