CONTACT PERIOD ROCK ART: GIS ANALYSIS OF SOCIAL AND SPATIAL INTERACTIONS OF AUSTRALIAN ABORIGINAL PEOPLES AND EUROPEAN EXPLORERS IN ARNHEM LAND, NORTHERN TERRITORY, AUSTRALIA.

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ABSTRACT

The native Aboriginal peoples of Arnhem Land in the Northern Territory of Australia are prehistorically a hunter-gatherer society. They have strong connections to the landscape and the stories of their ancestors, which they express through rock art painting. The purpose of this research is to use archaeological data and Geographic Information Systems (GIS) methods to show various patterns and spatial relationships involving initial European contact and Aboriginal rock art paintings within the Northern Territory. GIS is a powerful tool for visualizing, analyzing, and interpreting data. Analytical methods using archaeological, historical and ethnographic accounts, and along with GIS data models, offer new ways of extracting and interpreting social and spatial structures. Mapping European explorer paths, distance to rivers, locations of Contact era paintings, and natural landscape barriers provide insights into how people interacted with each other as Europeans moved into Australia. Archaeology in Northern Australia has a history of spatial and social cultural reconstruction and the inclusion of GIS in this project contributes to a wider understanding of the regional landscape and the complex relationships that arise during European contact.

INTRODUCTION

Rock art is not only just an artifact for archaeologists to study; it is a window into the human experience. The form, function, and spatial distribution of rock art can reveal a great deal of information about the actions of the people, their environment, and the system to which they are deeply embedded.

Initial contact between European explorers and Aboriginal people in Arnhem Land, Northern Australia was a complex series of engagements. The assumptions are that the Contact Period is a singular event, stressing European dominance, and life-changing impacts on the Aboriginal community (Torrence and Clark 2000:26). The Australian Aboriginal response to both direct and indirect contact with European explorers is reflected in the distinctive changes *(or lack thereof)* in painting style, material, and subject matter of their rock art paintings (Frederick 2000, Chippendale and Taçon 1998). The interaction descriptions, which are Aboriginal rock art paintings and European publications, come from two dissimilar socio-cultural backgrounds. The common bonds between Aboriginal people and European explorers were the shared geographic setting and basic human needs.

This research aims to use multiple perspectives to provide a balanced study of intercultural engagements and reactions using Aboriginal rock art paintings, published expedition journals, and regional landscape analyses to recognize spatial patterns of interactions prior to pastoral colonization. The manner in which introduced subjects such as ships, guns, people, and non-native animals are portrayed reveal important Aboriginal insights to provide a more nuanced view of the Contact Period, which have traditionally been dominated by European accounts.

Geographic Information Systems (GIS) map overlay methods display multiple variables for the patterns of land exploration in relation to Aboriginal rock art paintings. Regionally plotting the patterns of European expedition movement, Aboriginal interaction, and responses from both sides, correlations can be made about impacts of intercultural engagements to Aboriginal social contexts, which provides another line of evidence for exchange and influence within a large region between multiple Aboriginal groups.

BACKGROUND

Western Arnhem Land – Alligator Rivers Region

The area of study is known as the Alligator Rivers Region. It is located in the northern section of the Northern Territory in Australia. The East and South Alligator Rivers flow NW towards the Van Diemen Gulf as shown in figure 1. The Alligator Rivers Region is a wetland system rich in plant and animal varieties. Low relief alluvial plains, mangrove swamps, and stony uplands characterize the landscape (Nott 2003:1).

This region experiences a monsoonal wet season from November to March and an arid dry season from May to September. October and April are transitional months (Commonwealth of Australia 2013). Aboriginal people divide the wet and dry seasons into six periods, which are based on human activities, temperature, and weather conditions (figure 2). Permanent water sources in the dry season are restricted to waterholes, springs and billabongs that provide reliable freshwater sources (Commonwealth of Australia 2013, Chaloupka 1983:3). The Alligator Rivers maintain flow throughout the year and extensive seasonal flooding cover the low-lying flood plains.

The Arnhem Land plateau (stone country) is a steep sandstone escarpment that separates the uplands from the lowlands. The plateau varies in elevation from 100 to 300 meters above the lowlands (Nott 2003:1, Williams 1991:11). Some sandstone residuals rise to 520 meters above sea level. The movement of the escarpment over time has caused outlying sandstone massifs and boulders to lie over a 1km from the cliff line (Commonwealth of Australia 2013). The erosional forces along the escarpment have created overhangs, caves, and other rockshelter features.

The Arnhem Land plateau and outlying massifs are significant places for rock art. Many of these natural erosional features house rock art, burials, and wet season camps. The Arnhem Land plateau and sandstone outliers are used as a physical geographic obstacle in this analysis to illustrate the barriers for movement of European inland explorers and the freedom for movement of Aboriginal groups.

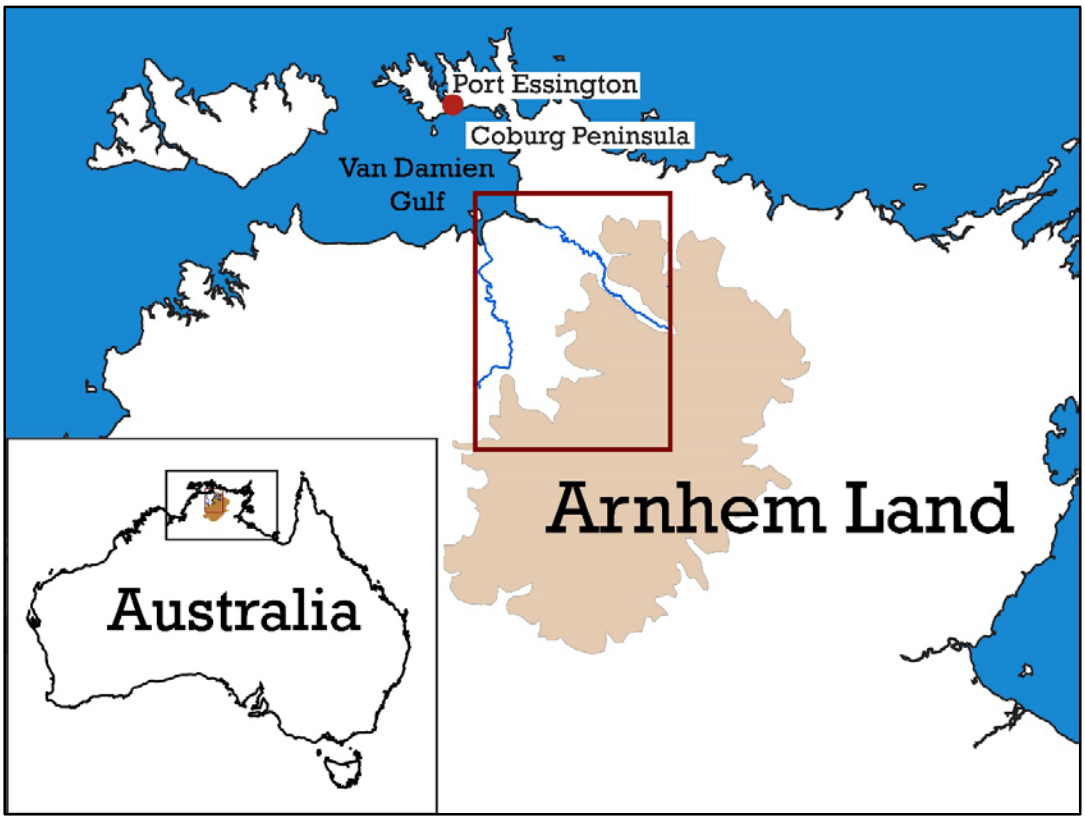

Figure 1. Extent of study area in boxed red. Arnhem Land escarpment in light brown. East and South Alligator Rivers in blue.

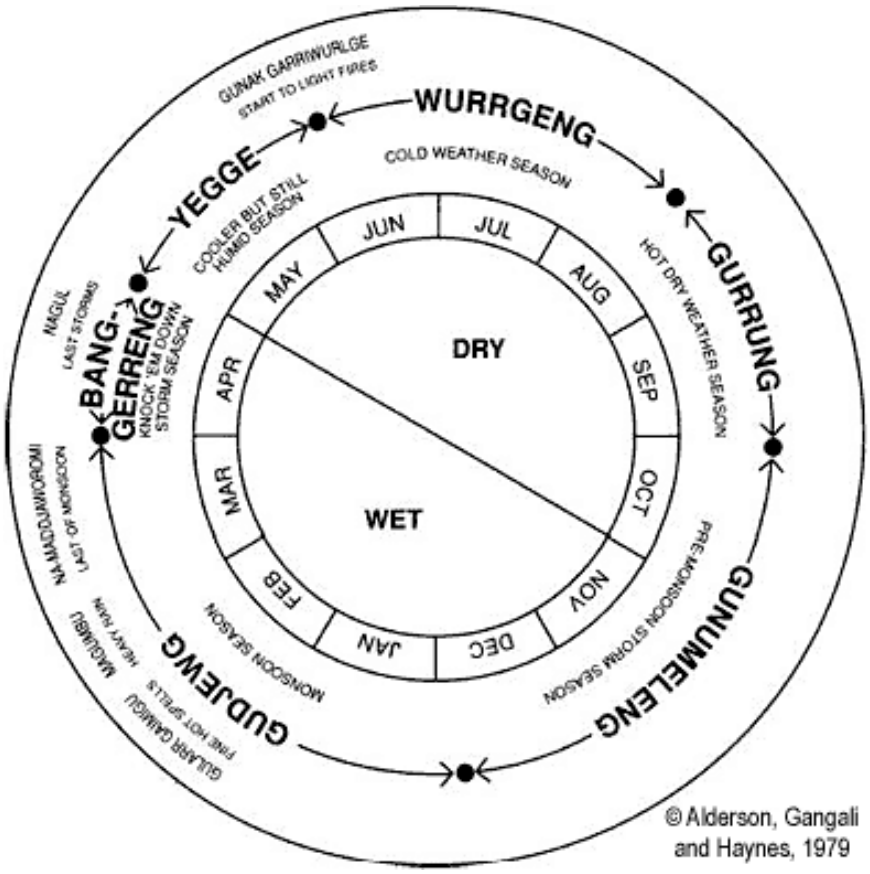

Figure 2. Wet and Dry seasons split into six descriptive categories.

Aboriginal People in Arnhem Land

The area of focus contains several hunter-gatherer Aboriginal groups, which have occupied this area and have created culturally significant spaces for 50,000 years (Taçon 2001:531). Well-defined estate boundaries are flexible, yet have solid social and religious relations. Groups within this region are both matrilineal and patrilineal. They practice exogamy, so marriage within a clan is forbidden (Layton 1992:32). Clans were connected across estate boundaries by common customs such as intermarriage, overlapping foraging rights, and the ability to speak several languages. A representation of the various language groups can be seen in figure 3. The boundaries are variable and are subject to change from season to season and year to year.

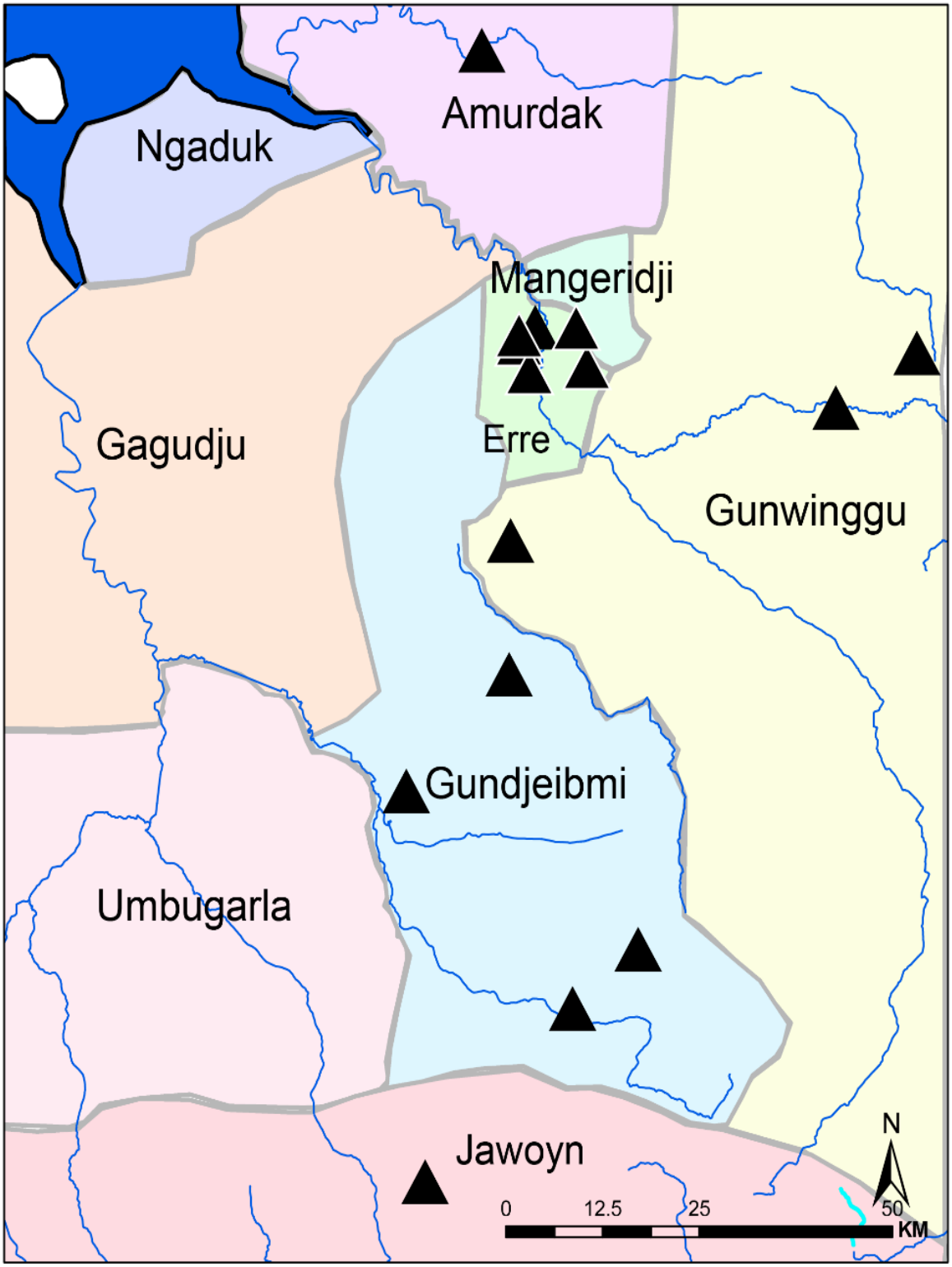

Figure 3. Language groups in Alligator Rivers Region.
Triangles represent selected Contact rock art sites.

The attachment to areas of land is more stable than the attachment of the group names to the people (Harvey 2002:23). Claims to ownership of specific countries, estates, or sites may overlap between groups. The estate boundaries are part of an unmarked system for discussing land in relation to their language (Harvey 2002:31). The term clan could be used to refer to the groups of co-owners of estates. All of these rules were set up by the 'First People' who were the creator beings originating from the Coburg Peninsula as seen in figure 1.

The movement of the 'First People', like the mythological ancestor Warramurrunggundji, created people and the variety of languages in the region today. A depiction of her was confirmed by the Aboriginal community and can be seen in figure 4. Namangeminj, another one of the 'First People' traveled from the Coburg Peninsula to the Alligator Rivers Region calling out names and establishing hunting traditions and circumcision rituals during initiation (Chaloupka 1993:69). There are numerous creation beings, ancestral beings, totemic beings, and spirits both malevolent and benevolent. Trickster beings or spirits such as the Mimi taught the Aboriginal people how to sing, dance, paint, and use the environment to their advantage for hunting, gathering, and fishing (Chaloupka 1993:64, Layton 1992:79). These myths may be symbolic of ancestral migrations across Northern Australia in abstract form (Chaloupka 1993:46). The retention of knowledge across many centuries demonstrates the power and importance of cultural traditions in Australia.

Figure 4. Warramurrunggndji, a principal ancestor for most Aboriginal groups in this area. Seen with 15 dilly bags suspended from her head ring. (Chaloupka 1993:46)

The environment provided a rich setting for subsistence, life, and ceremony. Unlike the desert conditions of most of Australia, the Alligator Rivers Region is a monsoonal floodplain. Black soil coastal plains, paper bark swamps, rock country, and the stringy bark woodlands are ecological zones in which Aboriginal people exploited for a variety of food resources. Tropical fish, Barramundi, Skink, frilled lizards, Long-necked Turtles, Rock Geckos, Death Adder snakes, freshwater and saltwater Crocodile, Magpie Geese, Kangaroo, and Wallaby are some native animals also used as totem figures for clans.

Figure 5 illustrates a simplified cross-section of the major landscape features in the Alligator Rivers Region. Aboriginal people used their knowledge of plants, animals, and environment to navigate this rugged landscape. The transitional zones between ecological regions are the locations of wet and dry season camps (Layton 1993:70). The placement of camps on boundaries between resource zones maximizes the opportunity for a varied diet.

This research focuses on the rock paintings found at sandstone outliers and within the Arnhem Land Plateau. The distribution of rock art sites is correlated with shelter locations and relative food supplies. The regions with the most food resources are the places where Aboriginal rock art paintings are numerous (Edwards 1979:64). The majority of rock art paintings are found at rockshelters, caves, and overhangs on walls and ceilings. The shelters with yearlong occupation have the greatest amount of rock art superimposition.

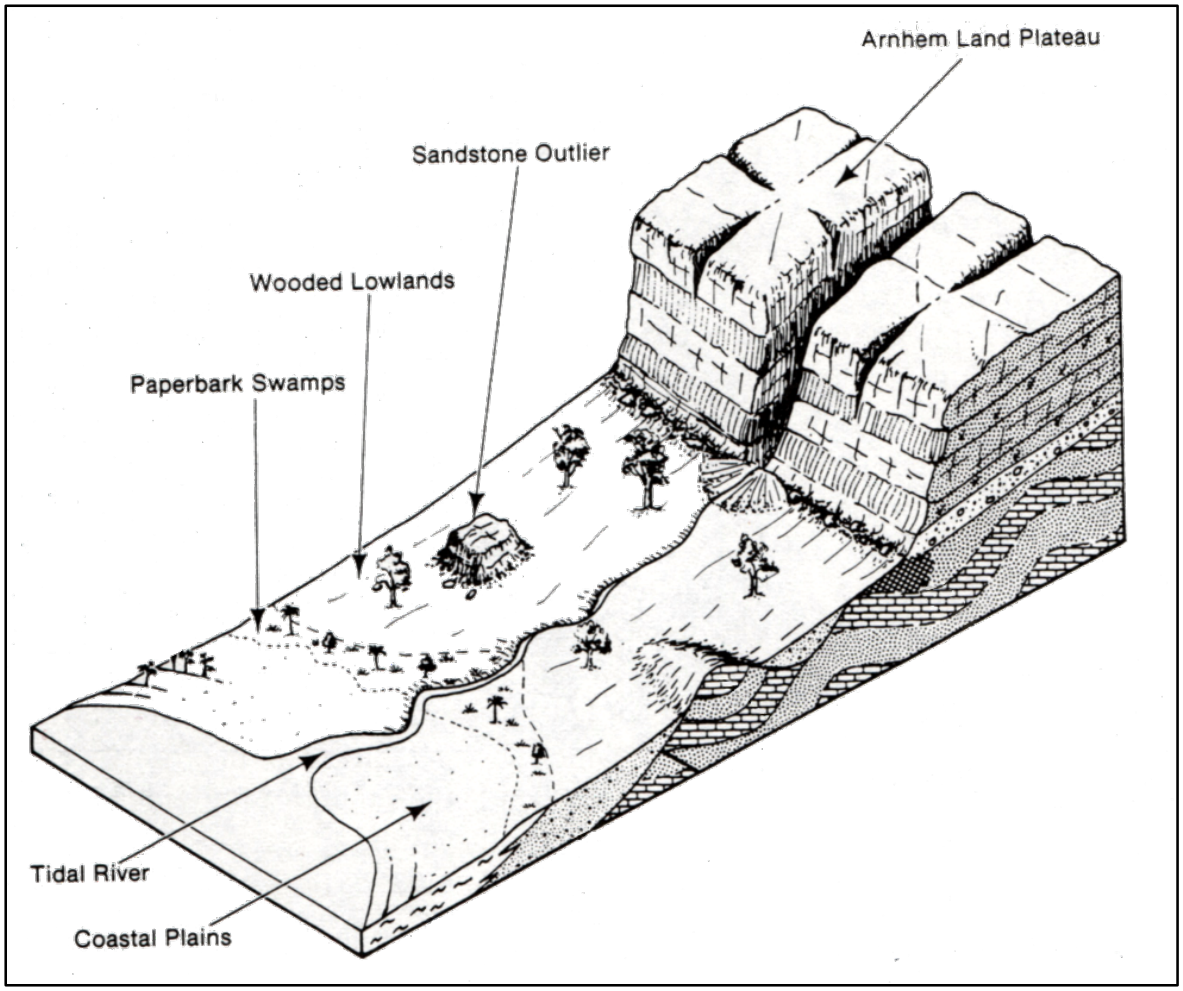

Figure 5. Major landscape features of the landscape of the Alligator Rivers Region (Williams 1991:10)

Arnhem Land Rock Art Paintings

Rock art was an essential part of Aboriginal daily life and a potent expression of socio-cultural identity (Frederick 2000:300). Rock art commemorates aspects of their worldview, ancestral traditions, records day-to-day secular events, and facilitates magic. The connection to the land, ancestors, and dreaming were illustrated through etching, stenciling, and painting. Subjects included various signs, symbols, figures, sought-after animals and objects. The ochre used for painting was for ritual and decorative purposes (Chaloupka 1993:83). The four basic ochre colors are white, yellow, black, and red. They are found on the ground surface and also collected from stream banks. The geochemical properties and sources for pigments by color can be analyzed, but very hard to date due to the inorganic ochre pigments. The dating of rock art paintings will become part of the discussion as Contact Period subjects are introduced. The chronology of rock art can be divided into four periods associated with environmental change. This research focuses on the Freshwater period in which the Contact Period is argued to be a part (Chaloupka 1983:14).

Table 1. Chronology of Arnhem Land Rock Art Styles. Gathered from Chaloupka 1993

Period	Date	Environment
Pre-Estuarine	50,000 - 8,000 y.a.	Arid, open savanna vegetation, forested river margins
Estuarine	8,000 - 1,500 y.a.	Rising sea levels, extensive mangrove swamps
Freshwater	1,500 - 300 y.a.	Freshwater wetlands
Contact	300 y.a. - Ethnographic present	Freshwater wetlands

X-Ray Rock Art Paintings. To understand Contact Period rock art, we must first study the continuation of the X-ray style. The X-ray style first appeared during the Estuarine Period and continued into the Freshwater Period (table 1). The shift in the depictions of new animal species is a reaction to environmental change in the Alligator Rivers Region about 1,500 years ago. The extensive mangrove swamps developed into freshwater wetlands with billabongs and paper bark swamps (Chaloupka 1983:14; 1993:185). The influx of new species of animals such as turtles, geese, barramundi, and many other species of fish characterize most of the rock art of this period.

The majority of rock art paintings in the Alligator Rivers Region is X-ray style and is distributed along the Arnhem Land escarpment for nearly 250 kilometers (Layton 1992:74). The term X-ray is a label that has been given to this style of rock art by non-aboriginal investigators. The paintings are characterized by an outline of the animal, human figure, or object. Anatomical sections corresponding to major joints are emphasized and the interior of the subject is also highlighted. Infill patterns of hearts, lungs, muscles, stomach, backbone, or long bones are usually depicted (Layton 1992:74). Figure 6 shows an outline of magpie geese depicted in the X-ray style. This is considered X-ray art from the Freshwater Period because it is a water bird species and the artist uses thick lines to emphasize the femur and esophagus. Not all interior features are emphasized and each artist may emphasize different parts of the subject. For this research, Pre-Contact X-ray paintings are very important because it provides a base to which Contact Period paintings can be evaluated. It is also important to note X-ray paintings are generally painted during the wet season while Aboriginal people are in their wet season camps.

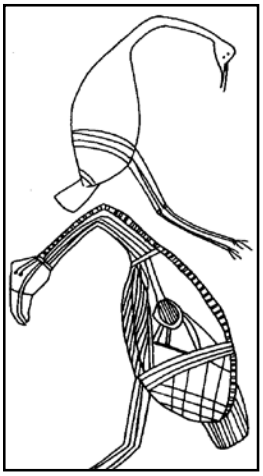

Figure 6. Freshwater period – X-ray style Magpie Geese.
Location: Inagurdurwil (Chaloupka 1983:30)

Contact Period Rock Art. Contact Period rock art is generally set within the Freshwater Period because it is a continuation of the X-ray complex. Contact Period rock art is traditionally evaluated based upon the depictions of introduced subjects (Chaloupka 1983:14). The Alligator Rivers Region is rich with Contact Period imagery. Many of the Contact era subjects are easily recognizable as ships, rifles, handguns, horses, pipes and other historical objects, most depicted in the X-ray style. Figure 7 is a Contact Period depiction, which demonstrates the continuation of the X-ray style. The bullet in the breach of the rifle and the diagonal lines indicating wood grain shows the artists' interest in the level of detail and the importance of continuity in depictive painting techniques.

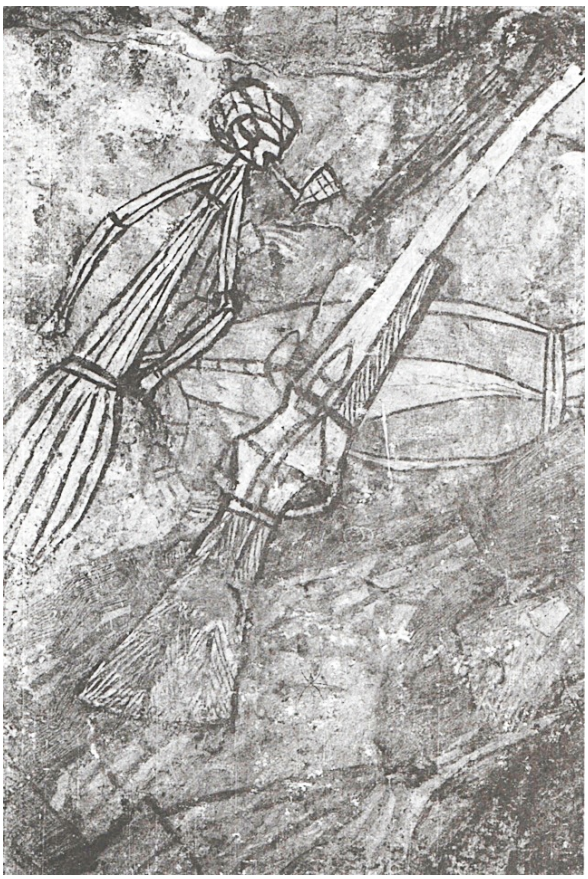

Figure 7. Rifle depicted in X-ray style. Note bullet in breach.
Location: Upper East Alligator River (Layton 1992:94)

Some of the earliest examples of Contact Period rock art are ships and boats sailing the coastline and docking in harbors (figure 8). The activities of early European explorers can be coupled with the Contact Period imagery found in the rockshelters of Arnhem Land Plateau. The descriptions of initial contact and the history of European settlement can be reconstructed from the rock paintings (Chaloupka 1983:15). The linked rock paintings can be dated by subject matter. Painted depictions of introduced animals such as cattle, horses, and water buffalo can be dated to after the settlement at Port Essington in 1838 (Chaloupka 1983:14.) This research focuses on the activities of early European explorers and Contact Period rock art paintings loosely dated between A.D. 1800 - 1900.

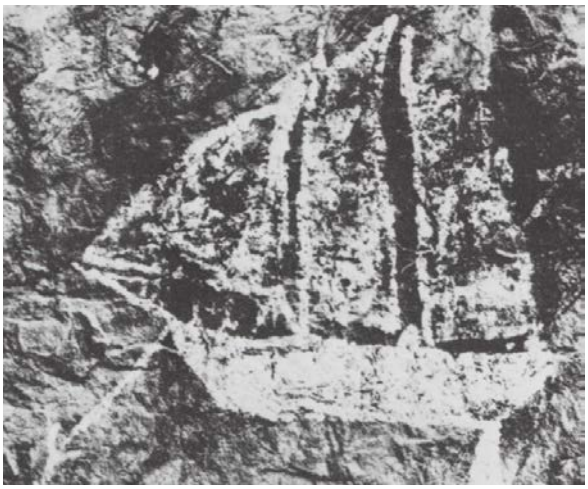

Figure 8. European sailing ship painted in white ochre.
Location: Cannon Hill (Edwards 1987:32)

Non-Aboriginal people in Arnhem Land

Macassan Fisherman The first contact did not come from European ships, but from Macassan praus or merchant ships (figure 9). The Macassans of Indonesia had been trading with coastal Aboriginal people since around AD 1664 (Taçon et al 2010: 6). The Indonesian fisherman sailed to the Northern coast of Australia each year in search of sandalwood, pearl shell, tortoise shell, and sea slug called trepang. The trepang was prepared various ways to make soup and aphrodisiacs (Flood 1983:234). The Macassans came to the shore annually and the Aboriginal people benefited from their visits. New materials such as smoking pipes and dug out canoes were traded with little incidence of conflict. The relationship with the Macassan fisherman was mostly positive. The conflict and disagreements would have been over exchange rates and not land or territory (Layton 1992:89-90). The trade environment beginning with the Macassan fisherman may have encouraged an expectation of equal benefits from the Europeans.

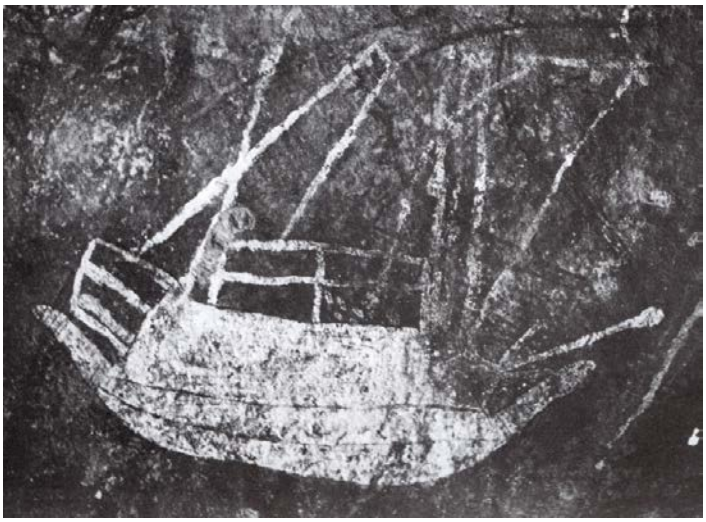

Figure 9. Macassan *prau*
Location: Upper East Alligator River (Edwards 1987:6)

European Explorer: Philip Parker King. Philip Parker King named the Alligator Rivers on his journey to survey the Australian coast in 1818. King made a taxonomic misidentification that has not been corrected. There are no alligators in the Alligator River Region, only crocodile. King made his way into Van Damien Gulf in May 1818. His crew travelled down the East Alligator River. He noted many Aboriginal peoples' fires and iron tools most likely obtained from the Macassan fisherman (Edwards 1987:4). He traveled down the South Alligator River soon after. The movements of King were some of the first accounts of possible settlement of Northern Australia. The British first occupied the Northern Territory in 1825 with the establishment of the Victoria Settlement at Port Essington on the northern most section of the Coburg Peninsula, as seen in figure 1. Port Essington was abandoned by 1849 because of major setbacks due to weather, health, and remoteness.

Ludwig Leichhardt. A well-known explorer named Ludwig Leichhardt made the first inland journey through Arnhem Land to Port Essington in A.D. 1845 (Evans 1987:1). His 14 month journey took him took him precipitously down the Arnhem Land Plateau and through the low-lying grasslands of the Alligator River Region. He recorded locations for possible settlement, the species of many plants and animals, and encounters with various Aboriginal groups exploiting wetland resources (Chaloupka 1979:93). The Aboriginal people showed great interest in Leichhardt and his team (Edwards 1979:16). They traded gifts at his campsites and Leichhardt participated in communication when he could. Leichhardt and explorers after him experienced the hardship of traveling through this area. "If it weren't for the aboriginal's help, explorers would have starved in abundant garden of unfamiliar foods, smashed wooden boats into shark infested reefs, or died near hidden waterholes" (Taçon 2001:530).

John McKinlay The next major overland exploration through Arnhem Land was the Northern Exploring Expedition of McKinlay in A.D. 1865. His mission was to stake out specific places for European settlements. McKinlay had a particularly terrible time moving through the region. A quote from McKinlay's journal is as follows, " [The Alligator Rivers Region is] the most rugged country a man would ever wish to behold" (1866:Camp 43). He was marooned for months on areas of high ground because of the flooded landscape (Chaloupka 1979: 94). In June 1865 McKinlay had had to kill the last of his horses to create a raft to float down the East Alligator River towards the Van Damien Gulf back to Darwin (Edwards 1987:21). The encounters with Aboriginal people were scarce; he made little mention of Aboriginal people in his report. The Aboriginal people would have been up in their wet season rockshelter camps at this time of the season. Even from their camps, they were aware of McKinlay's travels.

The varied experience between the travels of Leichhardt and McKinlay are important to this analysis because their exploration paths were evaluated based on Geographic Information Systems (GIS) least cost models. The season of travel and their experience in this landscape is important to understanding why Arnhem Land was one of the last places to be dominated by Europeans. The term dominated is used because of the nature of land claim activities used by the Europeans and their mindset as they name, map, and claim the land as their own.

Mindsets, Approaches, and Attitudes

Terra Nullius. The objectives of the first European expeditions into the interior of Australia were to generate accurate geographic maps, indicate prospective agro-pastoral regions, claim territories, and assess the potential of mining operations. These explorers did not have the rights of Indigenous people in mind when they named, mapped, and marked the land as their own. The European explorers subverted indigenous ownership by denying the validity of place names and territorial boundaries. The usual negotiation, declaration of warfare, and mediation protocol was bypassed (Mulvaney 1987, Reynolds 1987, Rouse 1993 as cited by Taçon 2001:530). Terra Nullius is a mindset in which Europeans saw themselves as settlers, instead of invading conquerors (Ireland 2003:58). The land was seen as empty, threatening, and unoccupied because the Aboriginal people did not develop or improve the land in the eyes of the European people.

Aboriginal Mindset. It may not be possible to fully understand the Aboriginal mindset without being an integral part of the community. Many levels of initiation ceremonies and ritual traditions are key components to understanding Aboriginal Dreaming or law. The Dreaming is a creation time, place, and force. It shaped the landscape and the ancestral energy has remained embedded in the trees, rocks, and animals (Frederick 2000:307). Elaborate oral histories pass on knowledge from one generation to the next recounting the actions of Ancestral Beings, demarcating kinship networks, and mapping travel routes (Taçon 2001:530-531). As initiates move through

the landscape as told in The Dreaming, a strong bond is united from the present to the past. The embedded traditions and deep knowledge of the land was the key to survival in Arnhem Land (Taçon 2001:530).

This research attempts to provide a more nuanced study of intercultural engagements during the Contact Period by utilizing Aboriginal rock art paintings, published expedition journals, and regional landscape analyses to recognize spatial patterns of interactions prior to pastoral colonization. The manner in which introduced subjects such as ships, guns, people, and non-native animals are portrayed reveal important Aboriginal perceptions and insights.

Geographic Information Systems (GIS) map overlay methods display multiple variables for the patterns of land exploration in relation to Aboriginal rock art paintings. Regionally plotting the patterns of European expedition movement, Aboriginal interaction, and responses from both sides, correlations can be made about impacts of intercultural engagements to Aboriginal social contexts.

METHODOLOGY

Landscape Methodology

The spatial distribution of activities of both Aboriginal people and non-aboriginal people from the Contact Period of A.D. 1800-1900 can be established with Geographic Information systems (GIS) from a regional landscape perspective.

"A pattern does underlie the spatial distribution of specific activities; the location or locations in which an activity takes place are not scattered at random, and the by products from many kinds of activities do form clusters that one can distinguish on the ground" (Yellen 1977:95).

The landscape of the Alligator Rivers Region was a stage in which many cross-cultural activities were facilitated. The main obstacles for the explorers were the geographic features themselves. In general, the interests and concerns of the explorers shifted from discovery to basic survival while in the Alligator Rivers Region (Frederick 2000:310). McKinlay, for example, had to abandon his expedition at the East Alligator River because of the rugged terrain and the severe reduction of many food and water resources.

The Arnhem Land plateau is also an important factor in the geography of the region. The location of the plateau forced the European explorers to take routes mainly within the floodplain during the dry season and along the base of the escarpment during the wet season. The Aboriginal people were fairly unrestricted in their movements across the landscape. The Aboriginal people moved often, even in the wet season. A group did not usually stay at one shelter throughout the whole wet season (Thomas 1996:30). The main routes of movement for Aboriginal people during the wet season were along the foot of the escarpment or across the top of the plateau (Layton 1993:69). A man walking along could cover 16 km a day and a family traveling with children 8 km between camps (Layton 1992:70).

Dreaming Tracks or Songlines. The dreaming tracks could be an agent for movement of ideas across space. The dreaming tracks or songlines are communication and religious routes that have been used for many generations. The vast stretches of dreaming landscape link diverse language groups, particular individuals to other people, groups to their past, and also to the land itself (Taçon 2010:83,86). Unfortunately, a detailed map of dreaming tracks or trade routes was not obtained to georeference and overlay with Contact rock art locations. It may be plausible to assume that communication lines would flow both north to south and east to west because of the Aboriginal peoples' deep knowledge of the landscape.

Plotting Rock Art Locations

"Mapping geographical continuities discontinuities between art and establishing boundaries of cultures and social interactions among neighboring groups, this is especially achievable through rock art studies because rock art is fixed in place" (Sanz, Fiore, and May 2008:20-21). Rock art complexes in the Alligator Rivers Region consist of dozens of rock art shelters, sites, and caves. Each site may contain hundreds of paintings superimposed over thousands of years. The limitation of this dataset is the fact that many archaeological sites have not been formally recorded, or have a great lack of descriptive accounts (Flood 1983, Frederick 1999).

For this research design, occurrences of change in the form of presence or absence of European Contact depictions are plotted in relation to the general location rock art complexes because the amount of detail in site

records are extremely variable. The confidentiality of specific geographic coordinates is important, so general locational plotting is done in this research. The map scale of this research also allows for general locations. Specific coordinate locations of Contact rock art paintings are not only rare, but also endanger the conservation efforts by modern Aboriginal and non-Aboriginal people in Arnhem Land.

"It is expected that these sites will remain under Aboriginal Custody. To date the remoteness of the area and the restricted access has served, to a large degree to discourage visitors and at the request of the Aborigines concerned, no detailed data is given in respect of the precise locations of sites" *(Edwards 1979:63).*

Many research projects and published works had come out of The Alligator River Region, but there was no example of a comprehensive database. For this research, instances of well-known rock art complexes were gathered from many sources. The main sources were Layton 1992, Chaloupka 1993, and Edwards 1987. Instances of Contact Period subjects such as European ships, Macassan ships, guns, introduced animals, and non-aboriginal human figures were added as columns to a spreadsheet and joined to points set up as input data for GIS. The names of sites were variable. Some sources gave the European name, while others gave the Aboriginal name. There was no information on frequency of introduced subjects, so a presence/ absence tally was used in the GIS table. The table can be referenced in the Appendix (table A1). The sites were narrowed down to 15 well-known sites as seen in figure 10.

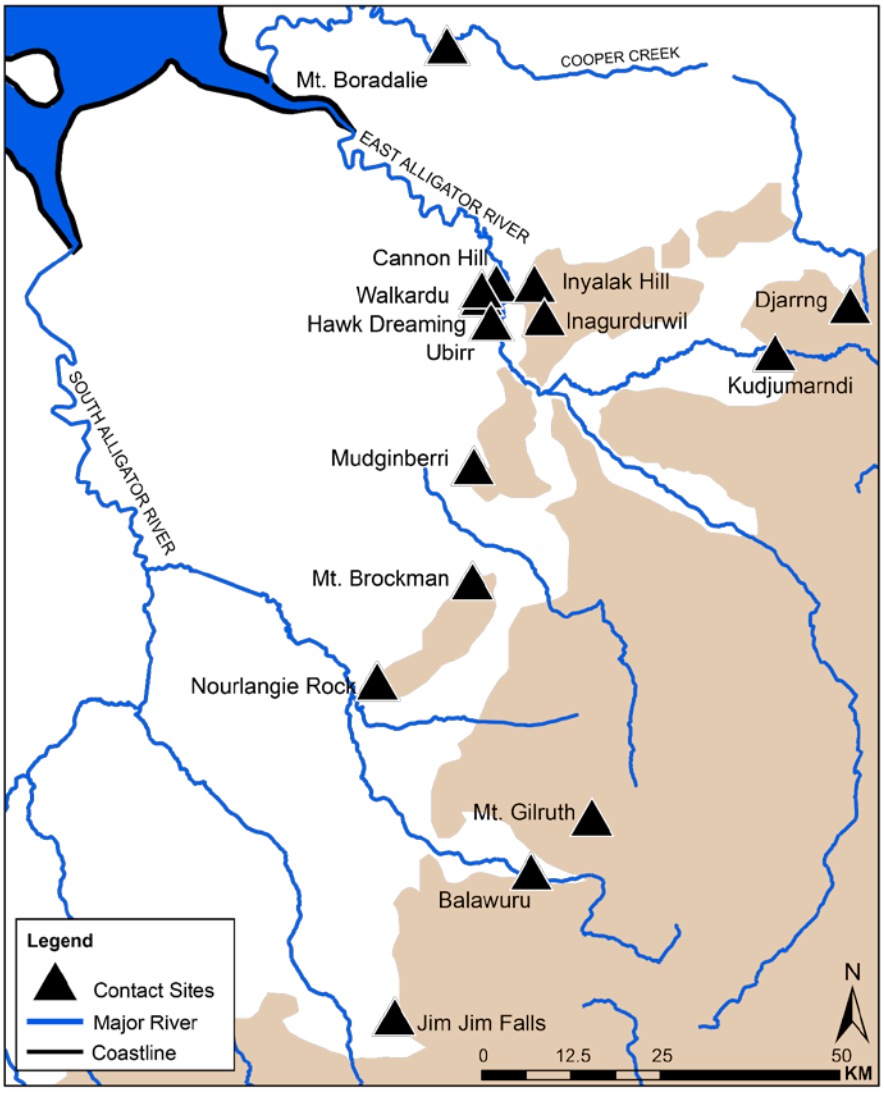

Figure 10. Locations of Contact Period painting sites in the Alligator Rivers Region.

Geographic Information Systems

GIS is a powerful tool for visualizing, analyzing, and interpreting data. Analytical methods using a variety of data sources and GIS spatial analyst tools offer effective ways of extracting and interpreting social and spatial structures. GIS is capable of incorporating multivariate data to create visual representations of spatial relationships.

The variety of data sources come in raster and vector formats. Raster data show continuous features formatted in a grid structure (Esri 2014). This includes pictures, maps, and the digital elevation model. Vector data are composed of point, line, polygon nodes that store geometric locational attribute information of geographic features (Esri 2014). In this research, vector data include shapefiles of rivers, waterholes, and rock art complexes gathered from the Northern Territory Spatial Database (NTSD) and Geoscience Australia's Spatial Database (GASD).

Georeferencing. European exploration route maps, Aboriginal language group maps, locations of painting sites maps, and other raster datasets that have no spatial reference needed to be georeferenced to a coordinate system. The base map, which was a shapefile downloaded from the GASD, was the base to which the raster maps were aligned. At least three reference points were used to accurately align two maps. The raster was transformed or warped to fit the basemap. Georeferencing maps allow for viewing, querying, and analyzing of data within the same coordinate system and projection (Esri 2008). For this research, all raster maps of explorer paths rock art locations were georeferenced and features were redrawn into vector line format with a Geocentric Datum of Australia (GDA_1994) coordinate system (figure 11).

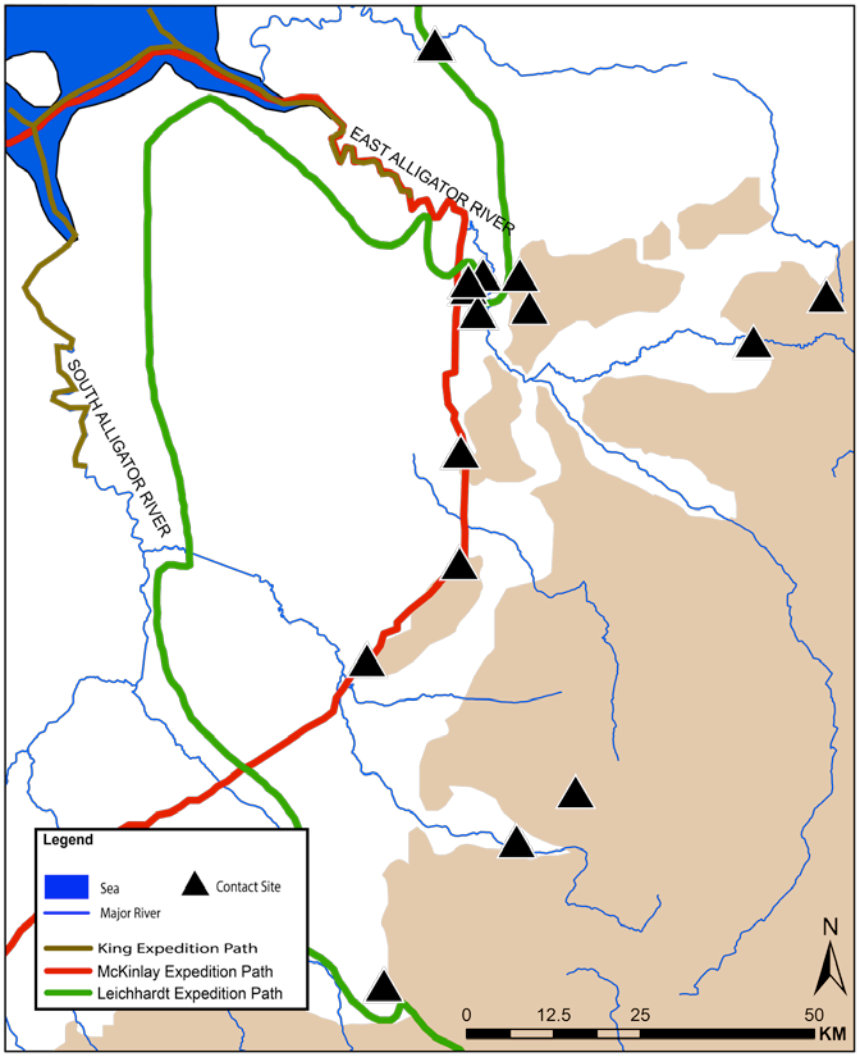

Figure 11. Routes of King, McKinlay, and Leichhardt

Spatial Analyst Tools. The Spatial Analyst tools in ArcMap 10.1 are powerful spatial modeling and analysis features where raster and vector data can be used to derive new information from existing datasets (Esri 2008). Euclidean distance and cost distance was used create new raster datasets for overlay operations. Euclidean distance is the calculated straight-line distance buffers from one feature to another, while cost distance displays distance buffers when a factor, like slope, is input into the calculation. For this research multiple distance buffers were calculated to support a greater dataset for the next steps.

The contour elevation data from the Geoscience Australia's Spatial Database was transformed from vector line data to a raster to create the digital elevation model (DEM). The DEM was used as an input to calculate percent slope, which was an important layer for the weighted overlay operations.

Weighted Overlay Operations. After all of the maps have been spatially referenced and spatial distance analyses had been conducted, they were stacked into layers. The stack of map layers were combined and manipulated to show where things co-occurred (Ahlqvist 2009:50). Common combined characteristics of multiple features were singled out and spatial relationships appeared.

To utilize the weighted overlay tool, vector features were reclassified to create homogenous data for both the dry and wet season respectively. Each factor in the weighted overlay was reclassified to 3 categories, Easiest / Best (1), Moderate (2), and Hardest / Worst (3). These categories represent the terms used for moving across the landscape in relation to vegetation, slope, locations of waterholes, distance to rivers, and season (figure 12).

The modified slope layer was reclassified into 3 categories (figure 12a). For the both the dry wet season, areas with a relatively low percent increase in slope received a 1, higher elevation and greater percent increase in slope received a 2, and areas with highest elevation and the highest percent increase in slope received a 3.

The rivers were reclassified into 3 categories based on distance (figure 12b). For both the dry and wet season, less than 2km from a river received a 3, from 2-5km received a 2, and all other distances from rivers received a 1. Leichhardt noted in his expedition journal that his team steered clear of rivers because of the swampy environment and to avoid crocodiles. "…avoided the gullies by keeping at a distance from the river" (Leichhardt 1847: June20).

The Pre-European settlement (1778) vegetation data gathered from the Geoscience Australia's Spatial Database (GASD) was also reclassified into 3 categories (figure 12c). The categories were based on how easily a horse could walk across that particular vegetation cover. For both the dry and wet season, hummock grasses received a 1, tree/forested areas received a 2, and the tufted grasses received a 3. The tufted grasses received a 3 because it had the greatest chance of becoming inundated and may exhibit a tendency to contain crocodile nesting sites.

The locations of waterholes were plotted and reclassified into 3 categories based on distance (figure 12d). For both dry and wet seasons, the exact location of waterholes received a 1, within 2km of waterholes received a 2, and all other distances from waterholes received a 3.

The extent of river inundation can be seen in figure 13. Areas of land between the East and South Alligator Rivers were presumed to be too muddy and swampy for a horse to travel and were masked out to prepare for the wet season weighted overlay map.

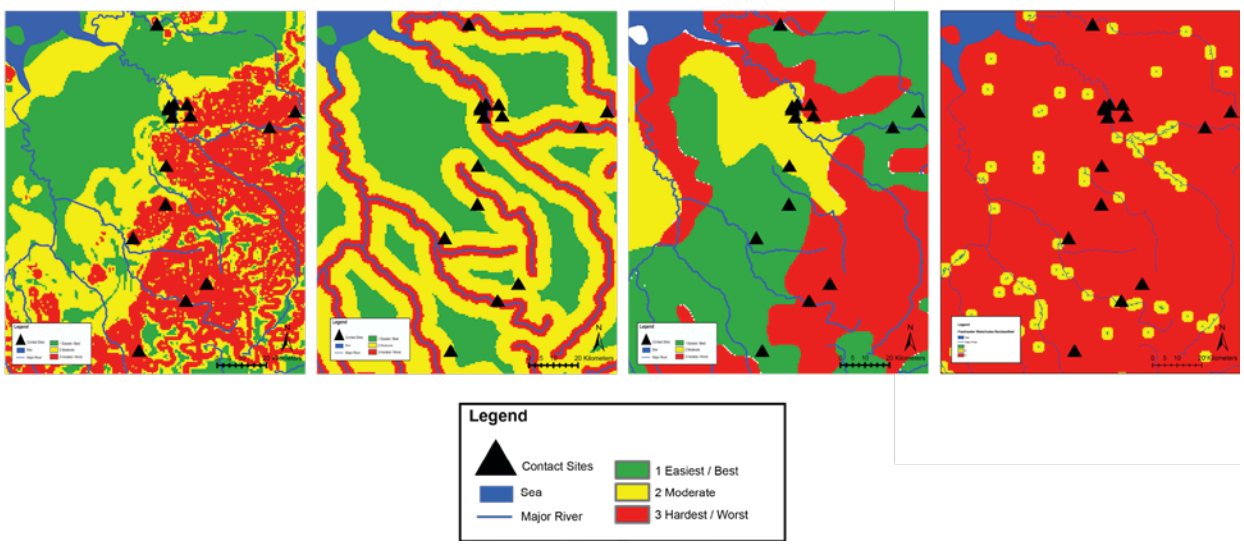

Figure 12. (a) Reclassified Slope, (b) Reclassified Rivers, (c) Reclassified Vegetation, (d) Reclassified Freshwater holes

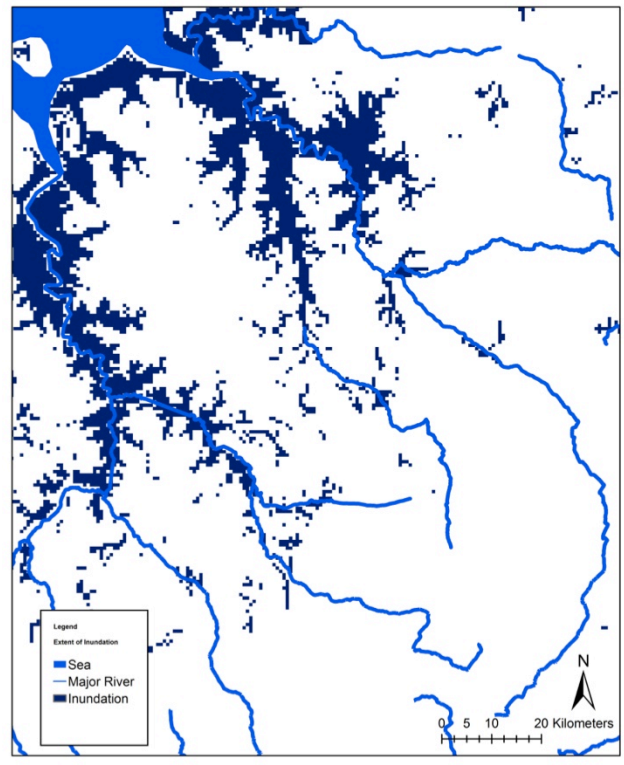

Figure 13. Extent of wet season inundation.

After the four raster maps were reclassified for both dry and wet season, they were ready to be used in the weighted overlay operation. The weighted overlay operation assigns weights of influence on classified layers adding up to 100%. The difference between the wet and dry season overlays was the percentage influences given to each layer and the inclusion of an inundation mask for the wet season.

For the dry season, the slope layer was set at 50% influence, waterhole layer was set at 20% influence, the vegetation layer was set at 15% influence, and the rivers layer was set at 15% influence. The percentage influence is an arbitrary classification scheme, but based on the European explorer accounts, slope set at 50% is an adequate figure because incline and decline were the main contributions to difficulties in traveling across the landscape during the dry season.

For the wet season, the inundation mask received the highest influence at 50%. The slope layer was set at 20% influence, waterhole layer was set at 10% influence, the vegetation layer was set at 10% influence, and the rivers layer was set at 10% influence. The inundation mask received the highest influence because the extreme difficulty of travel in swampy and flooded plains. This was one of the main reasons why McKinlay's exploration was delayed and eventually aborted.

The influences were set for each season and the weighted overlay operation was executed. The resulting cost raster maps were comprehensive best/moderate/worst conditions to be used for the least cost path analysis discussed in the results.

Least Cost Path Analysis The vegetation, slope, waterhole and distance to rivers layers were combined into a cost raster map outlined in the previous step. The cost raster map was used to derive a computer generated shortest path through the landscape. The least cost path function determines the path from a destination to a source (Esri 2008). Points were created for the beginning and end of the path. The starting points were positioned from the bottom left of the map extent and end point was positioned at the top right of the map extent. An example of this can be seen in Appendix B (figure B2). The least cost path function calculates cell-by-cell the best way to move from the start to finish points. The least cost path analysis is used to spark discussion about the efficiency of travel across the Alligator Rivers Region during the dry and wet seasons.

RESULTS / DISCUSSION

The weighted overlay operation is a variable process, but the results were reasonable for this analysis. Establishing the changes in the regional landscape from dry to wet season provides more insight into behaviors documented during the Contact Period. It is now more evident to see why Aboriginal people camp in the Arnhem Land Plateau during the wet season, why this area was so late to establish European control, and also why Leichhardt chose a different path than McKinlay. The obstruction of movement by the Arnhem Land Plateau and the inundation of the floodplain during the wet season are the largest contributors to all of these questions.

Dry Season Weighted Overlay Figure 14 shows the results of the dry season weighted overlay operation. The map indicates that the floodplain is the easiest part of the landscape to move across (seen in green). The red section of the map shows the hardest part of the landscape to move across. The Arnhem Land Plateau is definitely a barrier to movement in this area. The most noticeable feature about this map is the extended amount of moderate or yellow color. The extended amount of moderate land cover means that even in the drier conditions, the Alligator Rivers Region is a rugged and difficult landscape to move across.

Wet Season Weighted Overlay Figure 15 shows the results of the wet season weighted overlay operation. The map indicates that the floodplain is the hardest part of the landscape to move across. This is due to the high influence given in the previous steps. In the wet season the Arnhem Land Plateau becomes a more viable location for movement across the landscape (seen in the moderate or yellow land cover). The Aboriginal people are wise to use the Arnhem Land Plateau for shelter during the wet season. The easiest way to move across the land during the wet season would be to travel along the base of the escarpment where the percent slope increase is not as high. The least cost path analysis in the next step will evaluate the routes of Leichhardt and McKinlay in relation to the dry and wet season weighted overlay.

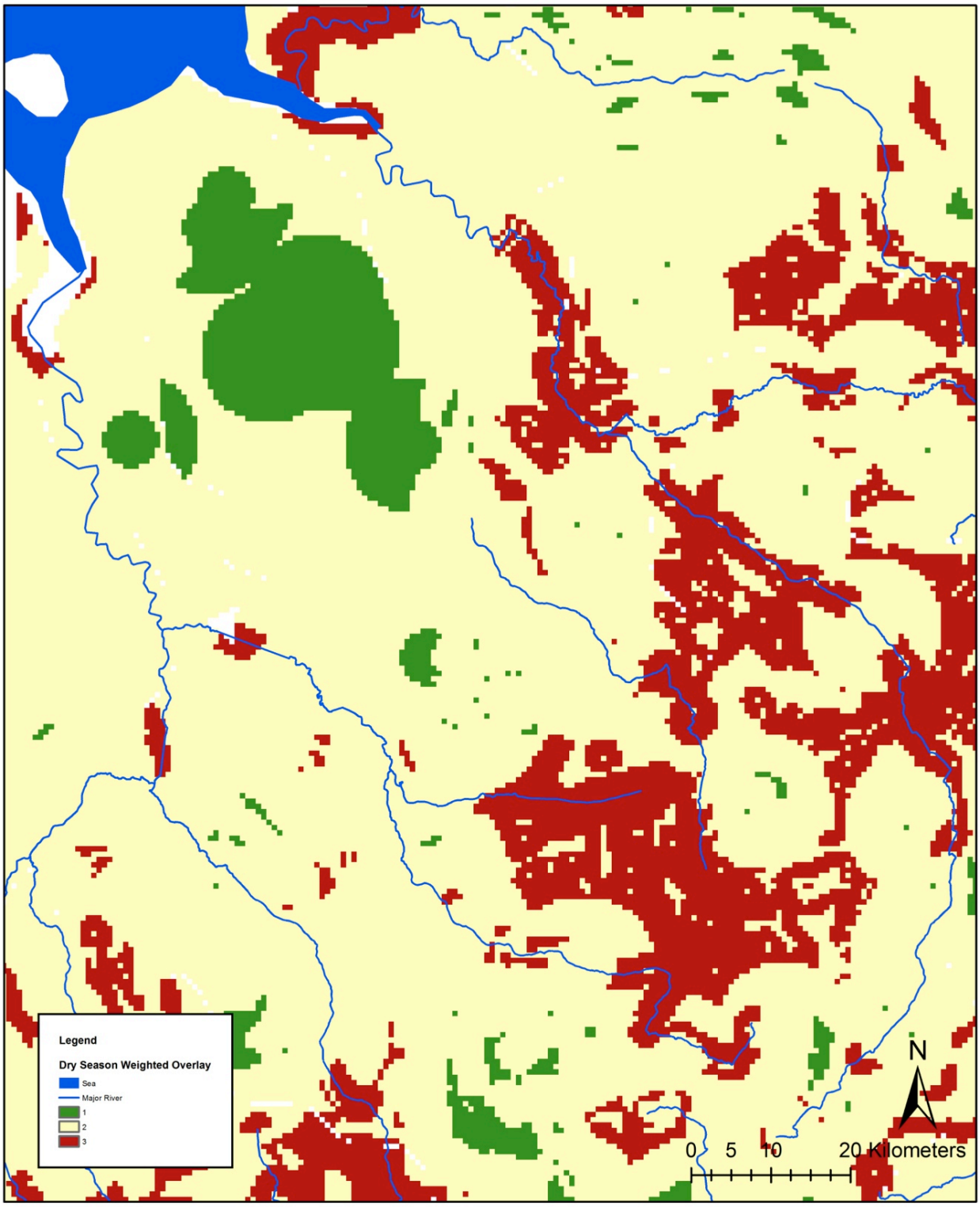

Figure 14. Dry Season Weighted Overlay

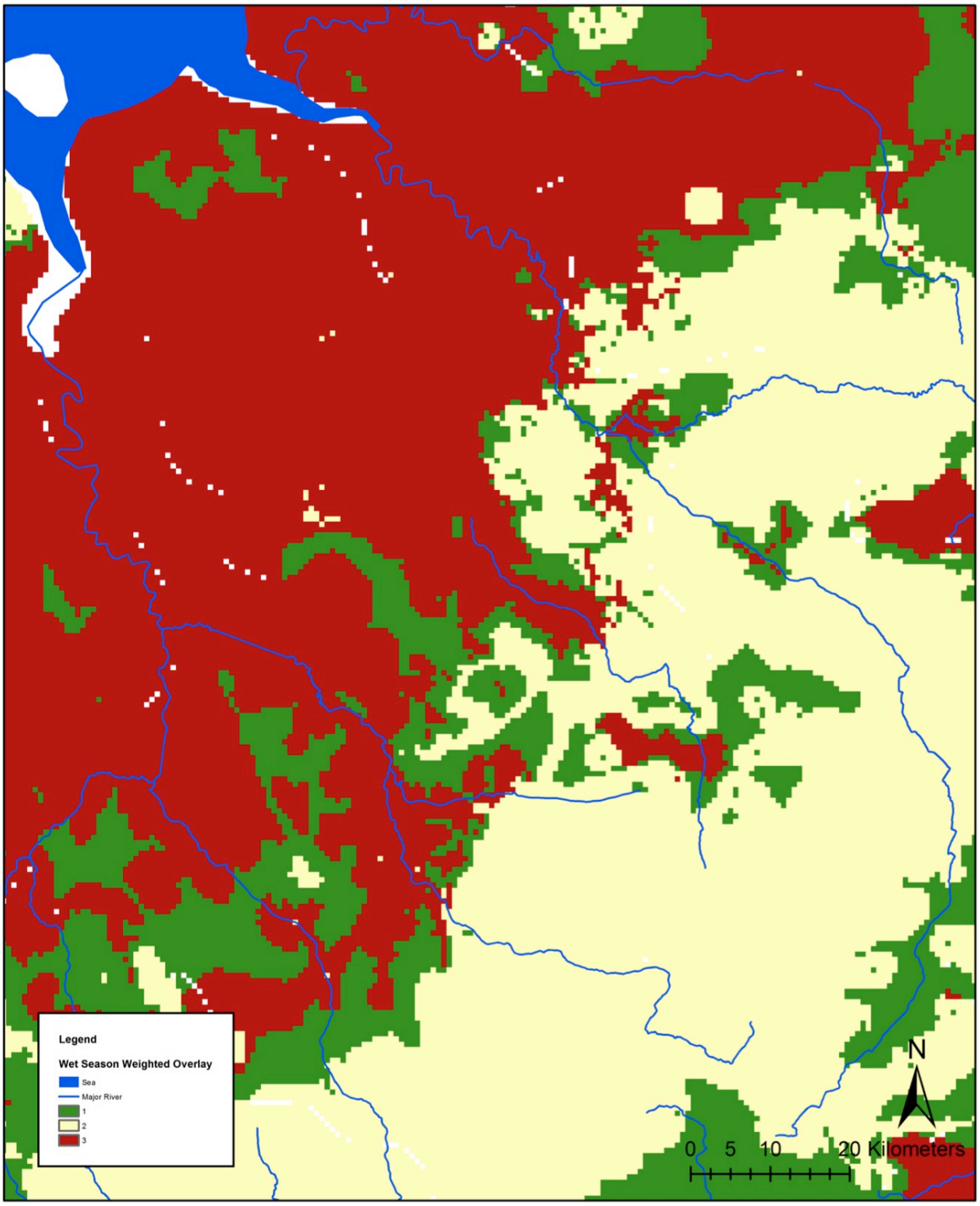

Figure 15. Wet season weighted overlay

Least Cost Path Analysis. The cost path analysis was very interesting. The least cost path function calculated cell-by-cell the best way to move from the start to finish points based on the cost conditions set in the weighted overlays of the previous step. The routes of the explorers were predominantly dictated by the season and slope. The dry season least cost path was executed twice to see if there was a difference between staying near, or away from the rivers (figure 16a). The path did not change too much when the distances to river factors changed because the highest influence on during the dry season weighted overlay was percent increase in slope. It is plausible that another factor besides low percentage slope could be set as the main contributor to ease of movement, but for this analysis it was reasonable and effective. The wet season least cost path was only executed once because it was evident from the wet season weighted overlay that there were considerably less choices for movement during this season. The inundation of the floodplains and the swampy, muddy environment of the lowlands during the wet season forced McKinlay to travel along the base of the escarpment (figure 16b).

The computer generated least cost paths display interesting data. The implementation of this technique could also be used to understand Aboriginal songlines or dreaming tracks. This research was not able to find reliable data to implement a least cost path between camps and instances of other sacred sites to compare against Aboriginal communications lines. Future research into weighted overlays, least cost paths, and comparative maps may reveal information about Aboriginal movement never before seen from a regional perspective.

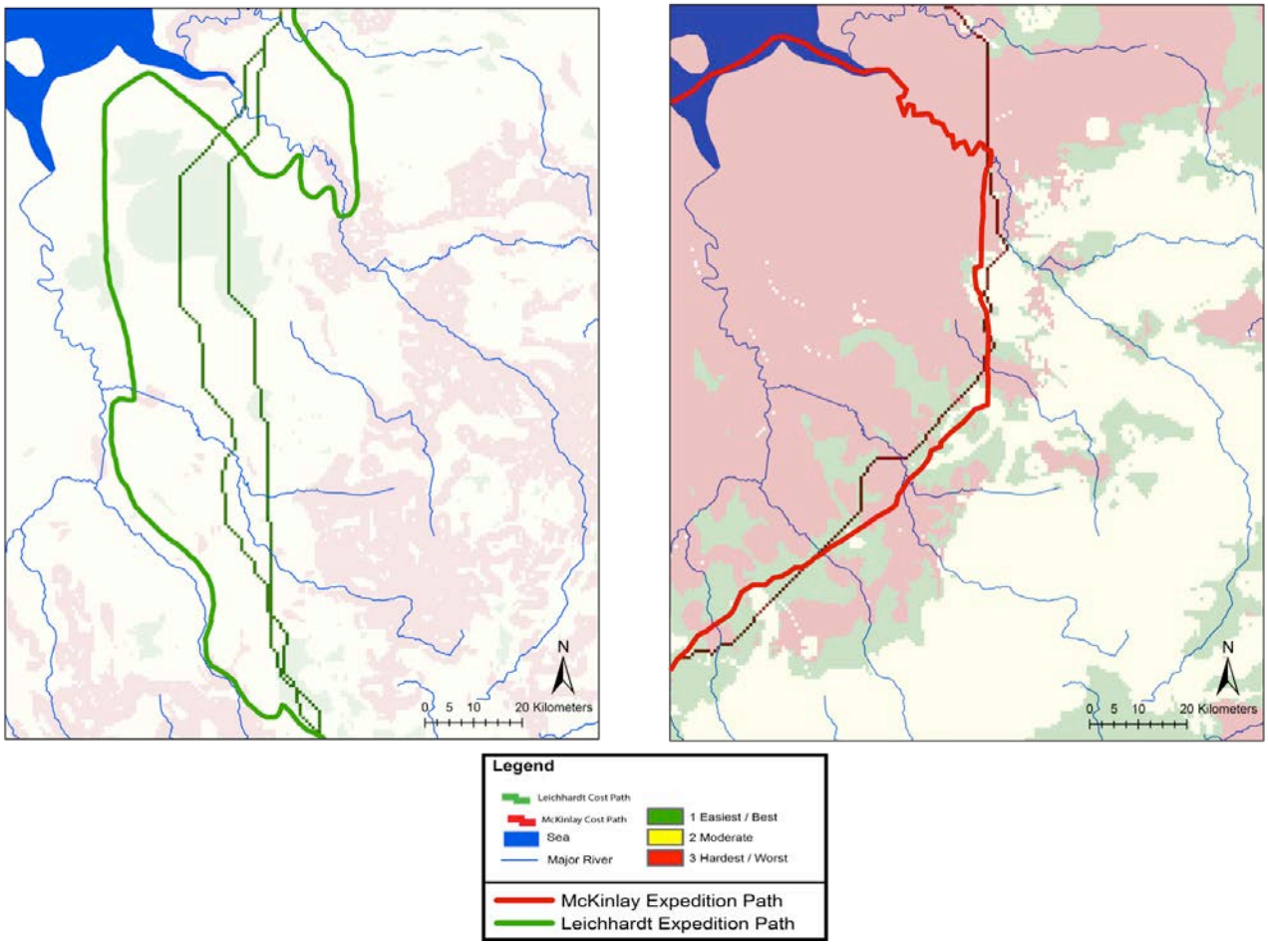

Figure 16. (a) Transparent weighted overlay under dry season cost path results.
(b) Transparent weighted overlay under wet season cost path results

Handgun and Rifle Depictions

Gun depictions have a scattered pattern, yet still occur mostly in the northeast portion of the map extent (Figure 17). I consider this pattern to be consistent with the accounts of water buffalo, European buffalo shooters, and the abandonment of Port Essington. Between 1825 and 1843, 80 buffalo were brought to the Cobourg Peninsula for a food supply. When the settlements were abandoned due to weather, health, and remoteness, the buffalo occupied the swamps and freshwater springs (Commonwealth of Australia 2011). Water buffalo spread in thousands across the Alligator Rivers plains (Chaloupka 1983:3). Nomadic European men were known as buffalo shooters. They followed the feral buffalo herds to sell skins and horns for profit (Layton 1992:113). Depictions of both guns and buffalo should be plotted to better understand this connection.

The outlier gun depiction in the southeast corner in the narrow valley is at Balawuru (figure 17). The Aboriginal artist was aware the rifle could kill, but was unsure how the rifle was used. The painting depicts the rifle held above the explorer's head. This is indicative of how a spear thrower was held and thrown (figure 18). This depiction is a significant indication of the generally pleasant relations between early explorers and Aboriginal people.

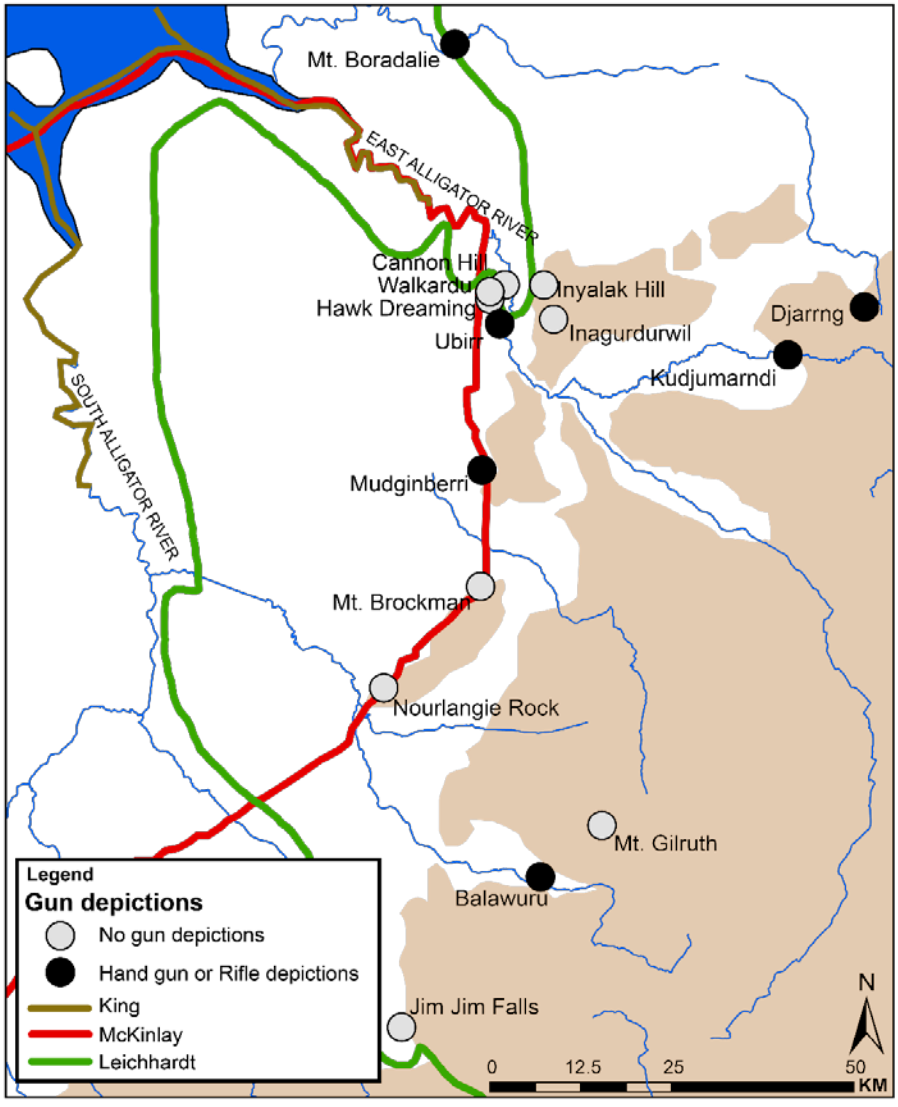

Figure 17. Rock painting depictions of rifles and handguns in the Alligator Rivers Region Plotted with Arc Map 10.1 Shapefile from GASD

Figure 18 (a) Explorer depiction with rifle held like a spear thrower.
(b) Line drawing of depiction
Location: Balawuru/ Yuwunggayai (Chaloupka 1993:194)

Connection to past traditions. I consider the gun depictions to be a form of sympathetic magic. Imitative or sympathetic magic is performed to enact a desired result. The numerous fish paintings (figure 19) are a type of imitative magic. "If a native misses a fish, later returns to the cave and draws in careful detail the fish and he will not miss next time" (Dyer 1934:26 as cited by Edwards 1987:108). The sympathetic paintings were a way of ensuring a good catch the next time the artist hunts or fishes. The same principle can be applied to the numerous rifle and handgun paintings (figure 20). The detailed depictions of rifles and handguns may be a way of encouraging the likelihood of the artist obtaining their own gun. Guns in the Alligator Rivers Region were used to instill fear, dominance, and power. The Aboriginal artist may have wanted to possess his own powerful weapon.

Figure 19. Detailed x-ray style barramundi and eel-tailed catfish
Location: Ubirr (Edwards 1987:121)

Figure 20. Detailed x-ray style rifles and handguns
Location: Amurdak / Awunbarrna / Mt. Bordaile (Chaloupka 1993:196)

Ship Depictions

The locations of ship depictions in rock art are near watercourses (figure 21). There are no reported ships at interior sites. This may be due to distance from rivers and coastal areas where ships would be actively sailing. To test this hypothesis I created a cost distance buffer from the location of King's expedition down the East and South Alligator Rivers (figure 22). The cost distance was calculated based on slope. The 6 classes, from low to high, were divided based on natural breaks (Jenks) in the data. There seems to be a correlation between distance to coastal inlets and rivers, low cost slope and depictions of ships as there are only ship depictions at the rock art locations in the lowest two cost zones, with none found at the highest cost areas, even when directly on a river.

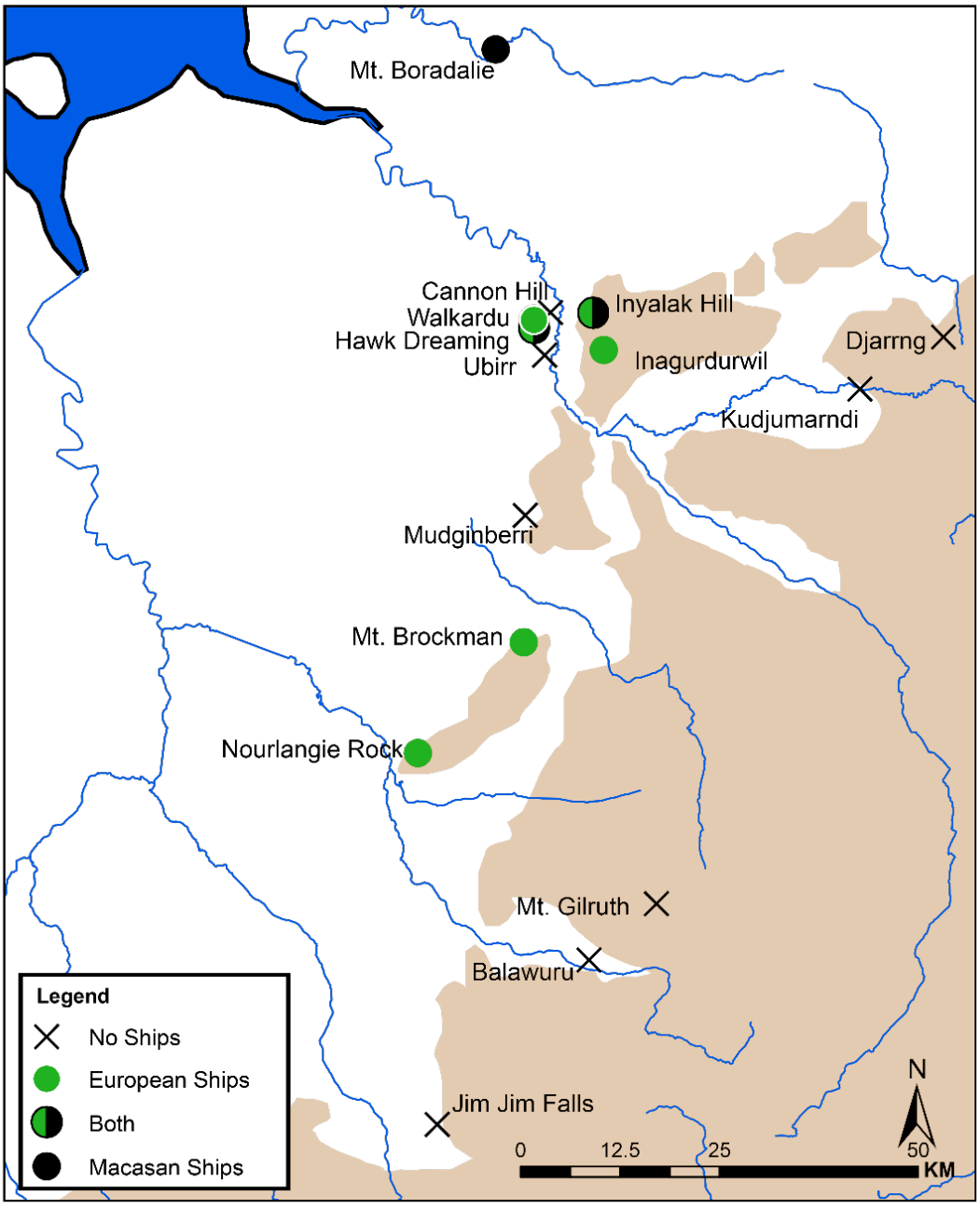

Figure 21. Ship depictions in the Alligator Rivers Region
Plotted with Arc Map 10.1 Shapefile from GASD

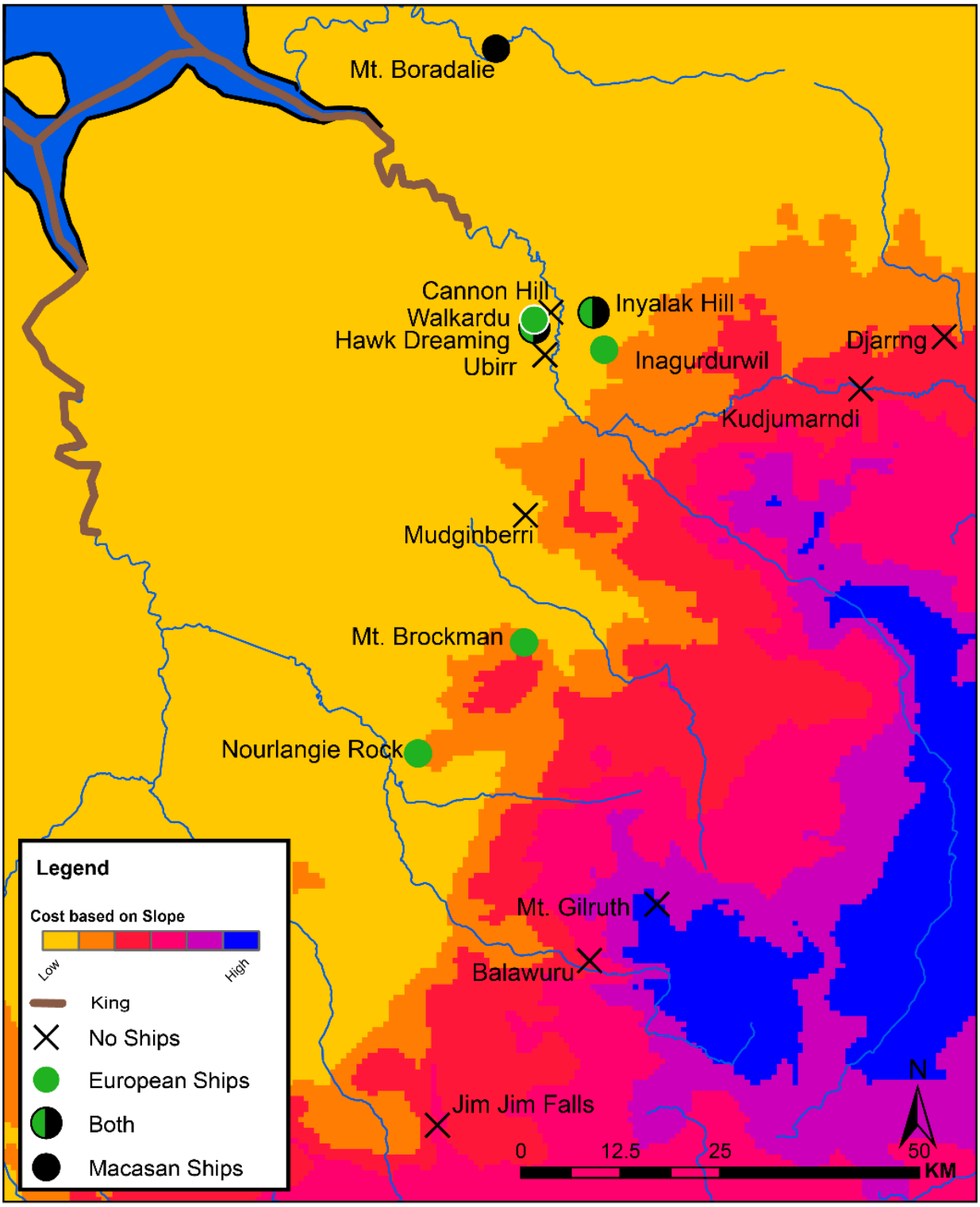

Figure 22. Cost distance buffer from King exploration path.

Linking Rock Art to Explorers

This research also aims to make the connection between known historical activities and rock art depictions. The rock art is a way for the Aboriginal people to express their perspectives on interactions within the Contact Period in the Alligator Rivers Region. The Australian Aboriginal response to both direct and indirect contact with European explorers is reflected in the distinctive changes *(or lack thereof)* in painting style, material, and subject matter of their rock art paintings (Frederick 2000, Chippendale and Taçon 1998). The painting style and disposition of depictions within this Initial Contact Period suggest that the interactions with the early European explorers were not hostile and participatory in nature.

Leichhardt 1845. During the Leichardt expedition, the meetings with Aboriginal people were not hostile whatsoever. "He descended the escarpment into the Alligator Rivers Region he met several Aboriginal people who came up to exchange presents: of red ochre, spear, and spears head. He gave them nails and a hammer" (Edwards 1979:15-16). The yearly encounters with the Macassan fisherman encouraged a sociable atmosphere during Leichhardt's journey. Leichhardt notes that the indigenous peoples spoke some Macassar at the time of contact (Leichhardt 1847:245). Leichhardt made his way through the Alligator River Region in November, near the onset of the wet season while the floodplains were still dry and stable. Aboriginal people were still out on the plains gathering roots, hunting geese, and storing food for the wet season ahead. Figure 23 is a depiction of Leichhardt on his journey, as demonstrated by the straw hat he consistently wore and by Aboriginal attesting. If Leichhardt came through later in the wet season, like McKinlay, he would have met up with a flooded and inaccessible landscape.

Figure 23. A depiction of Leichhardt
Released to the public in 2009 by the Aboriginal community
Location: Ubirr (Phoenix Group 2013)

McKinlay 1865. There is a confirmed rock art painting depicting the movement of McKinlay and his group at Ginga Wardelirrnmeng in the Magela Plain nearby Mudgenberri shown in figure 24. Note how the horses resemble macropods, or kangaroos. This may have been the first time the artist had seen horses, or says something about how new subjects are incorporated into the artists worldview and expectations.

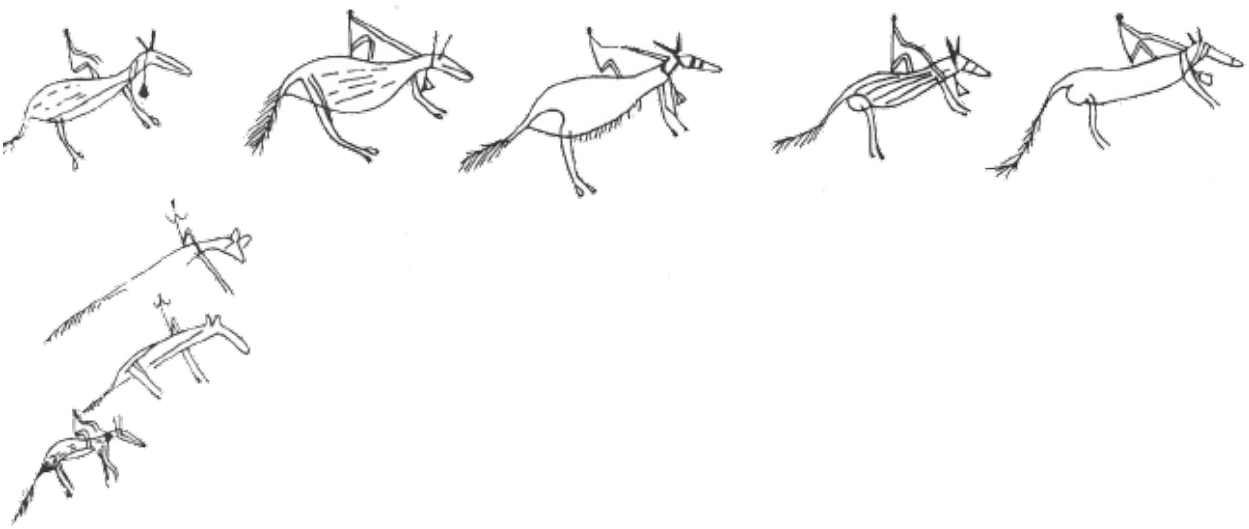

Figure 24. Depiction of McKinlay Expedition
Location: Gina wardelirrhmeng, near Mudgenberri (Chaloupka 1993:195)

Rock Art Linked to Explorer Path Map Results. The rock art depictions of the explorers linked to the paths of each explorer had very interesting results. The depictions were located right along the explorer pathways (figure 25). Cost distance based on categories of similar percent slope was also calculated for the explorer paths (figure 26 and 27). The yellow or low cost distance grouping includes the explorer depictions. It seems as though Aboriginal painters did not exert a lot of energy to depict the explorers at hidden or farther away locations.

Dating Contact Period Rock Art. Direct dating ochre is a challenge for Australian Rock Art Research (Taçon 2012:422-423). The superimposition of traditional subjects like kangaroos, emu, and x-ray fish over European Contact Period subjects can be relatively dated. The combination of relative dating of rock art paintings with the recorded time and dates of European travel accounts can broaden the range of knowledge about traditional subjects being depicted during the Contact Period. For example, the Leichhardt rock art depiction can be dated to December 1845. The McKinlay rock art depiction can be dated to May 1866. Any rock art superimposed, or placed over these depictions can also be attributed to the Initial Contact Period.

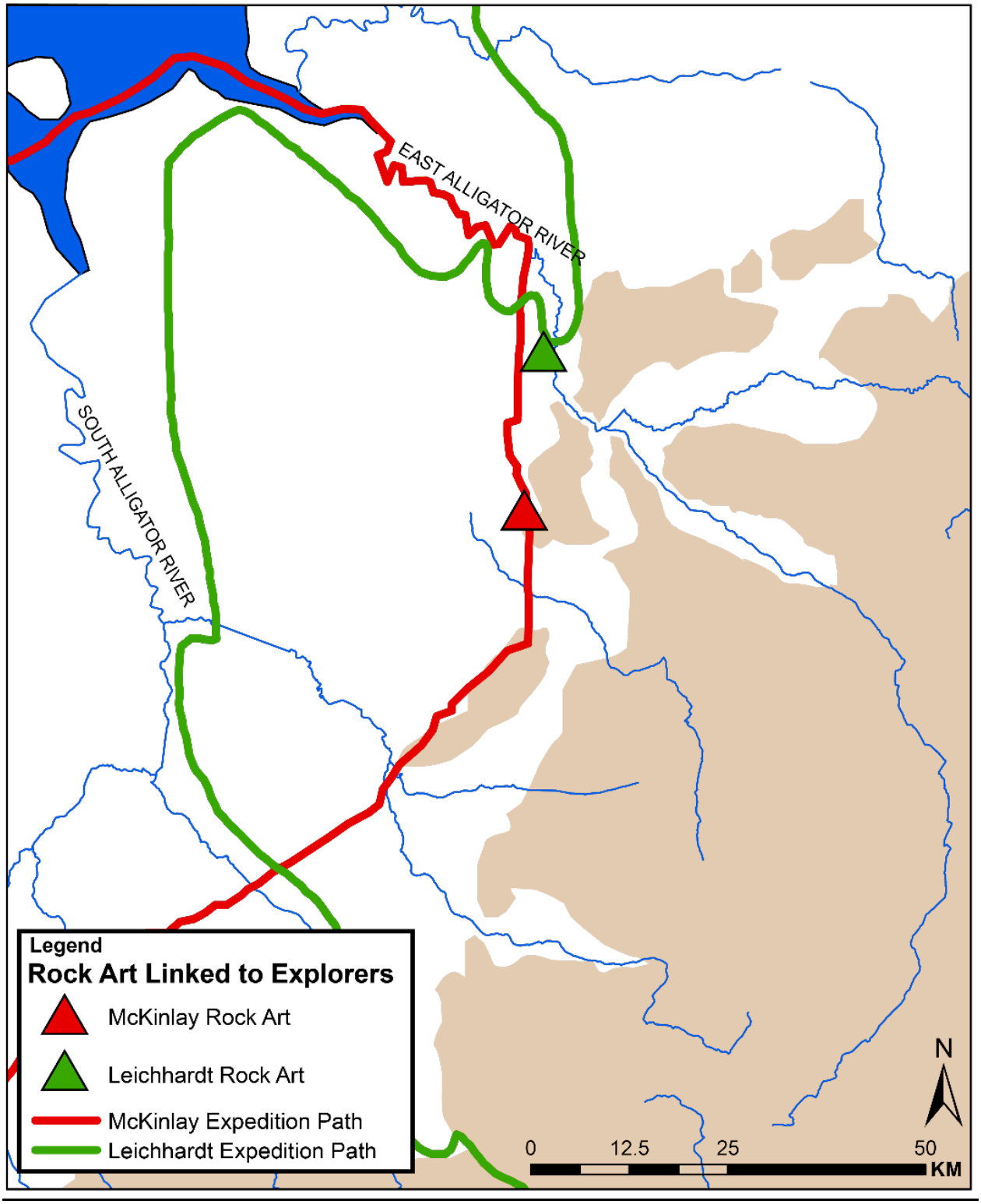

Figure 25. Rock art depictions of the explorers linked to the respective explorer path

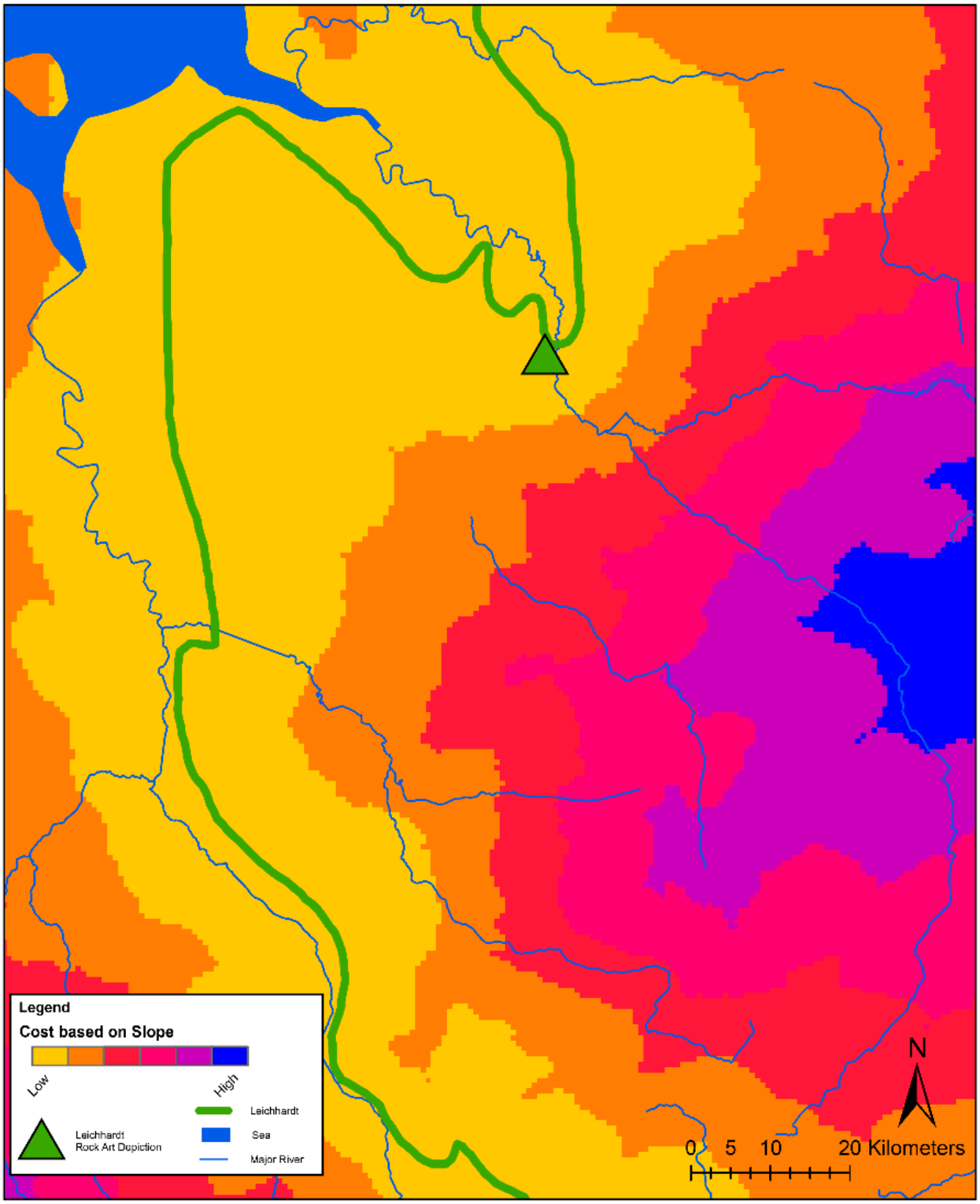

Figure 26. Cost Distance from Leichhardt path

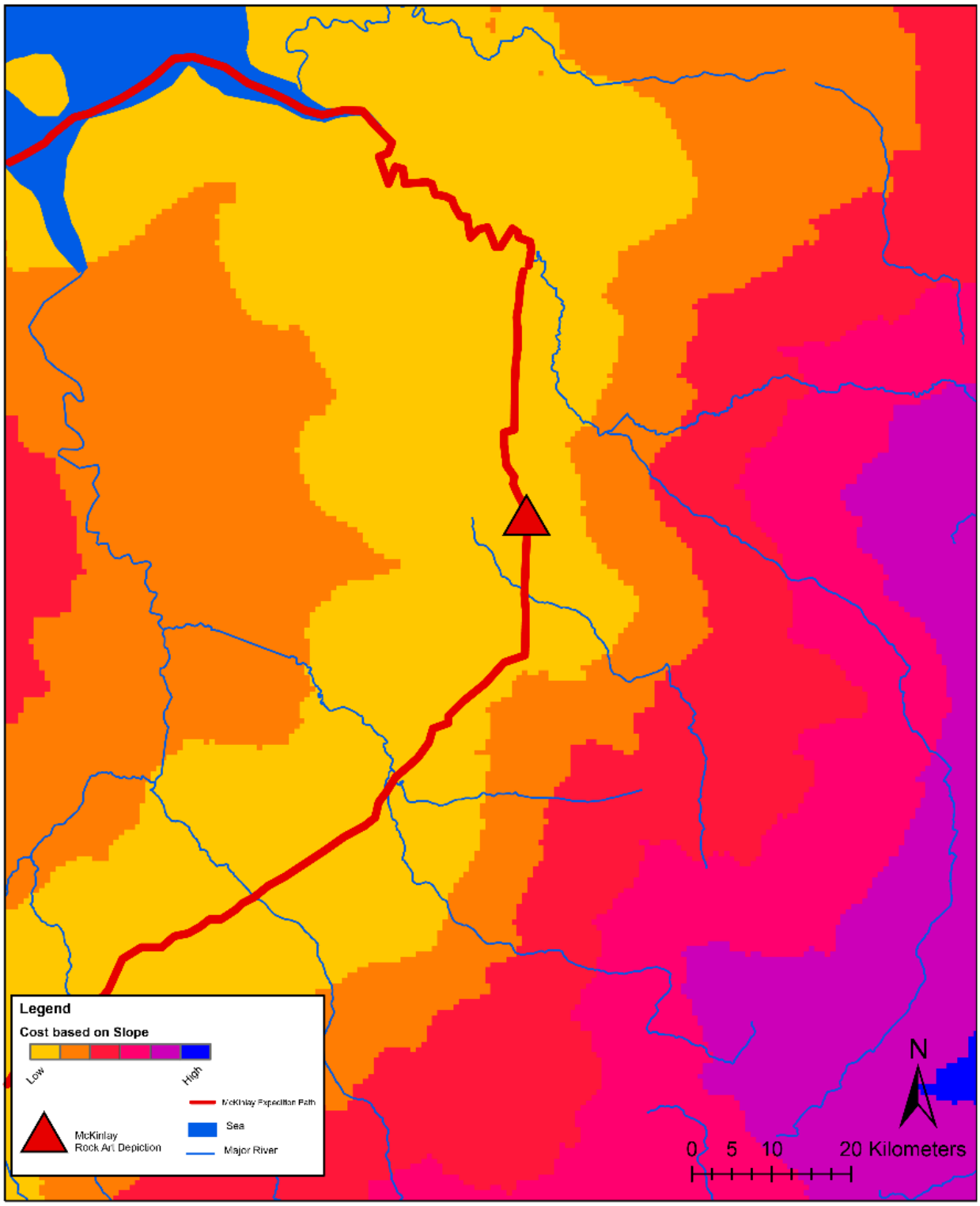

Figure 27. Cost Distance from McKinlay path

CONCLUSION

Rock art is an important archaeological resource, which offers informative and expressive indigenous views of the Contact process. The rock art from the Alligator Rivers Region shows the movement of people, the diversity of introduced subjects and encounters, and the lengths that Aboriginal people took to incorporate new and exotic phenomena into their worldview (Frederick 1999:134). The combination of both European and Aboriginal documentation show a more nuanced and balanced view of the engagements carried out within this period.

Based on the information from the explorer accounts and the increase in sorcery rock art depictions when Europeans move into the area, it seems as though there is a definite variance between what could be called the Initial Contact Period and what could be called the Settlement or Displacement Period. The Initial Contact Period in the Alligator Rivers Region can be thought of as a transition phase. The accounts from both sides reflect a somewhat positive or sociable relationship between European explorers and Aboriginal people in the Initial Contact Period. Some examples include: Aboriginal people trading gifts with Leichhardt during his expedition, the docile rock art depiction of Leichhardt on his horse at Ubirr, and the depiction of the explorer with a rifle held as a spear thrower at Balawuru. The underlying assumption in the cordial encounters and engagements by the Aboriginal people was that the Europeans were temporary travelers and traders much like the Macassan fisherman (Lister and Wallis 2001:107-108).

Rock Art as a Historical Source

Frederick notes, "it cannot be assumed that Contact art will occur only in the specific geographical location where these negotiations are actually played out" (1999:140*).* This may be true for other parts of Australia, but the observational detail of the x-ray style paintings and the occurrence of rock art depictions of specific explorers may prove that Contact art can be connected to specific events in the Alligator River Region. There is definitely a correlation between the distance to rock art depictions and historical events. The cost distance factor calculated from European explorer paths and their rock art depictions reveals spatial and temporal information about Aboriginal painters. The artists did not exert a lot of energy to depict the explorers at hidden or far away locations, which mean they were most likely, painted a short time after the interaction. This may be an important observation because parallels can be made to earlier period paintings. For example, when an artist depicts a fish, kangaroo, or crocodile from the Freshwater Period, perhaps they had seen the animal within a short distance and time frame from the location of the depiction. The location and range of extinct or extant animal species could subsequently be mapped from this information.

Contact Period rock art be used to date superimposed rock art paintings, corroborate historical documents, and also provide new narratives for this period. "The contention that there has been a complete break in indigenous traditions may be correct for more heavily colonized areas of Australia, but not in Arnhem Land" (Layton 1992:113). The knowledge of the land and information passed down from generation to generation had always been the key to survival in Australia (Taçon 2001:530). The conventions for rock art established deep in the past continued long after first contact. This attests to the strength of Aboriginal cultural traditions (May et al 2010:64).

LIMITATIONS

Sorcery Paintings

Due to the secrecy and religious confidentiality of the Alligator Rivers Aboriginal people, confirmed locations of sorcery paintings are archaeologically rare. The exclusion of sorcery paintings from this analysis was the main limitation to this study of Contact Period rock art in the Alligator Rivers Region. Sorcery paintings play an integral part in understanding the reaction to European invasion, but their exact meaning and locations are illusive. Sorcery paintings are done in secret and are intended to cause harm, bad luck, sickness, death, or exact revenge (Layton 1992:33). The paintings are depictions of stylistic humans in unnatural poses. Some are depicted with dart-like needles sticking out of their body, joints and genitals (Taylor 1987 cited by Layton 1992:50). Figure 28 is a depiction of a woman posed unnaturally and is categorized as a sorcery painting. The traditional way of life had been disrupted and the Aboriginal response was a dramatic increase in sorcery paintings. The increase occurred after prolonged contact with Europeans because of introduced diseases such as small pox, measles, and influenza (Chaloupka 1993:207, Frederick 1999:134). It is reasonable to claim that the increased stress from enforced social change, displacement, and new unknown diseases were main motivators for sorcery paintings. It is suggested that not all images are sorcery in nature, but may simply depict a person conflicted with sickness. The importance of sorcery paintings in this analysis would have been used to better separate the Initial Contact Period with what should be called the Settlement or Displacement Period.

Figure 28. Sorcery Painting (Chaloupka 1993:207)

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APPENDIX

Table A1. Contact Period Sites used in Analysis. 0 = absence 1= presence

Name	**Euro-pean Ship**	**Mac-assan Ship**	**Euro-pean Figure**	**Other Non-Aboriginal Figure**	**Gun**	**Euro-pean Object**	**Intro-duced Animal**	**X-ray Art**	**Other information/ *Sites included***
Balawuru	0	0	1	1	1	0	0	1	Rifle held like spear thrower
Cannon Hill	1	0	0	1	0	0	0	1	Spirit Figures
Djarnng	0	0	0	1	1	0	0	1	Chinese men, 3 buffalo, guns
Hawk Dreaming	1	1	1	0	0	1	0	1	tomahawk
Inagurdurwil	1	0	0	0	0	0	0	1	Also a steamer ship (not included in total)
Inyalak Hill	1	1	0	0	0	0	0	1	Dutch ships
Jim Jim Falls	0	0	1	0	0	0	0	1	Leichardt mentions Jim Jim
Kudjumarndi	0	0	0	0	1	0	0	1	Buffalo hunt
Mt. Bordalie	0	1	0	0	1	0	0	1	Buffalo hunt, hands
Mt. Brockman	1	0	0	0	0	0	0	1	*Includes Djerlandjal Rock*, goat, domestic animals, hands
Mt. Gilruth	0	1	0	0	0	0	0	1	
Mudginberri	0	0	1	0	1	1	0	1	*Includes Djwawumu, Gina wardelirrhmeng*
Nourlangie Rock	1	0	0	0	0	0	0	1	*Includes Nangaloar and Ship Cave*
Ubirr	0	0	1	0	1	1	0	1	European pipe
Walkardu	1	0	1	0	0	1	1	1	Sydney harbor bridge, cat, axe