THE SCALE OF CONFLICT: A LEVELS OF WAR AND GIS APPROACH TO THE BATTLE OF ROI-NAMUR

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ABSTRACT

The World War II Battle of Roi-Namur represents a culmination of overarching facets of planning, tactics, and application. Though taking place in a small region of the Pacific Ocean, this battle involved components that originated well beyond the size of its landmass. This thesis seeks to combine a Levels of War framework and a Geographic Information Systems approach to better understand and analyze the Battle of Roi-Namur. The Levels of War framework assigned all components of the battle to its various levels, which established a foundation for analytical processes. Geographic Information Systems allowed for a visualization of the battlefield through a multiscale approach and provided the means for each component to be spatially represented. Using these methods allows all elements of this conflict to be understood both independently and holistically. Together these methodologies elicit new understanding and interpretations of the conflict while exploring the potential limitations of the Levels of War framework in furthering the understanding of conflict.

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DEDICATION

To my loved ones, family, and friends.

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Chapter 1: Introduction

Despite all the research and recapitulations of stories pertaining to the Second World War (WWII), there remains much to learn about its various theaters and the events that occurred within them. *Operation Flintlock* was part of an island-hopping strategy used during WWII, wherein American forces operated with the goal of infiltrating and capturing Japanese-held islands and atolls in the Pacific Ocean (Eastern Mandates Campaign 2004:69-70; Waag 2021:9-10). This operation focused on the taking of the Marshall Islands. Securing these remote but strategically significant locations facilitated progress into enemy territory and in turn, helped to shift the balance of power in the region. One of the largest concerted efforts of *Operation Flintlock* was the Battle of Roi-Namur. Analysis of this battle forms the core of this thesis which illustrates the depth of information that can be extracted through WWII research (Scott and McFeaters 2010:105). The Battle of Roi-Namur was given new life through this study and the representation of its elements alongside the various analytical processes applied to them. The history of events for this conflict is recorded through maps, charts, and other documentary sources, as well as archaeological remains. An analysis of this battle of WWII using a Levels of War (LOW) approach and a multiscale Geographic Information Systems (GIS) framework utilizes each individual component's potential to elicit new information about the strategies and tactics employed throughout the battle (Fanning et al. 2013:101; Geier et al. 2010:56; McKinnon et al. 2015:1-2).

A LOW analysis seeks to fully understand a particular conflict or campaign. By separating a war into various components and considering them as an interrelated plan, a holistic understanding of a conflict or campaign may be achieved. To better understand the geospatial relationships of the strategy, GIS was used to spatially represent all involved components of the

Battle of Roi-Namur to better understand the conflict. A multiscale approach was applied through GIS to separate the various levels of war individually. This approach resulted in a geospatial representation of the levels the LOW analysis provides. It also created the platform for the application of various analytical processes to further the goals of the thesis. While each of these methodologies offered a good choice for independently analyzing specific elements of warfare, their combination provides new interpretations of this important chapter of WWII. Ultimately, the elucidation of new information pertaining to the Battle of Roi-Namur is at the core of this study, and the combination of these methodologies resulted in a new approach that could be applied to research at other conflict sites (Spennemann 2012:119-120).

Research Questions

This study explored the Battle of Roi-Namur through an approach that combined battlefield analysis and digital visualization. Though other studies have utilized a LOW analytical approach, the scope of this thesis revolved around the union of this framework with GIS to further analyze the Battle of Roi-Namur. To guide this research, several research questions are proposed:

Primary Question

- Can GIS visualization through a multiscale approach and LOW analysis provide new insight into the Battle of Roi-Namur?

Secondary Questions

- How can a combined LOW analysis and GIS multiscale approach derive pertinent information regarding the efficacy of the tactical plans utilized by Allied and Japanese forces in the Battle of Roi-Namur?
- How can historical records pertaining to Roi-Namur be visualized using GIS?

- How can GIS be used to help analyze archaeological data pertaining to the Battle of Roi-Namur?

Justification and Significance

This study combines two approaches to the analysis of a WWII battlefield. Focusing on the Battle of Roi-Namur through a multiscale and LOW approach allows for data outputs and viewpoints that were otherwise unknown. These results expand the archaeological understanding of the region through data acquired through the GIS processes. Though such data could have been collected independently of the LOW framework, its incorporation resulted in a geodatabase which encompasses the tactics used at the battle, clarifies battlefield assessments, and highlights the site's archaeological composition as it stands in the present. Ultimately this study presents a methodology that could be modified for similar studies to further the knowledge of a conflict.

Thesis Structure

This thesis is organized in a manner that facilitates the understanding of all processes used for data analysis. Discussions of historical background for the Battle of Roi-Namur and the larger events that led to it, the subdiscipline of battlefield archaeology, and the use of GIS for analysis to understand conflict all provide context for the study. To achieve these goals and fulfill the scope of the thesis, this study is organized into seven chapters.

The first chapter introduces the study and presents the research questions that guide it. Chapter 2 offers an overview of the main events that led to the Battle of Kwajalein Atoll, and in turn sets the stage for the Battle of Roi-Namur. Chapter 3 explores the LOW framework and provides a comprehensive description of its structure and some previous studies, as well as a classification of its elements as they pertain to this study. This information provides a segue into Chapter 4, which outlines the subdiscipline of battlefield archaeology and the utilization of GIS within it. Chapter 5 discusses the processes used to create the products of this thesis. A showcase of the variables that exist within the geodatabase is also given during this chapter. Following this, Chapter 6 delves into the analytical results of this study and discusses the meanings of the outcomes. Finally, Chapter 7 considers the efficacy of the study itself and the analytical results in relation to the proposed research questions.

Chapter 2: A History of the Battle of Roi-Namur

The Pacific Theater of WWII was a major battlefront that sprawled throughout the Pacific Ocean. Skirmishes between Allied and Japanese forces were fought through various means spread out across thousands of miles of bare ocean and small islands and atolls. The expansive Pacific Theater was a brutal yet critical component of WWII that enabled Allied forces to defeat Japan and led to the end of the war. Of the many events that took place in this theater, the Battle of Kwajalein Atoll holds potential for further study as a critical phase of WWII in which Allied forces applied hard learned lessons to secure an early and decisive victory in their march toward Japan. Before analyses of any of those events can occur, however, the overall history that led to them must first be understood (Shaw et al. 1966:117-154).

Though there were hints of what was to come in the years preceding WWII, it officially began in September of 1939. The conflict began when Germany invaded Poland, prompting Great Britain and France to declare war. At that point the war was concentrated primarily in Europe, though this would change dramatically in two short years. The war quickly spread throughout the rest of the world, with even the most untouched regions being permanently affected. With battles fought for several years in predominantly European countries, the uncertain direction the war would take led many strategists and members of militaries worldwide to plan for various outcomes (Gilbert 2014:1-2). Alongside emerging technology developed throughout this war, so too were new military strategies and techniques. The Pacific Theater was host to a dynamic format of conflict due to the set of environments and circumstances US troops faced. From naval battles at sea to amphibious assaults on thin strips of defended sand, this theater of WWII was incredibly diverse (Hart 1970:190).

Pearl Harbor

The nations involved in the war changed following the attack on Pearl Harbor, Hawaii on December 7, 1941.Under the leadership and command of Admiral Isoroku Yamamoto, Japan attacked Pearl Harbor with the intention of preventing United States (US) participation in the war (Gilbert 2014:139). The result of this action was entirely opposite to its intended goal. The surprise attack on Pearl Harbor consisted of 360 Japanese aircraft intent on destroying as much of the US naval fleet stationed at the base as possible. The raid resulted in 3,435 US casualties, four US battleships sunk and four others severely damaged, several cruisers and destroyers wrecked, and many smaller vessels, aircraft, and structures such as oil tanks on the base being destroyed. This offensive was also meant to preemptively cripple US naval capacity with the hope of prompting surrender before ever joining the war. Instead, the US declared war on Japan on December 8, 1941, which prompted Axis powers Germany and Italy to declare war on the US on December 11, 1941. With the subsequent US declaration of war on those countries, America was officially thrust into WWII (Pike 2016:248-262). The decision to conduct a surprise attack on a US naval base held drastic consequences for the Japanese Empire as it was a catalyst that eventually led to the defeat of Axis powers. Prior to the attack, Japan largely controlled the Pacific region. To turn the tide, an Allied plan was created that would simultaneously prevent further Japanese expansion in the Pacific Ocean while also setting the stage for an assault on its mainland (CNSG 1994q:1; Hart 1970:213-217; Pike 2016:248).

Japanese Occupation in the Pacific Ocean and Geography

Prior to WWII, Japan sought to expand its reach following its continuation of escalating conflict with China and other Asian powers. By establishing itself as a world power, Japan created a buffer zone that would effectively prevent its homeland from being attacked by other countries. To do this, Japan created outposts, defensive structures, and strongholds throughout the many islands of the Pacific Ocean. Their strongest harbors and fortifications were on Saipan, Guam, Iwo Jima, and Okinawa. These defensive positions were heavily fortified, making any attempt to assault these islands costly for Allied forces. Those fortifications were not the only locations upon which defensive positions were constructed. Japanese defensive structures were established on many of the islands, island chains, and atolls within their reach (CNSG 1944f:17). By the time the US joined the war against them, Japan had already created a strong sphere of influence that would make an invasion of Japan incredibly difficult. This prompted strategies by Allied forces that would ultimately bring about the defeat of Japan (Hart 1970:617).

The layout of Japanese positions established throughout the Pacific Ocean varied widely but all were designed to effectively defend against Allied attacks. Though the composition of each fortification was unique to the island on which it was situated, a common occurrence throughout the bases was a network of pillboxes, bunkers, and tunnels that spanned across, throughout, and under the landscape. Utilizing the terrain of these islands, the Japanese created positions to complement their strength of training and armaments. Taking advantage of the local landscape was a common trend for many of the island fortifications, with structures commonly created inside hills, mountains, and other naturally occurring land formations. Pillboxes used throughout most of the Pacific Theater were often small concrete structures hidden in areas suspected to be an eventual host to invading forces. They also incorporated openings that allowed for firearms to be used while simultaneously offering good cover from enemy fire. Devised from Japanese military expertise in guerilla warfare, such structures posed a difficult and dangerous predicament for Allied forces engaging in battle. Not only did they require extensive surveillance to determine the positions of these fixtures, but once found, they required concentrated attacks to deal significant damage (Headquarters United States Army Forces Central Pacific Area 1944:2).

New Strategies and Technology

Due to the environment of the Pacific Ocean, the methodologies used for fighting can be placed into an array of categories. Battles occurring with aircraft carriers were a new and soon-to-be defining characteristic of the Pacific Theater. Carriers provided a platform for aircraft to extend beyond the typical range of land-based airfields (Hastings 2012:501). The overall area where aircraft could be deployed increased with the removal of reliance on land-based airfields. The utilization of carriers enabled the creation of dynamic battle plans that would be used for a variety of situations. Increasing aircraft range to a suitable location where planes could be launched increased fuel efficiency and decreased overall distances to be flown and became a fundamental premise of the Pacific Theater. Battles fought using carriers and fighter aircraft took place between other carriers, battleships, and defensive positions held throughout the islands and atolls of the Pacific. Overall, aircraft carriers were a useful development of technology that allowed for the advancement and progression into Japanese territory (7th Infantry Division 1944a:6-a).

Alongside aircraft carriers, battleships were another commonly utilized vessel type by both Allied forces as well as the Japanese Empire in the Pacific Theater. These vessels were host to a wide array of armaments used to attack enemy vessels, aircraft, and defensive positions. They could also be used in a variety of fashions for both defensive and offensive operations. Battleships proved to be a staple in firepower throughout the Pacific Theater due to their heavy armor and capacity for delivering devastating ordnance. They were typically utilized alongside other types of watercraft that would in turn supplement one another. Destroyers frequently accompanied battleships, as did aircraft carriers; by combining the firepower of the battleships and destroyers with aerial support, a wide variety of applications were achievable (USS *Louisville* 1944:10). Submarines were also an offensive component of both Allied and Axis powers through their ability to conduct stealth missions that were coupled with torpedoes. Altogether, the vessels used throughout this theater varied greatly, since all served specific purposes (Gailey 1996:37-44).

The aircraft used in the Pacific Theater by both the Japanese Navy and Allied forces varied, with each type oriented toward a particular set of goals. Often covering long ranges of open ocean, common operations included surveillance operations, preliminary bombings, target disposal, and providing cover fire for amphibious assaults. The type of aircraft used changed depending on the mission, but the Japanese and Allied forces each developed an extensive array of aircraft for the different operations. The most common aircraft types used in WWII were fighters, bombers, and reconnaissance aircraft. Of those, fighter planes offered the greatest versatility and were employed to combat enemy aircraft and surface vessels, as well as to act as escorts on missions. Fighter planes were predominately equipped with machine guns but could be outfitted with bombs and other heavy armaments. Another commonly used type of aircraft was bombers. Generally equipped with munitions to bombard vessels and enemy positions, many bombers had long range capabilities. Reconnaissance planes were another important type of aircraft, though they focused less on engagement and more on stealthily obtaining information pertaining to enemy positions, capabilities, and forces. Unique methodologies and battle plans were able to be created through the utilization of these aircraft. The combination of advancements in aircraft technology and the usage of carriers enabled the creation of a new type of warfare for the entirety of the Pacific Theater (Gailey 1996:33-37).

Alongside the utilization of developing aircraft and ship technologies, new strategies for advancing toward enemy-held defensive positions were also devised. Amphibious assaults are an excellent example of one of the more commonly utilized strategies. They typically consisted of a coordinated attack on an enemy position through the delivery of troops from landing vehicles. Launched from landing ships, landing craft (e.g., LCM), amphibious assault vehicles (e.g., LVT), and other types of amphibious assault vessels advanced to a shoreline where ground troops were then released into the surf so a ground assault could ensue (Joseph 1997:4-5; Marston 2011:252). Cover fire from air and surface vessels was typically provided to assist in these assaults, with the goal of eventually overwhelming an enemy defensive position (United States Fleet 1944:1-18).

The Battles of the Coral Sea and Midway

Many WWII battles were waged to control land masses, but there were also several conflicts at sea. On May 4,1942, the Battle of the Coral Sea was the first naval battle to occur in the Pacific Theater. Japanese Naval forces were enroute to further their southward expansion by attempting to invade and take Port Moresby of New Guinea. Comprised of four aircraft carriers, two battleships, and several other vessels, the Japanese attacked two Allied aircraft carriers, two cruisers, and several destroyers. This battle was fought from these carriers with no direct fire occurring between the vessels. As stated by historian B.H. Lidell Hart (1970:349), "The Battle of the Coral Sea was the first in history fought out between fleets that never came in sight of one another, and at ranges that had been extended, from the battleship's extreme limit of about twenty miles to a hundred miles and more". This was vastly different from how previous battles were fought since instead of having a target in sight, conflict ensued when the combatants are within range of one another's aircraft. At the end of The Battle of the Coral Sea, Allied forces were able to secure a victory. Through the utilization of aircraft and carriers, it was the first victory against the Japanese in the Pacific Theater. This battle was a critical victory for US forces against the Japanese, with the results impacting events at the Battle of Midway by weakening their forces. Not only did this represent one of the first major sea battles of the Pacific Theater, but many of the Japanese aircraft downed at the Battle of the Coral Sea were among those that bombed Pearl Harbor; this in turn bolstered the morale of US troops (Gilbert 2004:322-323).

A month after the Battle of the Coral Sea, another major naval battle took place near Midway Atoll. The Battle of Midway was a decisive victory for the US Navy as it allowed for further penetration of Allied forces into Japanese-held territory. From June 4 to June 7, 1942, US forces destroyed the Imperial Japanese Navy (IJN) carriers *Akagi, Kaga, Hiryu* and *Soryu*. This enabled US forces to hold an advantage over a temporarily weakened Japanese Navy. Aside from early sorties against Midway Island, the Japanese engaged US forces exclusively through their respective carriers. Although all four of the Japanese carriers were destroyed (Hart 1970:351-353), the US suffered the loss of the carrier USS *Yorktown* and the destroyer USS *Hammann* (Marston 2011:123). Not only did the battle prevent the Japanese from expanding territory into the center of the Pacific, but it also weakened their forces and allowed US forces to drive further into Japanese territory. Alongside weakening Japanese naval forces, it gave more space for US troops to recover; as explained by Hart (1970:353), the battle "…gave the Americans an invaluable breathing space until, at the end of the year, their new *Essex* class fleet carriers began to become available. Thus, it can reasonably be said that Midway was the turning point that spelled the ultimate doom of Japan". Both the Battle of Midway and the Coral Sea showcased the efficacy and viability of using carriers and battleships, and the strategies taken from those battles set the stage for events to follow.

Island Hopping Campaign

Japan's influence in the Pacific region reached far from their homeland, as they occupied most of the small islands and atolls north and east of Australia. Japanese expansion in the Pacific Ocean began before the US entered the war, through the precautionary establishment of a presence suitable to defend against Allied advances (Hart 1970:199). When the US entered the war, Australia and Hawaii were the closest Allied-held regions which could serve as the primary areas for penetration into Japanese territory. With the goal of eventually neutralizing the Axis threat, Allied forces developed a plan for an invasion of Japan through an island-hopping campaign (Toll 2015:8). Island-hopping is a methodology wherein forces could conquer enemy-held islands to expand their advances, and once held, would provide support for later assaults (Morison 2001:226). An important concept and heavily utilized strategy by Allied forces in the Pacific Theater, the island-hopping methodology enabled captured enemy bases to be renovated and recycled (Toll 2015:232).

The use of the island-hopping campaign requires much consideration, as a core component of it revolves around attacking and taking specific Japanese defensive positions that were relatively less fortified than other defensive positions in the area. By focusing on territories viewed as less important by the Japanese, Allied forces were able to minimize loss while maximizing progress. This strategy also allowed for the closing of Japanese supply routes, which ended their expansion. By minimizing expansion and instead forcing Japanese forces to withdraw while simultaneously weakening them, Allied forces continued to use this methodology through the end of the war. The importance of these battles is significant as they allowed for deeper intrusion into Japanese territory. Though considered the "outer ring" of the

Japanese claim, the conflicts on those remote islands and atolls paved the way for future battles closer to its mainland (Toll 2015:9).

The plan of attack necessitated the creation of multiple campaigns designed around the goal of taking these relatively weaker Japanese positions. The operations generally had many steps, with each one focusing on specific regions or islands. Operations to gradually capture and maintain Japanese-held bases on these areas of interest were a major focus of Allied groups. For instance, *Operation Galvanic* focused on the capture of Tarawa in the Gilbert Islands in November 1943; *Operation Flintlock* on the capture of the Marshall Islands in January and February 1943; and *Operation Catchpole* on the capture of Eniwetok Atoll (Marshall Islands) in February 1944 (Toll 2015:315-386). Each captured region or island served as a location for further expansion into Japanese waters (Gilbert 2014:272). Both old and new tactics were commonly used upon the approach of each territory, with every battle progressing the overall strategy used for subsequent invasions. Though US forces sent to fight on the European Front had their own challenges, the Pacific Theater and the island-hopping campaign were entirely different due to the vastness of the ocean and the tactics needed to seize their desired objectives (Toll 2015:8).

The Battle of Guadalcanal

Following the Battle of Midway, the island-hopping campaign began to take advantage of the recently weakened Japanese navy. The island-hopping campaign first started at the Battle of Guadalcanal, taking place from August 1942 to February 1943 in the Solomon Islands. The purpose of this battle was to acquire the region to stage further advancements deeper into Japanese territory (Hopkins 2009:107-122). The Solomon Islands were in a suitable location to start the island-hopping campaign as they were far enough away from strong Japanese control whilst still providing a suitable staging ground for later attacks that would serve Allied forces well (Toll 2015:221).

The battle consisted of attacks from aircraft carriers, battleships, and amphibious landings. The attack on the island against the Japanese resulted in many casualties for both sides. Throughout the months-long battle, many strategies were employed by both sides. Allied forces continuously conducted bombardments from their battleships while simultaneously assaulting with aircraft. Troops followed the bombardment and charged the shores, where hand-to-hand combat took place (Joseph 1997:4). Ultimately, the Japanese suffered 25,000 casualties in total. This included deaths due to combat, disease, and starvation because the drawn-out battle forced them to be holed in the fortifications that were not destroyed. Suicides were also a common occurrence in the Japanese ranks. When faced with an inevitable defeat, "…a quick suicide was the path of least suffering" (Toll 2015:342). US forces suffered over 7,000 troop casualties and lost approximately 600 planes. Following the battle, Guadalcanal became a suitable base of operations for Allied forces to stage further advancement. This battle was important to the island-hopping campaign as it showed the effectiveness of capturing enemy islands that would then serve as outposts. Additionally, it provided the opportunity for the creation of a supply chain that reduced the time needed to transport reinforcements and supplies to the advancing front. The established US outpost on Guadalcanal was the first of many that would serve the island-hopping campaign well throughout the remainder of the war (Hart 1970:362).

Gilbert Islands

Following the start of the island-hopping campaign, the next area that served as a major base of operations following its capture was the Gilbert Islands (now Kiribati). Important battlefields for the next step in the island-hopping campaign were Makin and Tarawa Atolls.

Once captured, these atolls provided an effective staging base for the further advancement of the Gilberts, akin to how the Battle of Guadalcanal assisted in the capture of the Solomon Islands. To better understand the progression of this portion of the war:

> Admiral King had wanted to start with a thrust at the Marshall Islands, but this idea was discarded for the lack of shipping and trained troops needed to ensure success. Instead, it was decided to begin by a stroke at the Gilbert Islands, although they were a little farther from the Hawaiian base at Pearl Harbor, as their capture seemed a less exacting task while it would provide practice in amphibious operations and bomber bases for a subsequent attack on the Marshall Islands. In the Gilberts, the two most westerly islands, Makin and Tarawa, were to be the main objectives (Hart 1970:510).

This quote offers context for the argument behind taking the Gilbert Islands prior to the Marshall Islands. Understanding the logic behind why certain island groups were targeted before others is crucial in comprehending the progression of events.

Taking place synchronously, the Battles of Tarawa and Makin were critical to understanding of the correct methods for assault at these types of defensive positions. For the attack on Makin, Allied forces consisted of 7,000 troops, while another 18,000 were sent to Tarawa. According to Lidell Hart, a critical development of this battle was the addition of the Service Force, which was comprised of vessels to supplement the attacking vessels to ensure their service was operational and that troops had appropriate accommodations. The 800 Japanese troops on Makin were significantly less prepared for battle compared to Tarawa's 3000 strong defensive force (Hart 1970:511).

Due to the large number of Allied troops and frequency of naval bombardments and aerial strikes, the battle for Makin only took four days. Following the bombardment, Allied troops overtook the Japanese defenders and quickly captured Makin at a cost of 305 casualties. Tarawa proved to be a much more difficult target, resulting in a greater loss of life for both the Allied and Japanese troops. After only two and a half hours of naval bombardment and aerial attacks, Allied forces commenced the amphibious attack. Due to Tarawa being more heavily fortified than Makin, taking it proved to be much more deadly with the assault resulting in over 1,000 Allied and 3,000 Japanese casualties. Tactics like the intense bombardment of enemy-held territory from naval vessels to weaken enemy defenses prior to a combined amphibious and air assault commenced. These were among the major lessons learned through the battles at Makin and Tarawa. The tactics used throughout that and previous assaults on similar atolls and islands were educational in demonstrating effective methods for assaulting similar defensive positions. The overall capture of the Gilbert Islands was critical to this portion of the island-hopping campaign, as Allied forces slowly drew closer to the main "sphere of influence" of Japan (Shaw et al. 1966:103-104).

Operation Flintlock

Following the capture of the Gilbert Islands, *Operation Flintlock* commenced. This operation consisted of the capture of the Marshall Islands, a series of islands and atolls that would serve as a prime location for furthering the island-hopping campaign. Figure 1 displays a map of both the Gilbert and Marshall Islands to aid in the understanding of this portion of WWII (Rottman 2013:10). *Operation Flintlock* was planned in battle phases, with each building upon the previous success. The campaign for the Marshall Islands began soon after the hard-fought victories of Allied forces at the Gilbert Islands (Gilbert 2014:476). The entire region was important as control of it allowed US forces to continue attacking territories near Japan and provided an end to the long resupply journey from Pearl Harbor and neighboring territories. Following the capture of the Marshall Islands and the completion of smaller scale connected missions, the final stages of the Pacific Theater were established. The tactics for developing these areas changed through trial and error, with each addition honing techniques that maximized the overall success of future missions (Toll 2015:7). Though *Operation Flintlock* consisted of nine major phases, and each was dedicated to the capture of specific islands through various methods, some proved to be larger in overall scope and several required a multitude of steps (Commander Task Unit 58.2.2 1944:1-4). The first few phases of *Operation Flintlock* focused on the capture of the most heavily defended positions of the Marshall Islands, Kwajalein, and Eniwetok Atolls:

> Operation ‘Flintlock’ was divided into nine phases. The main phase was the first, the seizure of Kwajalein and Majuro Atolls between 29 January and 8 February. Phase II was the seizure of Eniwetok Atoll scheduled for 17-23 February. This was essentially a separate operation – ‘Catchpole’. The remaining phase would become known as "Flintlock, Jr." and involved the clearing of the largely unoccupied remaining Marshalls between March and April (Rottman 2013:18).

Though *Operation Catchpole* was its own operation that consisted of tactics pertaining to the overall goal of capturing Eniwetok, it still fell under the structure of *Operation Flintlock* as part of the second phase. Due to the victories obtained from previous battles, choosing the appropriate plan of attack was easily selected. Along with the lessons learned from battles fought before *Operation Flintlock*, several other considerations were in place that allowed for the highest rate of success. Such considerations consisted of having more time to plan, as well as having access to a higher quantity of materials (CNSG 1994p:53-58). Preliminary bombardment of defensive positions was another lesson taken from these battles that proved the value of this tactical plan, as it would thin out the enemy to ease the application of amphibious assaults (CNSG 1994i:1-7). These recommendations contributed greatly to the upcoming success of *Operation Flintlock* (Commander Task Unit 58.2.2 1944:3-4).

Figure 1 Map of the Gilbert and Marshall Islands (Rottman 2004:10).

The first phase of *Operation Flintlock* focused on the capture of Kwajalein Atoll. This atoll holds a high number of small islands, the largest of which were Roi, Namur, and Kwajalein. Though Kwajalein Atoll was the primary goal of this stage, the capture of Majuro Atoll was also a minor focus. Due to these atolls all having separate islands, attacks were conducted at the same time from January 29 to February 8, 1944. To prepare for the overall assault on these islands, secondary islands were first taken to provide artillery fire that worked in conjunction with battleship and carrier attacks focused on Roi, Namur, and Kwajalein. This strategy was taken directly from previous battles, with enemy defensive positions being much easier to capture after they were weakened by bombardments. On December 4, 1943, US forces began shelling the main islands of Kwajalein Atoll to weaken their defenses and prepare for the future invasion of the atoll later in January (CNSG 1994i:1-4). Majuro Atoll was one of the first targets to prepare for later assaults of this section of *Operation Flintlock* and what would later become known as the Battle of Kwajalein. US forces landed on Majuro Atoll after it was determined that there were no Japanese defenders present. Following that development, the remainder of the assault on the Marshall Islands commenced. The attacks on Kwajalein Atoll are all unique, with a multitude of events occurring in sync (Shaw et al. 1966:117-120).

Battle Of Kwajalein Atoll

While the Battle of Kwajalein Atoll was a part of the larger *Operation Flintlock*, the diverse and unique circumstances surrounding the multi-faceted approach of this part of WWII requires further examination. This battle consisted of multiple attacks on the islands throughout the atoll, with each having its own in-depth tactics planned and carried out using the materials and methods available to the appropriate landing forces. The battles consisted of aircraft attacks, naval bombardments, shelling, and amphibious assaults. Tactics employed were taken from previous island-hopping campaign battles and were developed over time to suit each mission. One successful plan did not necessarily mean that it would work without fail, but in the case of the Battle of Kwajalein Atoll, previous tactics applied to this terrain were incredibly beneficial for Allied forces (CNSG 1944c:1-50).

The Battle of Kwajalein Atoll, which took place from January 31 to February 3, 1944, is an excellent example of learning from past mistakes and opened the door to further analyze how applied tactics impacted the remainder of the war (Toll 2015:384). As mentioned above, the Battle of Tarawa had a heavy influence on this tactical approach since without preliminary bombardment, many US troops perished (Shaw et al. 1966:124-125). Preliminary naval and aerial bombardment resulted in devastation for the islands themselves and proved to be effective at hindering Japanese defense (USS *Cabot 1944*:1-5). Bombardment made way for amphibious assaults, effectively resulting in the capture of the islands (Rottman 2013:38). The effectiveness of these tactics is illustrated through the quote, "The bombardment and bombing plans, as prepared for the Kwajalein operation, worked out admirably because of the general similarity in type between above ground fortifications there and at Tarawa" (Headquarters United States Army Forces Central Pacific Area 1944:5). This combined assault strategy, in turn, paved the way for *Operation Catchpole* (CSNG 1994k:1-19; Gilbert 2014:499).

Kwajalein Atoll is part of the Marshall Islands and is the largest coral reef atoll in the world, composed of many small islands. It contains 93 islands and has a total land area of 6.35 square miles. Of the main islands, Roi-Namur is situated at the Northeastern end of Kwajalein Atoll, and the island of Kwajalein lays at its southeasternmost portion. Figure 2 illustrates the layout of Kwajalein Atoll, the islands of which are primarily strips of sand surrounded by an extensive coral network, with coconut palms and sparse vegetation comprising the landscape of the sandy land strips (United States Fleet 1944:126; Rottman 2013:12).

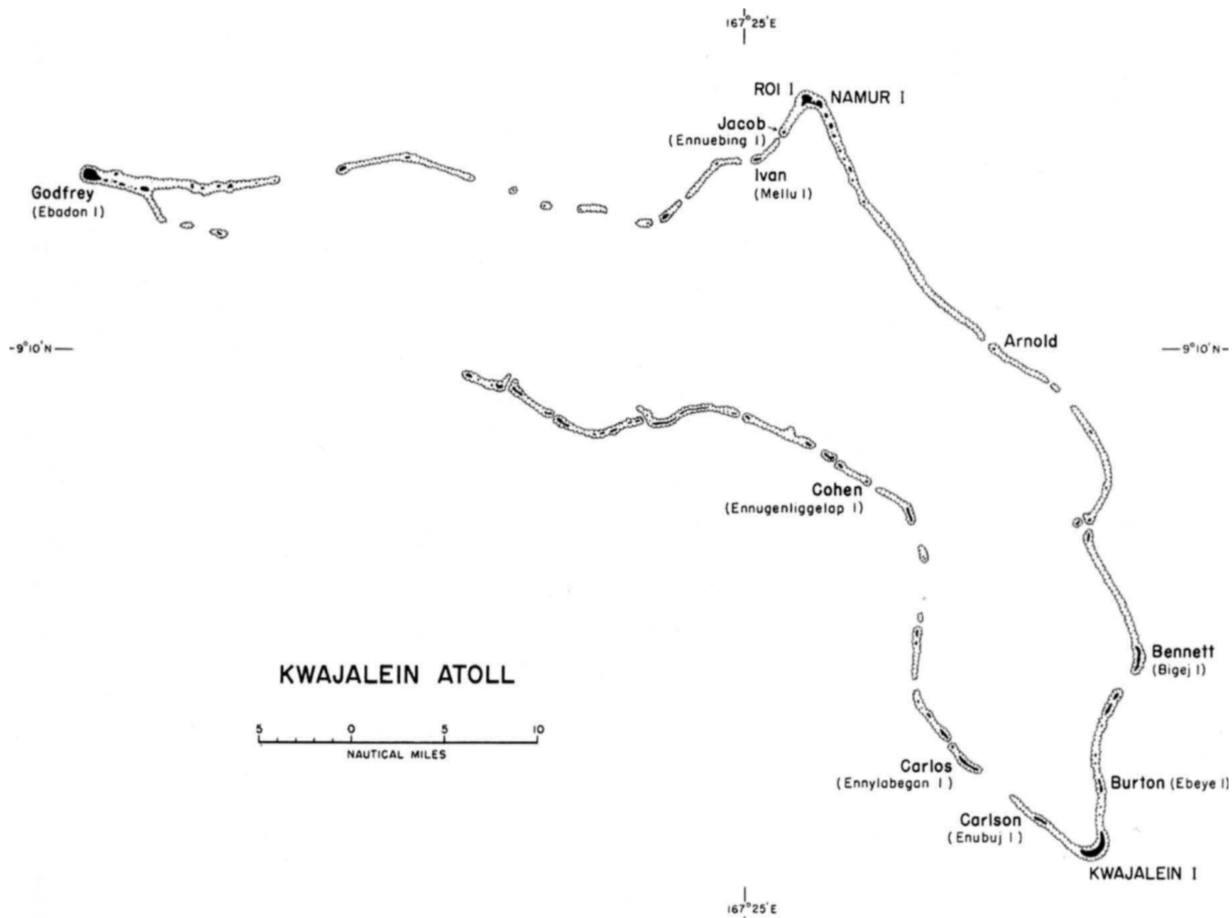

Figure 2 Image of Kwajalein Atoll (Rottman 2004:11).

The plan for the assault on the main islands of Kwajalein Atoll consisted of two main groups: the Northern Troop and Landing Force (NTLF) and the Southern Troop and Landing Force (STLF). The NTLF focused on Roi and Namur while the STLF focused on the Island of Kwajalein. The NTLF consisted of 20,778 Marines while the STLF consisted of 21,768 Army soldiers (United States Fleet 1944:5). Alongside these troops, several aircraft carriers, fighter planes, and battleships were utilized for the preliminary shelling of the islands. The defenders consisted of the Japanese 4th Fleet, with 5,000 troops positioned on the island of Kwajalein, and 3,000 defenders positioned on Roi and Namur (Rottman 2013:30-31).

The Japanese defensive positions were like those found on Tarawa and other islands with a similar landscape composition to that of Kwajalein. On Kwajalein, Roi, and Namur, predominant Japanese positions included fixtures to defend against air, naval, and ground attacks. Coastal defense installations mounted four 127-millimeter (mm) guns to protect against both aircraft and naval vessels; two were situated on Kwajalein, and one on both Roi and Namur. Several 76mm guns were also used to defend against these attacks. To defend against amphibious assaults, trenches, and pillboxes were created for infantry to occupy. There were also independent rifle holes created away from these trenches (CNSG 1994f:17). Though the anti-air and anti-naval guns were established in tactical locations, they suffered from a lack of cover which led to them being destroyed by aerial and naval bombardments quite easily (CNSG 1944b:21). This resulted in the bulk of the Japanese defenders having to resort to rifle fire and being overtaken with relative ease due to the superior firepower of Allied forces. According to the Joint Intelligence Center (1944:1), an accurate assessment of every defensive position established by the Japanese is unlikely to be ascertained due to the intensive destruction that occurred during the assaults.

The day of the attack was referred to as D-Day, and preliminary bombardments of Japanese defensive positions began on January 31, 1944. Following the D-Day bombardment of the major islands of Kwajalein Atoll, the NTLF commenced an amphibious assault on Roi and Namur in sync with the assault on the Island of Kwajalein (CNSG 1994u:2-9). The amphibious assault consisted of three battleships, five cruisers, twenty-one destroyers, and various other support craft (Rottman 2013:38). Like the assault on Kwajalein Island, naval support fire softened the landing of the amphibious assault (CNSG1994l:1-24). After suffering the loss of approximately 1,000 troops, the NTLF secured victory and effectively captured Roi and Namur on February 2, 1944 (CNSG 1994h:192-203).

The Kwajalein assault was carried out by the STLF the same time the battle of Roi-Namur was initiated by the NTLF. Alongside the troops needed for the amphibious assault, four battleships, three cruisers, eighteen destroyers, and other support vessels participated. The assault began with an attack on small, minimally defended islets such as Ninni and Gea. With cover fire from the vessels situated 6-10 miles southwest of Kwajalein Island, the amphibious assault commenced (CNSG 1994h:192-203). This resulted in waves of attacks and counterattacks by both Allied and Japanese forces. The STLF suffered seven casualties and 82 wounded before the island was captured on February 4, 1944 (Rottman 2013:38-66).

Following the capture of Kwajalein Atoll, the remaining phases of *Operation Flintlock* continued. After the war, there were still events and occurrences that tie into the overall progression of the Battle of Kwajalein, even though by that point the war had concluded. Following the arrival of the news that those stationed at Kwajalein Atoll were allowed to return home to the US, considerations were made to clear out the unusable vessels and vehicles that were no longer service-ready. To do this, a large majority of the wrecked vehicles were loaded onto barges and dumped inside the lagoon near Roi and Namur. Though there were vessels and aircraft in this vicinity that were downed during the battles that occurred, over 150 vehicles were intentionally dumped to clear the island of dangerous material so that the island inhabitants did not suffer from them. The expedient dumping of unneeded materials also quickly cleaned up the island which in turn expedited troop departures (Mueller 2018:19).

Impact of the Battle of Kwajalein Atoll

Following the Battle of Kwajalein Atoll, the main islands were converted into a base of operations for further advancement of the island-hopping campaign. The causeway between the two islands was expanded using concrete, which eventually connected the islands of Roi and Namur and created a single island known as Roi-Namur. The remaining phases of action in the Pacific Theater were heavily dependent upon the security of the Marshall Islands. The capture and securing of Kwajalein Atoll resulted in increased Allied control of Axis territory in the Pacific, while allowing for the further securing of the Marshall Islands. This territory was the start of the final steps of penetration into the main sphere of Japanese control, as the homeland of Japan was seen as being merely a few battles away (Eastern Mandates Campaign 2004:63-70).

The securing of the Marshall Islands proved to be an important part of the island-hopping campaign that would serve as a base to conduct further operations. Following this, the final battles and campaigns of the Pacific Theater commenced, using the Marshall Islands as a staging ground for the remaining assaults. The accessibility of the Marshall Islands eventually allowed Allied forces to mount operations against Saipan, Guam, Peleliu, Iwo-Jima, and Okinawa. Though these brutal battles would cost thousands of US and Japanese lives, they also led to the decision to drop the atomic bombs on Hiroshima and Nagasaki, which forced the Japanese Empire to surrender and ended WWII in the Pacific Theater (Hart 1970:696).

Operation Catchpole and Securing the Marshall Islands

Following the capture of Kwajalein Atoll, the second phase of *Operation Flintlock* began. This phase focused on the capture of Eniwetok Atoll, dubbed *Operation Catchpole*. Starting on February 17, 1944, shelling of the islands surrounding Eniwetok Atoll began in preparation for the direct assault. This made way for an amphibious assault, though it was not without struggle.

The Japanese defenders positioned themselves throughout the island, hidden away in positions designed to defend against a direct assault (CNSG 1994k:1-19). The series of battles fought throughout *Operation Catchpole* ended up costing over 1,200 US and 800 Japanese lives (CNSG 1944a:1-2). The newly developed tactics employed at Eniwetok were of mixed success (Hart 1970:536). The landscape of the island and troop strength were different from those found at Kwajalein Atoll. Instead of long strips of land, sand, and vegetation, Eniwetok had more crevices and positions for Japanese troops to use as "spider holes," which surprised and devastated US troops upon landing (Toll 2015:389). Although this battle ultimately resulted in another US victory of the Pacific Theater, the tactics taken from the Battle of Kwajalein were useful to a point, as the outcome proved to be elucidatory in the following stages of the war (CNSG 1994s:3). Though *Operation Catchpole* was only a part of *Operation Flintlock*, it was still important to the overall goal of securing the Marshall Islands (Hart 1970:512).

Following the main phases of *Operation Flintlock*, a sub-term was applied to it that would focus on the "mop-up" of the remaining islands in the Marshalls group (7th Infantry Division 1944b:1). Dubbed *Operation Flintlock Jr.* since it was still a constituent of the overall operation, it benefitted from the lack of in-depth strategy compared to the taking of Roi, Namur, Kwajalein, and Eniwetok. *Operation Flintlock Jr.* began on March 8, 1944, focusing on several islands:

> Operation Flintlock, Jr., dealt with five areas. Included in the West Group were Wotho, Ujae, and Lae Atolls. The South Group embraced Namu, Ailinglapalap, Namorik, and Ebon Atolls, as well as Kili Island. Bikini, Rongelap, Ailinginae, and Rongerik Atolls formed the North Group, while Bikar, Utirik, Taka, Ailuk, and Likiep Atolls and Jemo and Mejit Islands were assigned to the Northeast Group (Shaw et al. 1966:217).

Primary elements of this phase of *Operation Flintlock* consisted of sending out surveillance aircraft to determine the level of defensive opposition Allied forces faced upon attack. Most of these islands had few Japanese defenders, as the main islands of the Marshall chain required more Japanese troops. This component of *Operation Flintlock* ended on April 5, 1944. Though several small-scale “wrapping up” missions occurred after the official end of *Operation Flintlock Jr.*, its overall goal was completed with relative ease (Shaw et al. 1966:216-218).

The full completion of *Operation Flintlock* enabled Allied forces to hold dominion over the Marshall Islands after a relatively quick rate of capture of Japanese defenses. The level of success achieved during this operation provided total control of the main and outlying islands, which proved incredibly significant to the remainder of the war. Following *Operation Flintlock*, the Marshall Islands served as a staging ground for the final components of the Pacific Theater. Major battles that would take place at Saipan, Guam, Peleliu, Iwo-Jima, and Okinawa were all possible due to the bases established at locations made accessible through *Operation Flintlock*. The progression of those battles led directly to the establishment of the base on Tinian Island, which served as the deployment point for the atomic bombs that resulted in the surrender of the Japanese Empire on September 2, 1945 (Toll 2015:142).

Chapter 3: The Battle of Roi-Namur Through the Levels of War

Introduction

This chapter focuses on providing basic knowledge of the concepts of battlefield archaeology and Levels of War analysis. Along with a general overview, a developmental history of each is provided. This offers a clear understanding of the topics and facilitates their application to the study. An in-depth description to explain the purpose of each level within the LOW methodology and case studies of LOW analysis are also considered. These studies do not only focus on the classifications of relevant aspects of a conflict, but on the efficacy of the LOW methodology and the benefits of using the approach. Finally, the Battle of Roi-Namur and the events leading to it are classified using LOW. This creates an inventory of all elements of this part of WWII and the level with which they correspond and set up ArcGIS Pro analysis. In doing this, the LOW methodology is utilized to identify and segment facets of the conflict into distinct categories to allow for clarification when analyzed.

Battlefield Archaeology

Battlefield archaeology is a subdiscipline of archaeology that focuses on human conflict and the sites where battles occurred. This field of study is closely related to conflict archaeology, which focuses on human conflict more holistically, rather than focusing solely on battlefields (Scott and McFeaters 2010:104-105). Human behavior, tactics, and history are all surmised through conflict in battlefield archaeology, with each having its independent foci and methodologies for achieving goals pertaining to conflict. Under the term of battlefield archaeology, much can be further understood through the remains of battlefield sites (Knutson 2018:18-22). Fired armaments, troop positions, and structural remains are but a few examples of what can be left behind on a battlefield site. Altogether, battlefields become part of the archaeological record and have great potential for further analysis and understanding of what occurred. Alongside a primary focus on the physical remains of a battle site, other forms of archaeological material such as historical records, documents, and other forms of data can be utilized to better understand a battle (Scott and McFeaters 2010:104).

Within the field of battlefield archaeology, battle sites are the prime topic of study. Sites where battles were once waged are studied in this field through the combination of the historical and archaeological record to answer questions about a particular conflict (Scott and McFeaters 2010:103-104; Spennemann 2012:119-120). This subdiscipline allows for many methodologies to be applied to determine aspects like armaments used, and positionings of vehicles, troops, or vessels. It oftentimes requires the collection of artifacts for conservation and further study. Altogether, findings are interpreted to further understand a given site and a particular history. The study of battle sites can also add insight to a historical record that might be missing critical data to gain a complete understanding of a site and of the larger conflict (Scott and McFeaters 2010:106-110).

With the study of battlefield and conflict archaeology, a fundamental grasp of the core components of what constitutes a battlefield must be understood. In preparation for every battle throughout history, some semblance of a proposed plan was made before the engagement. The scheme for any battle would likely have been established to direct the landing and initial placement of troops or vessels, areas that are better or worse for an approach, and the general directions individuals will take (USAF 1997:1). These examples highlight the importance of the battle plan before fighting begins and its components can be sourced in a variety of ways and are oftentimes best represented through data and maps.

Battlefields host a wide array of elements that make up the overall composition of a site, with each variable being subject to different circumstances. Many components of battlefields change over time, though there are several components that are not altered easily. In larger-scale modern battles, landing areas or the initial placement of elements of a battle are very important. The areas of attack at the beginning of any conflict are critical in the development of strategies and in the analysis of its aftermath. For instance, with amphibious assaults, sections of a beach are oftentimes given names to differentiate them. Differences in terrain, enemy positioning, and capabilities of either side play major roles in determining where a party would initiate primary assaults, since knowledge of where the initial attack will occur is required for planning of most conflicts (Spennemann 2012:119-120).

Following the planning of landing sites and the locations for vessel or troop deployment, planned directions of a battlefield is another important consideration to factor in when trying to study historic conflict. This consists primarily of the areas of approach that troops or vessels will use to following landing. The direction of attack has numerous underlying elements that are crucial when planning a battle. As mentioned before, the placement of assets on both sides, and the methods being enacted to best attack an enemy all come into play. The direction of these components needs to be understood to keep track of elements of a battle and for additional tactical consideration. From the beginning to the end of a conflict, these considerations all contribute to the development of better strategies that will in turn influence future battles. This is seen time and again in the archaeological record and is critical in showing the progression of battlefield methodologies (Scott and McFeaters 2010:105).

History of Battlefield Archaeology

Many subdisciplines of archaeology exist, and battlefield archaeology is one of them. Within the subdisciplines that focus on components of the natural world, particular global regions, and particular eras, battlefield archaeology intersects many other subdisciplines. Douglas Scott developed the concept of battlefield archaeology in the 1980s with his research at the Battle of Little Bighorn. Battlefield archaeology's foundation was laid through the development and progression of conflict archeology (Scott and McFeaters 2010:104). While conflict archaeology focuses on human interaction with one another in the context of a violent or conflict-oriented manner, battlefield archaeology focuses on battlefield sites and all the components that lead to the battle and the combatants, as well as all other constituents of it. To better understand the progression of time with regards to this subdiscipline of archaeology, the history of its origins must be examined.

The archaeological excavation of the Battle of Little Bighorn in 1989 is the study that initiated the foundational interest in the study of battlefields in an archaeological context (Scott et al. 1989). The Battle of Little Bighorn was fought June 25-26, 1876, between several Native American groups and the US Army in Montana. Metal detectors were utilized to systematically locate and classify artifacts found on the battlefield, and later analysis provided a better understanding of the true locations and progression of the battle. Alongside metal detection, other archaeological methodologies were used to garner a better understanding of the conflict and battlefield. This example was the beginning of a process of employing a systematic approach to the collection and recording of metal-detected objects in an archaeological context. Through the flagging and categorization of artifacts identified, a map was created showing the composition of artifact types on the battle site. This methodology resulted in a cohesive archaeological report of the battlefield of the Battle of Little Bighorn (Scott et al. 1989:148-149). This study was important and formative for conflict and battlefield archaeology as it was the beginning of a methodological approach to mapping and understanding battlefields through artifact analysis (Scott and McFeaters 2010:106-110).

The categorization of artifacts allowed for better identification of positions of individuals on the battlefield, since "this information provided a means for tracking the movement of firearms around the battlefield and, by association, the combatants" (Scott et al. 1989:148-149). With the categorization of different components of firearm artifacts, the individual who owned it could be surmised, which in turn, allowed for the general positioning of the individuals involved to be estimated. Also, through the identification and flagging of artifact locations, higher concentrations of artifacts were identified with the hopes of finding human remains, or the "hotspots" of points potentially indicating other findings (Scott and McFeaters 2010:108-109). Ultimately, the outcome of studying this battlefield resulted in a new understanding of the conflict. This example of the beginning of the subdiscipline of battlefield archaeology depicts the efficacy of researching battlefields and other forms of human conflict due to the various amounts of information available.

Levels of War Analysis

The LOW is a form of military identification and analysis where a conflict can be viewed and interpreted according to various classifications (U.S. Government Publishing Office 2017:I-7). This method is used to better understand and analyze war through multiple set "levels" to which every major conflict naturally abides (USAF 1997:1). LOW allows for a more focused analysis of large-scale conflicts by separating the entirety of war into three levels: the strategic, operational, and tactical. "The three levels allow causes and effects of all forms of war and conflict to be better understood—despite their growing complexity" (USAF 1997:1). LOW analysis has been utilized by many the militaries of many countries since its creation (Harvey 2021:76). Figure 3 provides a visual representation of the LOW framework and the structure it follows.

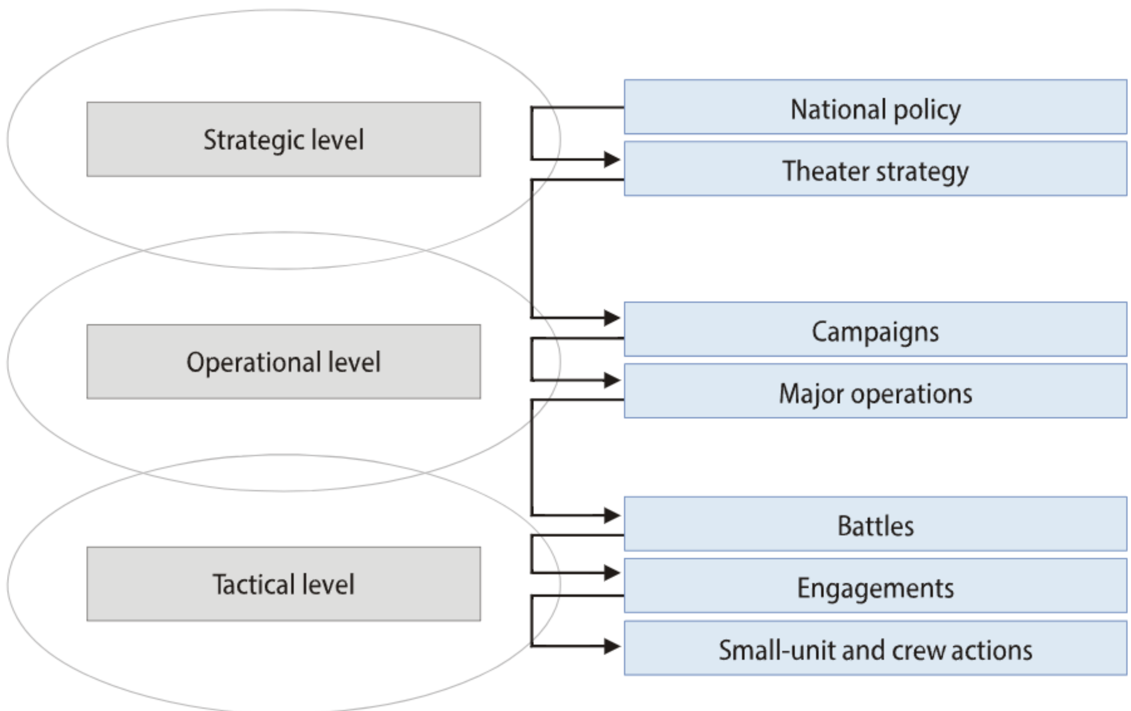

Figure 3 Image of the LOW (U.S. Government Publishing Office 2017:77).

Strategic

The strategic is the first of the three levels and focuses on the overall scope of the war. As explained by the United States Air Force College of Aerospace Doctrine, Research, and Education (CADRE), "The strategic level focuses on defining and supporting national policy and relates directly to the outcome of a war or other conflict as a whole" (USAF 1997:1). Governing bodies involved in a particular conflict actively participate in this scope as it encompasses overarching information and the reasonings behind them. This is the level at which the other two are directly dependent upon, with strategy, scale, and overall goals being its core (USAF 1997:1).

The overall political agenda of governments or other involved entities in a conflict are the direct participants at the strategic level. National goals, overall security objectives, and overall military directives are the fundamental portions that make up the strategic level (Pirnie and Gardiner 1996:xiv). Leading figures in the government of each participating entity directly influence and sway the overall goals and progression of the conflict based on the initial plans. Every following component of a conflict corresponding to the LOW framework is a constituent of these decisions and goals, with the following operational and tactical levels being a product of the commitments born at this level.

Operational

The operational level is where most campaigns and plans of a particular scope are carried out. It is defined as being "concerned with employing military forces in a theater of war or theater of operations to obtain an advantage over the enemy and thereby attain strategic goals through the design, organization, and conduct of campaigns and major operations" (USAF 1997:2). Though all levels of this approach involve their own format of strategy and methods, the operational level concerns different tangible sections of war, such as campaigns and other major operations. Campaigns that operate within a theater of war are classified at the operational level. While the strategic level focuses on the entirety of the war and the geopolitical environment, the operational level's strategy revolves around the tactics of each campaign that would best serve each side (Pirnie and Gardiner 1996:81-83).

The operational level is a direct link between the strategic and tactical levels, in that it directly follows the scope set out by the strategic level and relevant entities. The operational level is headed by governing individuals or groups that head widespread campaigns and operations in accordance with the strategic level's parameters. The commanders of the operational level dictate the fundamental directions for the war, while considering the logistics of warfare such as widespread campaigns, locations, and direction of the conflict, as well as determining how overall goals correspond to the operational level.

Tactical

The tactical level is the final level to understand in a LOW approach. Again, all levels share similarities in terms of overall strategy and tactics, but each focuses on its own independent aspects. Thus, the tactical level concentrates closely on individual battles and specific maneuvers, especially within the scope of the previous level. As further explained, "Tactics deal in the details of prosecuting engagements and are extremely sensitive to the changing environment of the battlefield" (USAF 1997:3). Whereas the strategic and operational levels focus on more widespread concepts of war such as overall planning, the tactical level focuses on actual conflict and the deployment of armaments and troop deployment, and the conflict that follows.

The tactical level is the point at which direct contact and confrontation with enemy forces intersect. The culmination of the previous levels leads to the direct battles that occur within the tactical level. These conflicts directly progress the plans set up at the operational level. Also, by furthering the progression of the war and therefore achieving the specific goals that were fundamentally created and surmised at the strategic level, a direct connection between all levels can be seen. By understanding the overlapping nature of the concept of a LOW approach, in-depth classification and understanding of a war can then be understood.

History of Levels of War Analysis

Comprehension of the origins of the LOW approach allows for a deeper and more nuanced understanding of the concept. The approach originated in the 19th century when a broader view was being taken to understand warfare. From that point, names for various components of warfare were added, resulting in what is utilized by militaries today. For this study, the modern, most common form of the LOW approach is utilized. It is important to note that without understanding where it came from, the importance of each individual level is lessened. Before its current form, the classification, capabilities, and overall utility of the approach granted to aid in the understanding of a war were limited.

The LOW approach began in the 19th century with Carl Von Clausewitz, following the publication of his 1832 book *On War*. Rather than viewing warfare as a simple series of battles, fighting, or even the people planning it, Clausewitz expanded upon the concept of an overall structure of war and the reasoning behind its existence (Clausewitz 1832:75-76). Throughout the work, components of war are explained and broken down into various classifications. This was revolutionary since it allowed for clearer discussion and identification of warfare as understood through concise classification. Alongside identifying the components of a war, the underlying motifs of its planning and execution are explored. Rather than viewing battles as being fought independently, Clausewitz explained that they are directly dependent upon the overarching wants, wishes, and ideologies of those who have set the battle in motion. The concept of levels in this context was introduced in the form of the strategic and tactical. All facets of command, planning, and fighting are described as having their own host of individuals responsible for their command (Clausewitz 1832:83). The strategic level is addressed and referred to as the overarching reasonings behind a war while also accounting for the individuals that create it, as well as addressing its overall goals. The tactical level is addressed as being host to the actual combat taking place in individual battles, on the battlefield. Although this realization aided in recognizing those responsible for various orders and executions of command, it later set the foundation for further elaboration upon those levels (Clausewitz 1832:75-89).

Following the initial construction of the strategic and tactical levels, Soviet Red Army member Aleksandr A. Svechin furthered the Clausewitz concept by establishing the operational level as the final component (Svechin 1927:159). In his book titled *Strategy* (1927), Svechin introduced the operational level of war as a connection between the previously established strategic and tactical levels. This new level revolves around the individuals, plans, and widespread operations conducted within the scope of the strategic level that leads to combat. It also serves the purpose of being what ultimately dictates the progression and components of the tactical level. Through this, the concept that all levels are interconnected surfaced, becoming a commonly held notion of the LOW approach.

The introduction of the operational level allowed for further contributions from other prominent military strategists from around the world, wherein these concepts of "levels" would become commonplace in the instruction of new military members in the form of a fully developed LOW approach. Starting in 1982, all members of the US military were first introduced to the concept of the "Levels of War" through "Field Manual 100-5, *Operations"* (Harvey 2021:76). Since the introduction of that concept to military members, the LOW approach has been taught to instill in all personnel the ways in which warfare can be classified, and how the identification of the components allows for further clarity in the comprehension of war. Through this, the LOW approach became a prevalent concept to all involved in some manner of warfare.

Case Studies

Any war can be viewed through the lens of the LOW due to its encompassing structure. The outcome of studies that utilize this approach allows for a better understanding of a particular element's position in the overall scope of war. Its utilization also allows for further analysis and the formulation of research questions that pertain to comparison, evaluation, and discussion. For the scope of this study, the classification aspect of LOW approach is the basis from which further analysis and understanding can be found. To better understand the methodology and the way warfare can be attributed to the LOW, examples of past use are considered.

The utility the LOW framework provides allows an archaeologist to clarify the interwoven components of a conflict. In "World War II Archaeology in Fiji: Assessing the Material Record", Allison Young uses the LOW as a tool to clarify the position Fiji had in the grand scheme of WWII (Young 2012:90-91). A chronological overview of Fiji's involvement in WWII allowed Young to explain the effects on physical locations, as shown by "The levels of war are excellent conceptual tools to better understand the objectives and subsequent actions of military forces." (Young 2012:80). Throughout the work, the author claims that the LOW allow a user to better understand the physical changes that occur because of variables existing within the framework. Utilizing the archaeological record in conjunction with the LOW grants a user understanding of how material ended up in its position because of the outcomes of events existing with the LOW.

In Peter Bleed's and Douglas Scott's "Contexts for Conflict: Conceptual Tools for Interpreting Archaeological Reflections of the North Platte Campaign of February 1865", the LOW is used to classify components of conflict and better explain the events of a historic battle through the archaeological record (Bleed et al. 2018:342-354). The authors sought to use the

LOW to explain the differences in combat between Cheyenne warriors and Civil War soldiers, as the archaeological record shows different outcomes even though the participants were the same (Bleed et al. 2018:349). The archaeological record is the focus, with the LOW being used to determine the cause for the physical material showing variation in positioning as a result of changing strategic, operational, and tactical goals. When discussing the strategic goals of a conflict changing, "…it shifted their strategic priority from plunder and valorous action to community security" (Bleed et al. 2018:351). In battlefield archaeology, the LOW can be applied to the archaeological record to determine the context and positioning based on all three levels. When the overarching goals and means to achieve them are known, physical outcomes can be better found and studied. The authors of this work further elaborates on the utilization of the LOW framework and the intricacies involved when using this methodology to better understand conflict in an archaeological setting in "Contexts for Conflict: Conceptual Tools for Intercepting Archaeological Reflections of Warfare" (Bleed et al. 2011:41-64).

In "Illustrating the Levels of War – *Operation Zitadelle* (Kursk), 5-14 July 1943, A Case Study", James Jacobs defines and classifies the various components of this conflict to each level through clear description and explanation (Jacobs 2005:79). *Operation Zitadelle* was a German plan in WWII that eventually led to the Battle of Kursk. As explained, Adolf Hitler's goal of taking over the Soviet Union and establishing Germany as a European superpower are examples of the strategic level. By segmenting the various levels, the author allows for a better understanding and stronger insight into the overall composition of the conflict (Jacobs 2005:92). Following this analysis, the importance of understanding each level of war prior to the presentation of an analysis of the topic avoids confusion, while also garnering the best understanding of the conflict. The study of *Operation Zitadelle* serves as an exercise in placing the components of a conflict into the various criteria defined by the levels of war. Though this example does not include analysis, the fact that the author classifies the elements of the operation into the various levels of war provides an avenue for future research. This study is an example of how other works can utilize a LOW approach to the components of a particular war.

Another relevant study that uses the LOW to identify and classify relevant components of a war is that of “Crete and the Three Levels of War: An Individual Study Project” (Miller 1989). This study relates the history of the Battle of Crete which took place from 20 May to 1 June 1941 between German and British troops. Following the introduction of context pertaining to the battle, the components of the battle are categorized according to the LOW with a focus on British forces. It was stated initially that the British did not have a strategic plan, which heavily contributed to their defeat. The strategic level in this regard pertains to Britain’s lack of holding clear national goals and overall aspirations for this event. Due to the lack of these critical components, the strategic level for this event was nonexistent, thus leading directly to uncertainty and poor considerations regarding the following levels. For the operational level, the author claimed that the British had little guidance and direction for where to direct their overall strength. Due to this confusion and uncertainty, the operational level for the British in this portion of the war resulted in poor and minimal directives that would dictate the progression and outcome of the tactical level. According to author Lieutenant Colonel John M. Miller, the tactical level of this conflict suffered due to the lingering trend of orders being given throughout the battle from commanders in their safe headquarters. This resulted in a lack of overall troop action and a failure to take advantage of opportunities set before them, with a quick British defeat due to lack of organization and command from those overseeing this level. Nevertheless, the battle was devastating for both sides, resulting in many casualties and the destruction of many vessels.

Overall, the conflict resulted in a German victory over Britain, which the author attributed to the lack of a British strategic plan. This resulted in the operational and tactical levels suffering greatly from disorganization and poor command. Through this study, Miller conveys that the classification of components of warfare through the LOW can be greatly elucidatory in determining why certain outcomes occurred, and what could have been done to change them (Miller 1989:27-34).

In “Revisiting the US military ‘Levels of War’ Model as a Conceptual Tool in Conflict Archaeology: A Case Study of WW2 Landscapes in Normandy, France”, the authors use the LOW to relate impact craters that were created during WWII battles in Normandy to the overarching goals of the strategic level of the conflict (Passmore et al. 2018:18-20). The advancement and utilization of LiDAR data in battlefield archaeology is a core aspect of this study, with the technology surfacing craters created during this conflict. This dataset illustrates how the tactical results stem directly from the overarching strategic goals of a conflict. The paper also highlights the importance of the landscape and the changes that were made to it due to the battle. In the case of this study, craters formed throughout the conflict are sourced from the overarching goals of the conflict and spark the potential for these sites to become heritage assets (Passmore et al. 2018:33). The evolution of technology available to archaeologists when studying battlefields constantly change what forms of data is available, and this paper demonstrates how this advancement requires adaptability in the theoretical frameworks needed to properly address the available archaeological dataset.

Classification of the Battle of Roi-Namur through Levels of War Approach

For the scope of this study, the Battle of Roi-Namur will be analyzed through various means. A core component of this research is organizing and identifying this battle by following the LOW approach. Through this, the Battle of Roi-Namur and all relevant events that led up to it are classified and categorized. Following this classification, further study and analysis can then be conducted as all elements are divided into core components. Rather than analyzing the Battle of Roi-Namur on its own, the utilization of LOW facilitates further study of GIS analysis by allowing for the creation of a multiscale framework, wherein every variable can be identified to its corresponding level. The methodologies that will be used to better understand the Battle of Roi-Namur will also be foundational in aiding similar studies to achieve related goals. A core goal of this study is to determine the efficacy of using this methodology for further analysis. To do this, all relevant aspects and elements That led to the battle, as well as the smaller battles within it, will first be identified and classified in accordance with the LOW.

Strategic

To utilize the LOW approach, each relevant component of the Battle of Roi-Namur was classified according to corresponding levels. The starting point for this process consisted of classifying the strategic level from pertinent features of this chapter from history. The strategic level within the scope of the Battle of Roi-Namur is multifaceted, as it is part of the overall scope of the Pacific Theater, but also within the overall context of World War II. For this study, the enveloping militaristic entities that governed the overall direction of the war pertain within the realm of the Pacific Theater. Rather than focusing on the entirety of WWII, the content explored is within the Pacific Theater. Though it could be argued that WWII was the environment to which the strategic level pertained for this study, the Pacific Theater is diverse and large enough with its own interests that, for the purposes of this study, the strategic level will remain apposite to.

Given that the establishment of the Pacific Theater of WWII is synonymous with the environment in which the strategic level resides, the classification of elements relevant to this level is clarified. The Pacific Theater had its own objectives, directives, and overall outcomes as dictated by those in the governing bodies. All facets of direction, planning, and widespread concerns and considerations for this theater are part of this level. Conducting operations and battles throughout the Pacific Theater with the overall aim of stopping Japanese expansion and further attacks on American forces is a clear example of one of the overarching goals attributed to the strategic level of the Pacific Theater. Viewing all constituents of the war allows the widespread classification of each level to be obtained.

In relation to the Battle of Roi-Namur, the strategic level includes a wide array of components. The components listed are all the core elements at the root of the Pacific Theater. This in turn means that all following levels are directly contrived from this one, with all constituents being represented and wholly influenced by the factors composing the strategic level. Within this level, overall operations and campaigns envelop the operational level, which in turn dictates the overall battles and similar events that make up the tactical level.

Operational

Following the assessment of what constitutes the strategic level regarding the Battle of Roi-Namur, the operational level was next considered. Multiple operations and campaigns spread throughout the Pacific Theater, with several pertaining to the Battle of Roi-Namur directly, indirectly, and alongside entities focused on completely different objectives. For this study, those relevant to the research questions are addressed and identified.

Though several operations and campaigns constitute parts of the operational level for this study, the most prominent are the island-hopping campaign and *Operation Flintlock*. Within these, there were of course other operations and campaigns that had their own goals and purposes, but these two are at the core of the operational level of the Battle of Roi-Namur. The island-hopping campaign covers the entirety of the premise of the operational level as its goals are widespread throughout the Pacific. Though it focused on leapfrogging from island to island to avoid strongly fortified Japanese defensive positions, it also focused on further advancement into Japanese territory. Directly related to the island-hopping campaign is that of *Operation Flintlock*. This operation inherently focused on securing the Marshall Islands, with the Battle of Kwajalein Atoll as a core component. This maneuver had multiple phases that all have their own goals and purposes and demonstrate the diversity of the overlapping features that comprise it. Overall, these campaigns were fundamental to the operational level of the Battle of Roi-Namur (CNSG 1994r;10-15).

Through the interconnected and overlapping operations and campaigns that make up the operational level for this study, this level demonstrates how a LOW approach operates. Demonstration of interconnectivity is displayed following the classification of components inside the operational level. All facets of the strategic level are enacted upon and focused within the operational level, where action to achieve these goals takes place throughout the tactical level. Thus, the operational level is as much a staging ground as is the strategic level, but it forwards the progression of warfare by initiating and composing campaigns and operations that the tactical level acts upon (Miller 1989:31-34).

Tactical

Like the operational level, the tactical level for this study has multiple physical locations that ultimately achieve the goals set by the previous levels. This is the level at which combat, and the result of prior planning take place, with much concern being applied to each side’s strength in arms, troops, and tactics employed. The tactical level for this study entails all battles fought that relate to and are a part of the larger Battle of Roi-Namur. All battles and physical events that take place that fall under the operational level are also considered to be part of the tactical level, but this study explicitly focuses on the classification of the tactical level with regards to the Battle of Roi-Namur and its overall umbrella classifications from the previous levels. Prominent battles and maneuvers taken by both Allied and Japanese forces within the Battle of Roi-Namur are part of the tactical level, with each event contributing to the goals set out before it by the previous two levels (USAF 1997:1-2).

Within the scope of the tactical level for this study, multiple battles and tactical maneuvers make up the composition of its elements. The most prominent and relevant components for this level consist of the major battles fought simultaneously within Kwajalein Atoll. The battles of Roi, Namur, and Kwajalein are the core battles that all have their own considerations, troop strength, and armaments. The battles within this overarching conflict have multiple phases and accommodations that were used to capture each island as efficiently as possible. The battles of Roi, Namur, and Kwajalein all had their own independent maneuvers that were all dedicated to minimizing casualties while decreasing the time it took to secure each island. Along with allied strength, the Japanese defensive positions and armaments also fall under consideration within this level, as they are directly within the realm of the overall mission. Nevertheless, the battles fought during this time and all their constituent parts, such as the plans, number of armaments, troops, and structures, constitute the entirety of the tactical level for the scope of this research (CNSG 1994r:6-10).

As described above, all levels within the framework of a LOW approach are all interrelated and connected. For the scope of this study, each level has their independent level of significance, though the levels observed in greater detail are the operational and tactical. The tactical level is host to the key components that directly furthered the progress and trajectory of the war, and the components within it are important to understanding the progression of the war through the LOW. Through the confusion of interconnectivity, the tactical level is host to the heart of what composes the Battle of Roi-Namur, thus being a representative of all the thought, planning, and considerations that went into the previous levels. While each level is connected in one fashion or another, the tactical level is the culmination of all the previous considerations (CNSG 1994r;6-10).

Archaeological Importance

Alongside the classification of elements that took place during the war, consideration of archaeological material left behind and visible in the modern day must also be classified according to the LOW approach. Though Kwajalein Atoll fundamentally healed from the flames of bombardment, the scars from this conflict remain. Archaeological material exists in this atoll in the form of dumped or sunken vessels and aircraft, and in the land bridge created after the US capture of Roi and Namur. This archaeological material does not exist outside the realm of the LOW, as it is a direct product of all three levels. Without the strategic and operational to lead the progression of the war that would then make the fighting that took place at this atoll necessary, this material would not exist. The tactical level contributes to the physical placement of several of the vehicles that crashed during battles. The land bridge that was created alongside the dumping of aircraft, tanks, and other vessels and vehicles in the lagoon after the battle is part of not only the archaeological record, but all three levels within a LOW framework. In the creation of the maps that follow this section, the archaeological materials that remain have levels attributed to their attributes, so they are visible regardless of what level is at focus.

Conclusion

Under the scope of a LOW framework, the identification of various features that led to the Battle of Roi-Namur provides a basis for further study and analysis. This could be beneficial for the understanding of these events as all relevant aspects are now in accordance and classified to the stipulations and structure of the LOW. Following this, each level can be viewed independently or in sync with one another to gain further understanding of the context for the Battle of Roi-Namur. A very important contribution that this phase of the study has provided is the inventory of all aspects of the Battle of Roi-Namur. This paves the way for analytical processes to be conducted upon these components based on the level within which they reside. Following the classification of all the constituents pertaining to this battle and the events that led to it, GIS will be the primary tool wherein further analysis is conducted. To conduct analysis with various processes on these elements labeled throughout this section, maps that contain relevant features within the strategic, operational, and tactical level were first created. The following chapters entail the processes used to create these maps, as well as the analysis that is the culmination of these steps.

Chapter 4: GIS in Battlefield Archaeology

Introduction

With the establishment of the historical background and the assignment of the LOW to each component of it, GIS and its application in battlefield archaeology can be further explored. This chapter focuses on overviewing the history of battlefield and conflict archaeology, and the usage of GIS to further the analytical outputs of these fields. It also details the structure the remainder of the thesis will follow. Through these components, all categorized components of this battle are visually represented using GIS and a multiscale approach.

The methodological approach for this study is represented visually in Figure 4. All strategic, operational, and tactical elements are taken from the historical and archaeological record, plotted in GIS, and then overlayed onto one another. Through a multiscale approach, the various LOW are plotted according to the necessary size demanded of each level. Following input of all relevant data into GIS, various methods of analysis are possible. The smallest scale, the strategic level, provides a wide swath of information with a focus on the Pacific Theater of WWII. The operational level is referred to as a medium scale wherein it showcases the operational level of war, which in this case is *Operation Flintlock*. Finally, the tactical level is the largest scale and focuses entirely on the Battle of Roi-Namur. Important elements of each level have all data represented on these scales, such as positions, landing sites, and destroyed vehicle remains.

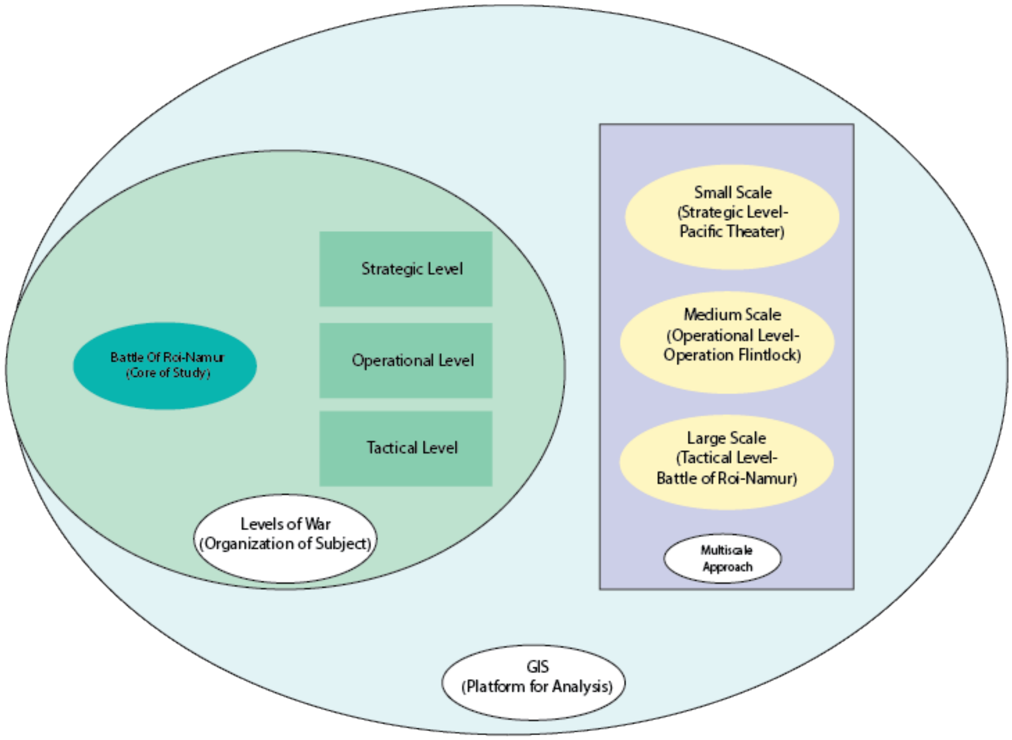

Figure 4 Diagram of the methodology for the study (Image created by Author 2023).

Primary historical sources provided the bulk of the information pertaining to locations of variables in a spatial landscape. All locations represent sources taken from archives, such as the number and positions of battleships, carriers, tanks, and defensive positions. A body of secondary sources related to the Pacific Theater was also useful in preliminary research, especially cohesive volumes such as *The Second World War: A Complete History* (Gilbert 2014), *History of the Second World War* (Hart 1970), and *The Conquering Tide: War in the Pacific Islands, 1942-1944* (Toll 2015). Special Collections at ECU's Joyner library contain a wealth of resources pertaining to WWII, particularly taped recordings of interviews with military personnel who served in the island-hopping campaign, such as an interview of Glenn B. Davis (ECU Digital Collections 1977).

Alongside primary and secondary resources that span all applicable parts of WWII history and the island-hopping campaign, additional formats of historical data were studied.

Naval charts depicting areas of travel of major vessels such as the USS *Essex* are also used (USS *Essex* 1944:16-17). This information was pertinent in visualizing and understanding the various engagements. These resources proved especially useful in the analysis of the various levels of this conflict. Primary sources oftentimes have maps of a landscape at a point in time, which can aid in plotting the relevant variables in accordance with the historic landscape. Alongside illustrating the historic landscapes, historical maps also are host to physical locations of positionings of various variables. They also often show areas of interest with regards to battle tactics, such as landing sites, areas that are suitable for bombardments, and areas the locations of enemy defensive positions. Archaeological data was also used to aid in visualizing the events that occurred, with a focus on the Battle of Roi-Namur. Recorded positional data for sunken and abandoned fighter planes and amphibious vessels serve as a primary resource for analyzing portions of the battlefield. These points were collected by Daniel Gunter as part of an imaging survey of Kwajalein Atoll. Specific information regarding these located points is proprietary, and details regarding their location and typologies are unable to be included in this study (Daniel Gunter 2022, pers. comm). The extant remnants of historically relevant structures on land are also considered throughout this study. The collected data of aircraft lost or dumped after the battle are representative of various stages of the conflict. All available data was collected and analyzed with the goal of obtaining a holistic and comprehensive understanding of the battles.

GIS Fundamentals

GIS is a mapping and geo-visualization system that allows a user to create, edit, and portray geospatial data. With the development and progression of this technology, archaeologists can view and interpret data pertaining to anything that is relevant to a research question. Not only serving as a visual aid, GIS also allows users to manipulate data with the intention of sourcing further information from it through different analytical means. Since humanity has endured warfare for countless centuries, the resulting battlefield sites include evidence and data that can be studied and interpreted (Sanchagrin 2013:44-65). By utilizing such data, a holistic understanding of past events can be uncovered and further developed. Analyzation is a strength of GIS that is completely unmatched by other forms of technology in this regard, as the wielder of a standard license of a GIS program has access to a huge swath of tools, functions, and features. Alongside analytical features, data creation and manipulation can also be utilized for not only visualization means but also to contribute to analyses (Ali 2020:3).

ArcGIS Pro and ArcMap are currently the leaders when it comes to modern mapping applications. Though ArcMap and ArcCatalog were a staple for the past decade or so in the world of geo-visualization for nearly every industry, the push for ArcGIS Pro has been prominent in the past few years with the developing company (Esri) pushing for a full switch to the new system (Esri 2022). Whichever program is used, the overall results will be generally the same. Key differences include the accessibility of an online-based interface, more accessibility in terms of assistance from the developer, as well as the combination of features only previously available in separate programs, such as ArcScene. To create data to represent more abstract concepts, shapefiles are the primary format in which data is portrayed. Shapefiles are a type of file that holds and represents data that can be manipulated to whatever form or function a user wishes (Ali 2020:5).

A key feature in the scope of utilizing these programs is the catalog feature, one in which a user can manage, edit, and create shapefiles that hold imperative data needed for more in-depth research and analysis. Through this creation feature, coordinate systems can be implemented, the type of shapefile can be determined, and in-depth specifications can be made. This feature alone enables the creation of maps perfectly suited to the field of archaeology, let alone for battlefield and site analysis. Created shapefiles in this case are incredibly useful as they can be used to showcase and visualize data that is not otherwise collected physically, such as battle routes, landing areas, or fields of interest. Essentially, they can be created in any format that would assist in the visualization and analysis of different campaigns, tactics, and battles. Both public and private data can be used for this, allowing a researcher to implement data as well as using publicly sourced shapefiles (Ali 2020:3-8).

Created representations of information not based on remaining features or remnants of a battle site are useful in battlefield analysis as they represent occurrences that can be further articulated (Scott and McFeaters 2010:108). In the context of battlefield archaeology such data can be sourced from battle reports, historiographical documents, books, or even other maps. From this, visual representations can be used to show a large amount of data, from the general layout of an area to in-depth and complicated battle recreations. In the following section, different methods are considered in detail to describe the most common ways GIS is utilized in the interpretation of battlefields and tactics employed through the analysis of different studies and examples.

GIS In Battlefield Archaeology

Prior to discussion or analysis of any archaeological battlefields, one of the most important and powerful aspects of GIS in this regard is the general ability for portrayal. GIS is a platform for displaying locations, data, and movement through time, as well as further analyzing desired features. The following methodologies and features are directly sourced from the abilities that GIS provides the user to showcase data and can be used to carry on with any technique needed to meet a goal. Without a platform for this data to be easily viewed and understood through built-in features, the following analytical methods for data analysis would not be as accurately or concisely portrayed. Maps that can be created allow for a viewer to directly understand what was done and what the data is portraying, as well as all elements present that are on display in the final layout view of the map. As Rajani (2009:21) notes, “Visualization plays an important role in archaeological research and in presenting the results, as they convey much more information than a descriptive approach and/or numerical representation”.

Conflict archaeology is a field within archaeology wherein human conflict is studied through the archaeological record (Scott and McFeaters 2010:104). Under this subdiscipline is battlefield archaeology, which uses battle sites as the prime topic of study. Sites that were once grounds upon which battles were waged are studied through the combined historical and archaeological data to answer questions about a particular conflict. Within the course of undertaking the analysis of a battlefield study, an archaeologist may seek to answer relative questions such as armaments used or the positioning of different elements of a battle such as vehicles, troops, or vessels. This also allows for data to be collected, analyzed, and interpreted with the goal of furthering knowledge of a given site and a particular history (Tunwell et al. 2015:167). The study of battle sites provides insight into the historical record that might be missing data critical to a holistic understanding of a site. With the various elements necessary to fully comprehend a historical battlefield, GIS systems allow for further analysis and study that aids research in a particular study.

General layouts of battle sites are first and foremost in the understanding of GIS capabilities. Most of the case studies showcased below have an overview map that includes all the pertinent data upfront, if not a description of what is discussed. Oftentimes in the field of archaeology, archaeological data greatly contributes to the understanding of a battle site (Geier

2010:38). This collected data can then be included with other known information, such as historical data consisting of reports and records. As stated by Scott and McFeaters, "Military sites also have unique aspects related to their function, in preventing or making war" (Scott and McFeaters 2010:104). This quote is important to note when viewing archaeological material pertaining to a battle site. This material offers the archaeologist insight into events and logistics of the battlefield (Pedro et al. 2016:1-16).

In conflict archaeology, various theoretical frameworks can be utilized to aid in answering relevant questions. As mentioned in the previous chapter, the LOW framework is a relatively new methodology for better understanding conflict. Another theoretical framework used for battlefield analysis is the KOCOA (Key Terrain Observation and Fields of Fire, Cover and Concealment, Obstacles, Avenues of Approach) framework. KOCOA analysis is a framework developed by militaries to better understand combatants' positions and movements in a landscape, as well as their relationship to relevant terrain (Sivilich and Sivilich 2015:51). Drik H. R. Spennemann overviews the core principals of KOCOA analysis in "Using KOCOA Military Terrain Analysis for the Assessment of Twentieth Century Battlefield Landscapes" (Spennemann 2020:754). Alongside the discussion of how KOCOA analysis can be used in battlefield archaeology, the cons of using it are also explored. While it is excellent in understanding militaristic operations in relation to the terrain of a battle site, it does not excel with explaining or defining concepts pertaining to overarching goals and components of a battle. As mentioned, when discussing alternative methodologies for interpreting the archaeological record and battle sites, methodologies such as the LOW can be considered (Spennemann 2020:755).

The following sections serve as an aid in discussing the general overview of how battlefield components can be implemented into GIS. Most of the descriptions of GIS application in battlefield archaeology are shown through examples. Given the wide variety of active components present in a battle, an archaeologist needs to consider the best possible way to represent them in GIS.

Planning

In preparation for battles throughout history, a proposal or plan of action was commonly put in place before setting out on any form of major battle or assault. Thus, the scheme of any battlefield was likely planned in some way to direct the landing and initial placement of troops or vessels, areas that are better or worse for an approach, and even general direction or locations for movements (USAF 1997:1-2). Especially in larger scale modern battles where components other than ground troops exist, landing areas or initial placement of elements of a battle are very important (Scott et al. 1989:6). The initial placement and areas of attack at the beginning of any conflict are critical not only in the planning of tactics but also in the analysis of what occurred. For amphibious assaults, sections of a beach are often time given labels for prioritization of resources. Differences in terrain, enemy positioning, and capabilities of either side all play major roles in determining areas of primary assault, and such spatial data is needed for initial attack planning in most conflicts (Spennemann 2012:120).

Following the importance of planning landing sites and positioning battlefield resources, direction is another key factor to consider in the analysis of battlefields. This consists primarily of approach areas and the direction of troops and vessels. The direction of attacks has numerous underlying elements that are crucial when planning a battle. As mentioned, the placement of enemy positions, one’s own positioning, and the methods being enacted all come into play. The direction of these components also needs to be understood to keep track of movements of the elements of a battle, as well as more tactical considerations. By understanding operational directions, the following scheme for a conflict can not only be mapped and assessed prior to a battle but also in its aftermath (CNSG 1994o:49). Even at a battle's end, such data is important for developing better strategies for future battles. This is seen time and again in the archaeological record and is critical in showing more technical methods (Geier et al. 2010:1-5).

These considerations can all be mapped and portrayed alongside any other forms of pertinent data. Be it any one of these planning components or a combination of them, the planning of conflicts in a historical setting can be clearly plotted out and displayed when analyzing battlefields. Oftentimes, the examples discussed take the form of created shapefiles backed with either historical or archaeological data. In the case of portraying information that is intangible, such as the scope of landing sites, past placements of troops, or the direction of a skirmish or series of assaults, can be portrayed using different functions of the software. Directional data can be viewed as vector datasets, such as arrows pointing the way of an assault (Janata 2016:55-56). Either way, the introductory phases of a battle are important to understanding the core themes and elements that directly play a role in the overall outcome of a conflict.

Armament

Alongside the importance of understanding a battlefield's components, the armaments of every party involved are another necessary layer for understanding and interpretating a battlefield (Geier et al.2010:71). This is perhaps the most technical section of battlefield analysis as this term loosely covers all components of weaponry and the physical materials used throughout the conflict. Not only does this section cover each side's arsenal, but all relevant information involving armaments is viewed. Blending the past and present, archaeological remains and historical documents of armaments help demonstrate data pertaining to ranges, fields of fire, and the number of rounds fired. All this information can then be isolated and used to create density maps, ranges, and much more (Geier et al. 2010:56).

Knowledge of the armaments used for a particular battle is crucial in understanding how a conflict played out, as well as for showing the advantages and disadvantages of different tactics. The types of weaponry employed are directly linked to what is needed to accomplish specific goals. Range, field of fire, transportation of heavier equipment or vessels, and concentration of fire can all be shown and represented. Post-battle, physical remnants of armaments, and destroyed vessels are part of a geospatial format that can be integrated into GIS. Through this, these sets of data can directly portray relevant information. As stated previously, this data can be displayed in GIS as shapefiles as either polygons, polylines, or points. Depending on what is to be shown, the most suitable data type can be plotted and manipulated using GIS, which can then be further extrapolated (Pedro et al. 2016:8-10).

Range and fields of fire go hand in hand when analyzing a battlefield. They are features of a map that shows positioning and aid in understanding an overall plan for a site in question. Metal detection of spent ammunition and rounds fired typically denotes a concentrated field of fire, as well as range for the general location of firing. In GIS, data can be clearly shown when overlain onto a battlefield map (Geier et al. 2010:136-227). Often a target was not hit with 100% accuracy, which leaves many areas behind it as home to rounds that missed their mark. All of this is to say that data collected in an archaeological context and combined with the historical record can come together to produce maps that showcase actual events and be representative of battle plans.

Outcomes

Following initial plans and overview of the firepower used, the outcome of battles is another important piece of the metaphorical puzzle for understanding a battlefield holistically. Most battlefield interpretations are not complete without an overall analysis of what occurred. GIS allows for a demonstration of multiple layers which is useful for showing the pre- and post-battle conditions. In terms of levels of a battlefield, the initial layout of troops, positions, and planned methods is needed to set the stage for a battle (USAF 1997:1-3). Following this, a description of weaponry and tactics is needed to gain a better picture of understanding how force interact, as well as the frequent changes to location for multi-faceted battles.

Coupled with the loose term of outcomes are the variables that led to a decisive end for a battle. Through armament tracking, directional approaches to a layout of a landscape, and positions are needed in the planning and interpretation of a battle, so too is understanding its general occurrences. Examples pertaining to this are events of importance in a conflict, such as major assaults, tactical explosions, and decisive operations within an overall battle. Battles are not simply single moments in time. They vary in time and intensity, and within the timeframe of a conflict, a multitude of individual events come together. Without knowing specifics, only broad statements can be made regarding the outcome.

The aftermath of a battle denotes outcomes, such as destroyed or captured points of interest, sunken vessels, and overall validation of an objective. Using GIS allows all of this to be shown either on its own or alongside other relevant layers. The outcomes of a battle visualized through GIS can be the final piece of understanding a conflict, alongside the previously mentioned methods. From the outlook of viewing outcomes of a battlefield, relevant research questions can address their independent questions especially well, as the overall occurrences are in view. Often, archaeological and historical evidence is derived from the final resting locations of physical remains. Either way, creating and inputting data from all facets of a conflict can allow for further data analysis. By understanding the outcome of a battle, with the relevant data being input into a GIS project, the options available to individuals for data analysis are immense (Pedro et al. 2016:16).

Typically, maps will have a scale bar, north arrow, legend, and necessary texts and labels. Of course, these styles and methods all change depending on the author, but the variances are not nearly as important so long as the necessary components are included in a final map. All information presented in a GIS project is geographically referenced, meaning all points correspond to a physical location on the globe. Whether a geographic coordinate system (GCS) or projected coordinate system (PCS) is used, the data represented will have a specific coordinate point denoting its location. Along with shapefiles having their own corresponding physical locations, data stored can also be stored within them (Ali 2020:1-6). In ArcGIS Pro, for example, the attribute table allows a user to view and understand what information a shapefile holds. This data can then be edited, moved, or manipulated to suit a user's needs. Following the understanding of the basic principles of each component of a GIS system, specific toolboxes and tools can create a desired result. Often these tools are used in succession with one another for a very specific outcome.

The Battle of Little Bighorn

In the case study conducted by Douglas Scott and Andrew McFeaters, a GIS system is utilized to showcase points pertaining to artifacts found on the site of the Battle of Little Bighorn (Scott and McFeaters 2010:106). This example initiated the process of using a systematic approach to the collection and recording of metal-detected objects, as shown in Figure 5 (Scott, McFeaters 2010:107). Through the flagging and categorization of artifacts found via metal detection, a map was created to illustrate different artifact types and their locations at the battle site. This formative study was important for conflict and battlefield archaeology as it represents an early methodological approach to mapping and understanding battlefields through artifacts distribution.

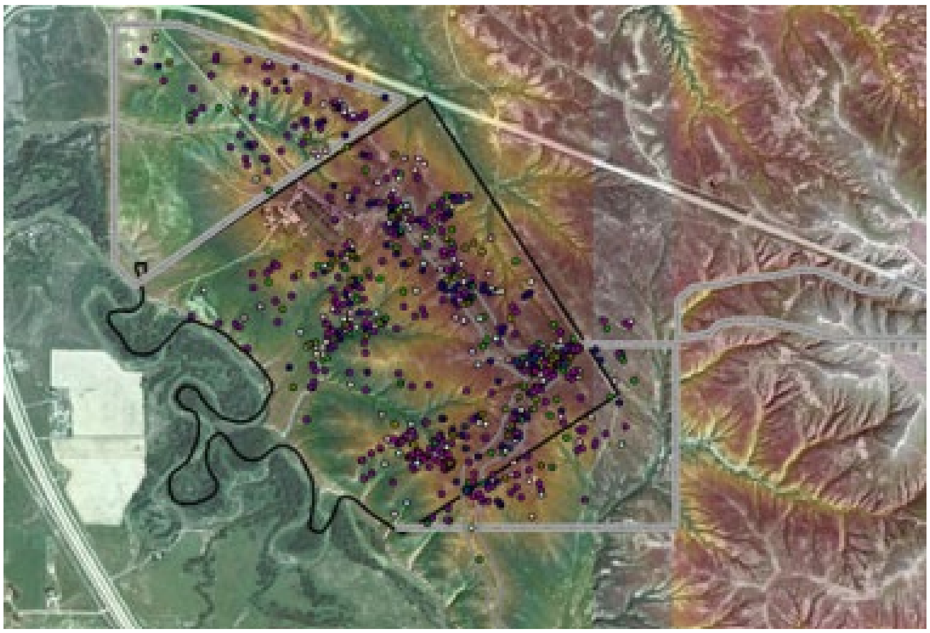

Figure 5 Map of the Battle of Little Bighorn showing points of interest (Scott and McFeaters 2010:108).

The categorization of artifacts allowed for better identification of firearm use at the site, as shown by Scott and others, "This information provided a means for tracking the movement of firearms around the battlefield and, by association, the combatants" (Scott et al. 1989). By categorizing different components of firearm artifacts, the individual who owned it could be surmised, which in turn allows for the general positioning of the individuals involved to be estimated. Also, through the identification and flagging of artifacts locations, higher concentrations of artifacts were analyzed in the hope of identifying human remains, with the "hotspots" of points potentially indicating other findings (Scott and McFeaters 2011). In GIS, the different categories of artifacts are easily denoted by different colors or shapes, with the legend of the map providing insight into what each point means. And since points can contain other information, further analysis may be conducted if relevant. As the varied amount of artifact types and frequencies were incorporated in GIS, the potential for future studies of quantifiable data exists. The locational value of the artifacts identified through this study and visualized through GIS show the merit of portraying data from battlefields geospatially.

The Battle of Monmouth

The Battle of Monmouth had the greatest number of artillery rounds fired throughout the entirety of the Revolutionary War. Eric and Daniel Sivilich (2015) sought to determine an accurate model for representing cannon positions based on artifacts found. GIS was utilized to represent the spread of rounds fired and to estimate original positioning of the cannons. The KOCOA framework was used to better understand the terrain's involvement as well. Combined with this research methodology, this is an excellent example of how powerful GIS is for geospatial analysis of a battlefield.

The initial sections of the article consist of an overview of the Battle of Monmouth and important elements about the battle, artifact assemblage, and the number of artifacts taken over the years. Through metal detection at the site, a database of fired projectiles was created using their in-situ positions. Grapeshot and caseloads were extensively utilized during this battle. Since projectiles that were spread through artillery were the only form of data considered, musket balls were not included. This is not to say that these artifacts were not discussed; they were simply excluded from the spatial analysis as shown in Figure 6 (Sivilich and Sivilich 2015:65).

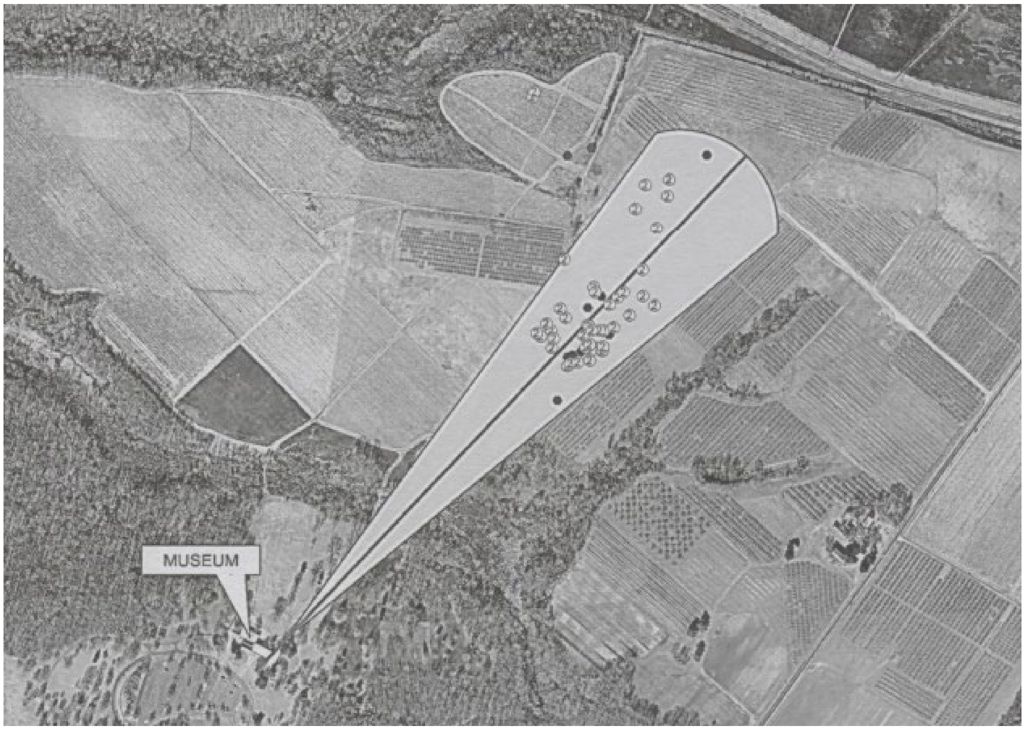

Figure 6 Map showing a cone of fire through GIS (Sivilich and Sivilich 2015:63).

Combs Hill was the presumed site for the artillery positioning, with historic maps showing the general area where artifacts such as grapeshot and cannonballs were identified. The specific positioning, the spread of artillery locations, and the development of the battlefield in such a movement that was not explicitly known, though further analysis was conducted with the goal of determining where these armaments were positioned, and their formation. As noted by Sivilich and Sivilich (2015:50), “Terrain analysis (key terrain and avenues of approach) is a key factor in directing fire onto an enemy position, especially by artillery”. The utilization of a KOCOA analysis for this study aids in the analysis of the line of fire of the artillery. Through this, the army’s field of view is better understood (Sivilich and Sivilich 2015:64).

Analysis of artifacts, historical maps, satellite imagery of the landscape, and an elevation map of the battlefield was conducted through GIS. The conical field of fire was determined after studying the positionings of the grape and canister shot, allowing for an estimation of where exactly the cannons were positioned. In GIS, the field of fire was represented through a polygon shapefile, with a polyline in the center of it denoting a proposed centerline of fire (Sivilich 2015:64). Artifacts found that were outside the average field of fire were considered outliers and excluded, as they did not contribute to the goal of the study. GIS proved to be a powerful tool in this study as it allowed for the physical data collected through a total station to be plotted on a map, which made way for further analysis.

Battle of the Atlantic

A MA thesis written by Jonathan Bright (2011) included a battlefield analysis for the Allied Convoy KS-520, which demonstrates well the application of GIS in battlefield analysis of naval scope. Among the many analytical elements of the study, one stands out for showcasing the efficacy of GIS in battlefield studies. To determine the relative locations of the remains of the KS-520 convoy battle, Bright initially determined the convoy routes of the Allied forces. Through the utilization of historical sources, relative points for those vessels were identified and represented in GIS (Figure 7).

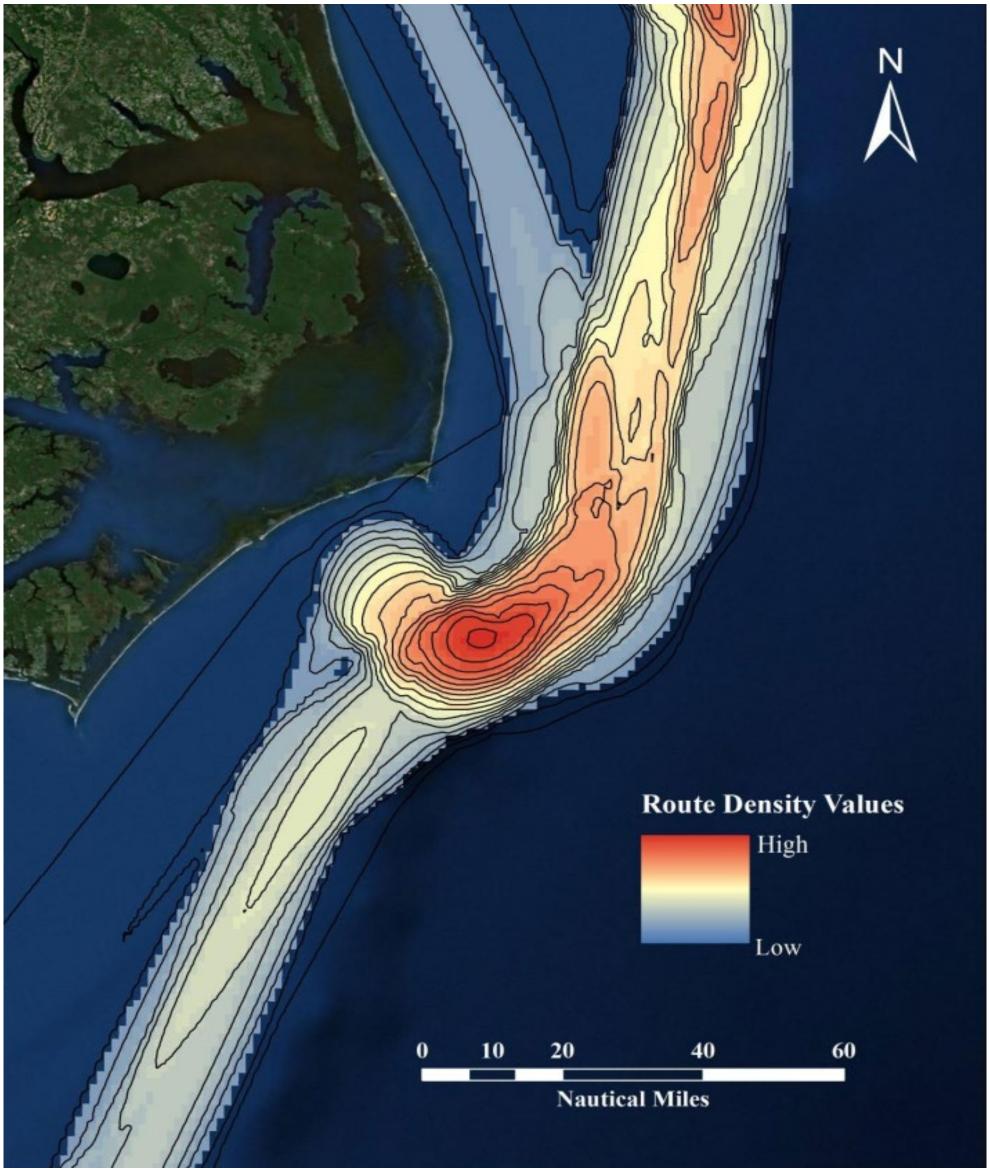

Figure 7 Map showing a route density analysis through GIS from the Battle of the Atlantic (Bright 2011:61).

A tool found within ESRI's suite of products is a "point-to-line" tool in which interpolated lines are created that connect points together (Bright 2011:58). Following this, the Hawths Tools extension was used to create and represent the density of these lines in a raster format (Bright 2011:56-58). This allowed for the representation of the point densities of the routes taken. After conversion to a vector density surface in which the densest areas (in terms of interpolated data) were represented by polylines, with denser areas having closer lines like bathymetry in which more exaggerated elevation changes are obvious (Bright 2011:58). Though much more analysis followed those steps wherein the location of the remains of this battle were found due to the processes utilized, this example deftly demonstrates how the historical record and GIS can be used for a battlefield analysis to gain further information. The methodologies used take essential concepts such as point, line, and raster data and develops them into a visual aid to allow for further analysis and interpretation of a site that was previously nonexistent outside of historical records denoting individual points. Overall, this study is an excellent example of utilizing GIS in a unique way for geospatial analysis of battlefield sites.

Multiscale Approach

A methodology to aid in visualizing the LOW analysis for this the multiscale approach. Multiscale approaches created with GIS consist of a series of maps that adhere to a scale dependent on what is depicted. This approach is useful in separating a subject into various components, especially when overarching elements exist at various scales. It not only allows for a simplification of a topic, but also for further analysis of a subject. Overlapping the various scales allows for viewing relationships between them, while also assessing parallels that may exist (Figure 8).

Multiscale approaches hold vast potential in simplifying complex topics, which has led to their usage in many disciplines. As shown in *Applying the Large Marine Ecosystem (LME) Governance Framework in the Wider Caribbean Region* (Fanning et al. 2013:100-101), a multiscale approach can be utilized to display the various policies associated with large marine ecosystems (LMEs) alongside their relationships. Various fisheries make up the LMEs, each of which has its own policies assigned by the government of the area. To better understand the complex relationships between them, the authors employed a multiscale approach to defining their characteristics and policies. Though Figure 8 demonstrates a multiscale approach for their goal of simplifying the complex nature of LME governance, it also portrays the fundamental nature and versatility of a multiscale approach – that various scales can adhere to whatever organizational method is required (Fanning et al. 2013:101).

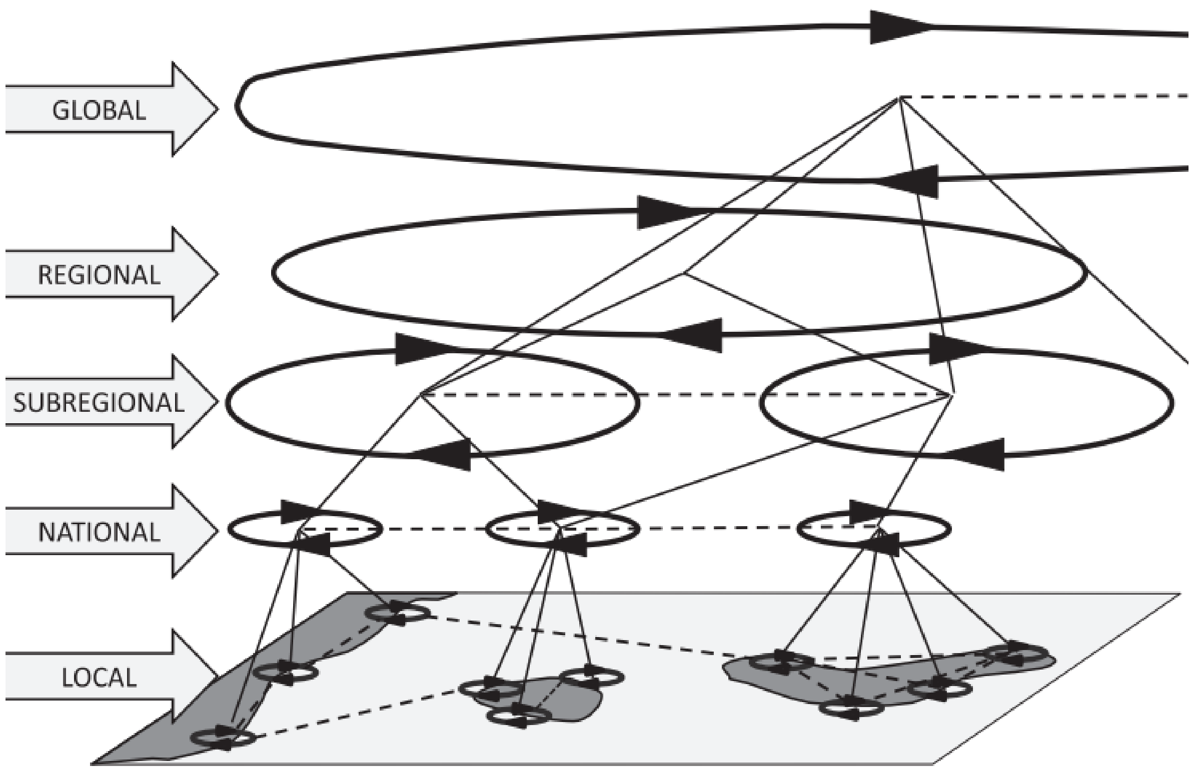

Figure 8 Diagram of a multiscale approach (Fanning et al 2013:101).

Multiscale approaches in GIS have also been utilized for archaeological studies. Not only applied for portraying multiple scales of different sizes, but a multiscale approach can also portray various elements and layers of a location. An example of this application is *Multi-scalar GIS at Merv, Turkmenistan: Bringing it all Together* (Barton et al. 2008), which combined two different archaeological studies concentrated on the archaeological site of Merv in Turkmenistan. Focusing on a survey of features of the earthen structures that exist at the site and an archaeological study focused on mapping the city of Sultan Kala, this study implemented and analyzed data collected by the previous two studies (Barton et al. 2008:2). This approach allowed for the entirety of the focus area to be viewed in GIS with each dataset overlapping with one another to achieve "archival unity". Archival unity is defined as "…enabling distinct datasets to be inter-usable through a series of compatible recording formats within a GIS framework" (Barton et al. 2008:3). Ensuring all facets of data are united in the same space can lead to "a more iterative interpretation process" (Barton et al. 2008:3). Overall, the study showcases how various archaeological datasets can be integrated to provide a platform for further interpretation. The current thesis project employed a similar strategy of assimilating historical and archaeological data to allow it to be observed at various scales, while also offering the opportunity to understand all facets of the conflict in a new light.

Conclusion

This chapter discussed the usefulness of GIS for battlefield archaeology. It provided an overview of foundational principles of GIS and how it can be used to visualize battlefield components, before exploring some important examples of its past utilization for battlefield archaeology. The concept of a multiscale approach was also discussed, highlighting how its utility in GIS. This was necessary as many of the processes and models created for this thesis pertain to multiple scales relevant to the core components of the analytical process created. Following the establishment of these components, the processes used to create the maps and models pertinent to this research are explained in the following chapter.

Chapter 5: Methodological Approach

Introduction

To better understand the various processes that were applied to the elements of the Battle of Roi-Namur, an inventory of every component must first be described. This chapter shows all elements of the battle visually represented using GIS with a description of what is being displayed, additional data that is embedded within it, and any other relevant info about the data in each element. This sets the stage for the analytical processes applied to each element. Without knowing everything about the dataset, conducting analyses to any degree becomes much more difficult.

Following the showcase of all participating elements within ArcGIS Pro, thematic maps were created and displayed here to offer a better understanding of how all components come together to make up the overall battle. An overview of how each variable was created and added into ArcGIS Pro is explained before discussing the steps used in the data analysis process. Though the overall output of the analytical results is not shown in this chapter, the processes used to create these results are given.

Methodology

To input a portion of the variables needed for further analysis, primary source maps and drawings were used. For several of the variables, these historic maps were georeferenced in ArcGIS Pro. This process consists of overlaying an image into GIS and choosing control points that are chosen in relation to spatial locations of a modern base map. Reference points that are most likely still in existence from the image are then matched to the actual modern location. Through autocorrection processes embedded within GIS, the historic map image can automatically format itself to correspond with the actual spatial location. This is incredibly useful when historic maps are obtained that hold data to be implemented into GIS. An important concept to keep in mind is that landscapes change over time, and in the case of this thesis, Roi-Namur is subject to constant erosion and deposition. This in turn results in the layout of the landscape not always being exactly matched to historic maps. In several of the maps that will be georeferenced for this study, these changes are apparent. Figure 9 displays the toolbar of all options available when beginning the process of georeferencing an item. In some instances, historic components such as Japanese defensive positions placed on the outskirts of the island are now overlayed on areas that have eroded and now display parts of the ocean. Nevertheless, this process is useful for the implementation of several of the variables needed for further analysis.

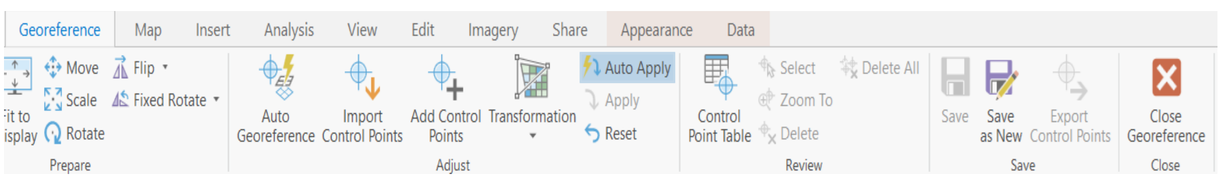

Figure 9 Image of the georeferencing toolbar in ArcGIS Pro (Image created by Author).

To begin georeferencing a historic map saved as an image, the first step is to import it into GIS. For ArcGIS Pro, a user would drag the image into the map overlay. Following import, the image is selected in the table of contents and then followed by choosing the “Imagery” tab. The “Georeference” icon should then be selected. The process of choosing control points first from the imported image that align with geospatial points on the base map is the overall goal of georeferencing, and the more varied controls points used result in a more accurate placement of the map. Rather than simply dragging a historic map image onto a base map, georeferencing ensures accurate positioning of the map, which is important when these images are host to valuable datasets. By clicking “Add Control Points” and choosing recognizable locations on the image and then clicking where they correspond on the base map, the most accurate representation of the historic map is overlayed on the base map. There is an option to determine the level of accuracy of the georeferenced image that provides the user with an estimated rate of error from the deposit of the historic map image to GIS. Following this, Figure 10 demonstrates an example of one of the georeferenced historic maps of Roi-Namur that was implemented into ArcGIS Pro.

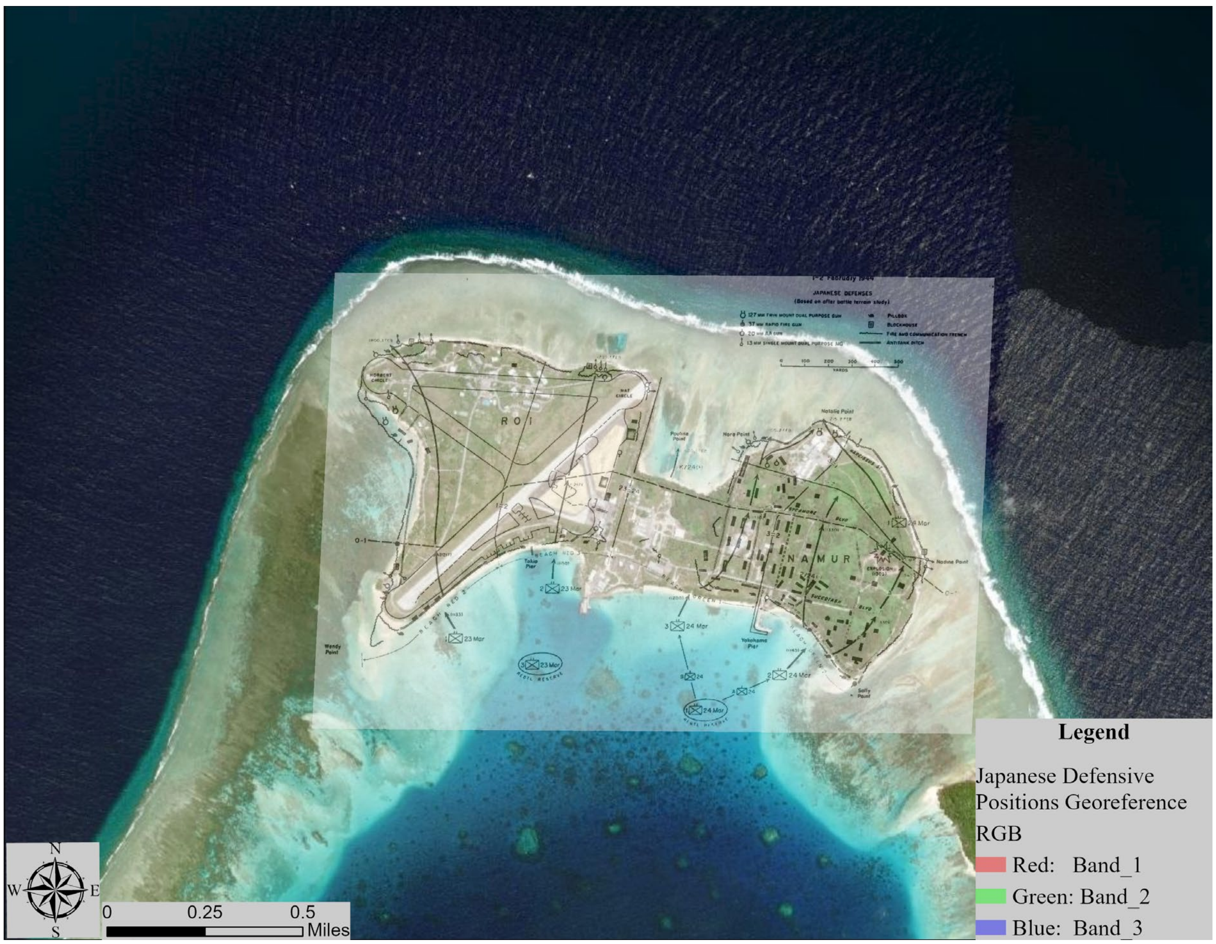

Figure 10 Georeferenced image showing Japanese defensive positions and the US plan of attack for Roi-Namur (Image created by Author).

The georeferenced historic map overlaid onto the base map depicts a reconnaissance map of Roi-Namur showcasing the spotted positions of all Japanese defensive positions that existed before the battle (Figure 10). In this instance, the overall result of georeferencing was quite accurate, and so the points were then plotted. By selecting the “Edit” tab on the toolbar, points, lines, and polygons can then be added and altered based on the user's needs. A georeferenced map from the Chief of Naval Operations Naval Security Group (CNSG) depicts all the buildings and typologies of the calibers of the defensive guns positioned on Roi and Namur (CNSG 1944e:58). All corresponding data that is found on these images were then implemented into the attribute tables of the points. All the variables that will be showcased in this section will be specified in the manner of their sourcing, be it through georeferencing of historic images or written records.

All other forms of data input into GIS were taken from primary sources that entail military reports that were written before, during, and after the Battle of Roi-Namur. A large majority of the data had additional supporting information that was discussed throughout the primary sources. This information was incredibly varied, covering information such as the average effective ranges of the various cannon calibers, and the frequency of fire from US bombardment vessels on specific parts of the islands (CNSG 1944d:38). Ultimately, all this data came together in GIS then became the foundation for the data analysis processes.

It is important to note that although the information taken from these primary sources are vast and cover a huge swath of the overall battle, it can never be definitively stated that every single piece of information is sourced for a study: all variables and data results that were created through the processes used for this study are the direct interpretation of the provided information, data, and resources. More time, resources, and funding would directly result in the overall honing of the information and data implemented, but for the scope of the thesis, the data employed, and the results have proven to be sufficient. Overall, the maps, images, and data outputs created for this study are valuable and could serve as a springboard for research covering similar battlefields. Following this, Figure 11 portrays the locations of all Japanese defensive positions on Roi-Namur at the beginning of the battle.

Figure 11 Image of all Japanese defensive positions on Roi and Namur (Image created by Author).

To gather spatial locations, a historic map showing reconnaissance drawings of perceived defensive positions was georeferenced which facilitated the placement of figures and symbols that represent each defensive positions' typology. A total of 21 defensive buildings, 17 pillboxes, four 127mm guns, two 37mm guns, nine 20mm guns, and 19 13mm defensive guns were present at the time of the battle. Alongside the various gun positions, the pillboxes, defensive buildings, and other structures intended to entrench the Japanese and defend against an enemy amphibious assault. Several of these elements had data embedded within them, such as the caliber of the gun and their average effective ranges (CNSG 1944n:1-6). In subsequent maps, the overall ranges of each caliber will be discussed and displayed to aid in various data analysis processes. The map created was important as it showed all the typologies of calibers used and positioned on the islands.

Figure 12 depicts the general positioning of all US amphibious assault groups. Though the actual positions of the troops involved are spread out throughout the many Landing Vehicle Tracked (LVTs), Landing Ship Tanks (LSTs), and other vessels, the symbols are representative of the general area in which each group was positioned to conduct the assault (CNSG 1994t:76-79). Were the information for specific vessels and groups to be displayed on every transport, the map would become densely cluttered. This manner of showing the user the general area each group occupied allows for a clearer image of the battle. The data used to create Figure 12 included a hybrid between historic written sources and a georeferenced image. A map detailing troop positionings from the Headquarters Fifth Amphibious Corps shows the overall layout of the troop groups used (Headquarters Fifth Amphibious Corps 1994d:173-175). This map was georeferenced into GIS to be used as a reference when placing the points. These points are not physical locations, but instead are representations of the overall areas where troops belonging to each group were situated. Primary sources detailing all information for these groups were used to create the map (CNSG 1994g:4). Thus, every symbol included on Figure 12 holds several forms of data; the number of troops that belong to each group is accessible in the symbol attribute tables, as is the general number of casualties each group faced (Headquarters Fifth Amphibious Corps 1994d:175). These values are useful as they hold the potential for future analytical work to be applied to this dataset.

Figure 12 Image of all US groups involved in the amphibious assault (Image created by Author).

The data included in Figure 13 displays the US plan of attack for the amphibious assault on Roi and Namur islands. Although these images do not belong to physical elements that participated in the battle, they were important to the overall strategy and execution of the assault conducted on the island. Various sections of the beach were divided into two segments: Beach Red and Beach Green. These beaches were then separated numerically to further differentiate them. The lines shown are assigned to the various US groups positioned throughout LSTs and LVTs and portray the direction of attack each group was assigned to take when storming the island. These elements are representative areas and directional flows of how the battle was organized to maximize efficiency, troop safety, and the time it took to secure the islands (CNSG

1994o:49). The overall flow of the battle and designated beach areas were created through a combination of written primary sources coupled with the same georeferenced image used to create Figure 13 since it showed both the general location of each troop group and the overall battle plan assigned for each of them (Headquarters Fifth Amphibious Corps 1994d:175).

Figure 13 Image of the US plan of attack for Roi and Namur (Image created by Author).

Figure 14 showcases all amphibious assault vessels used for the initial landings on Roi and Namur. These positions had no historical map plans displaying the exact placements for each craft, though several written reports included the statistical figures involved in the battle. In reports of battles that took place throughout the Marshall Islands, the general layout for the placement of these vessels is detailed, as reflected in Figure 14. Without the option to georeference a plan, this interpretation of data from relevant sources is the closest known portrayal for the spatial layout of these vessels. Within each craft's point, the caliber of weapons is included in the attribute tables to aid in further analysis (CNSG 1994m:1). Figure 14 did not include primary source information to be used as a guide for determining the spatial locations of the amphibious assault vessels. Instead, primary source documents were consulted to infer the overall positioning formations for these vessels (7th Infantry Division 1944:1). It is important to note that while no records were found depicting or describing the general areas or positions of the LSTs during the initial assault of Roi and Namur aside from the area at which they entered the lagoon, a representation of the position was estimated by historian Gordon Rottman (CNSG 1994j:3; Rottman 2004:42-43). Thus, the positions ascribed in Figure 14 are pure representations of their locations when dropping off the various landing craft.

Figure 14 Image of predominant amphibious assault vessels used for the initial landings on Roi and Namur (Image created by Author).

All bombardment targets were plotted onto the base map for Roi and Namur in Figure 15. Designated by the US military, there exist several historic maps depicting the island divided into 62 sections (Headquarters Fifth Amphibious Corps 1944d:165). Through reconnaissance missions flown to gather information on enemy positions, these sections were overlaid onto an image which would then serve as the numerical system to designate various portions of the island. These numbers are consistent throughout all operations that involve the bombardment and assault on the island. These maps were georeferenced to demonstrate in a geospatial format area sectioned explicitly for the amphibious assault and preliminary bombardments. This layer has several forms of embedded data including overall square mileage of each section and number of enemies reported in each section, as well as the number of times a section was under fire and the vessel that fired upon it. This map proved valuable for data analysis as it provides data regarding concentrations of fire, historic battle planning, and an overview of the effective execution of tactics. Figure 15 was created through a combination of methodologies. The geospatial positions of the sections were created using a georeferenced image, then all embedded information was drawn from various written primary sources. The sections are filled with information that could only have been implemented through this combination; the amount of data input would not have been possible without using both the map to accurately plot the regions nor would the information embedded in the attribute table be accurate without the written records that gave statistical figures for bombardments (CNSG1994d:38).

Figure 15 Map of all bombardment targets on Roi and Namur (Image created by Author).

Figure 16 displays all elements of the battle present at the amphibious assault of Roi and Namur. This is not the final extent of the variables that took place in this battle; instead, it represents all elements that were involved in the initial physical US landing of the battle. This map does not include any information from maps or processes pertaining to data analysis, naval vessels involved in the battle, ranges of visible elements, or assigned spatial representations of the LOW analysis. Nevertheless, it is important for understanding the general composition of the initial amphibious assault. Although other maps created for the study detail all elements of the battle previously mentioned that are not currently visible, this one is important for understanding the initial scale of the battle.

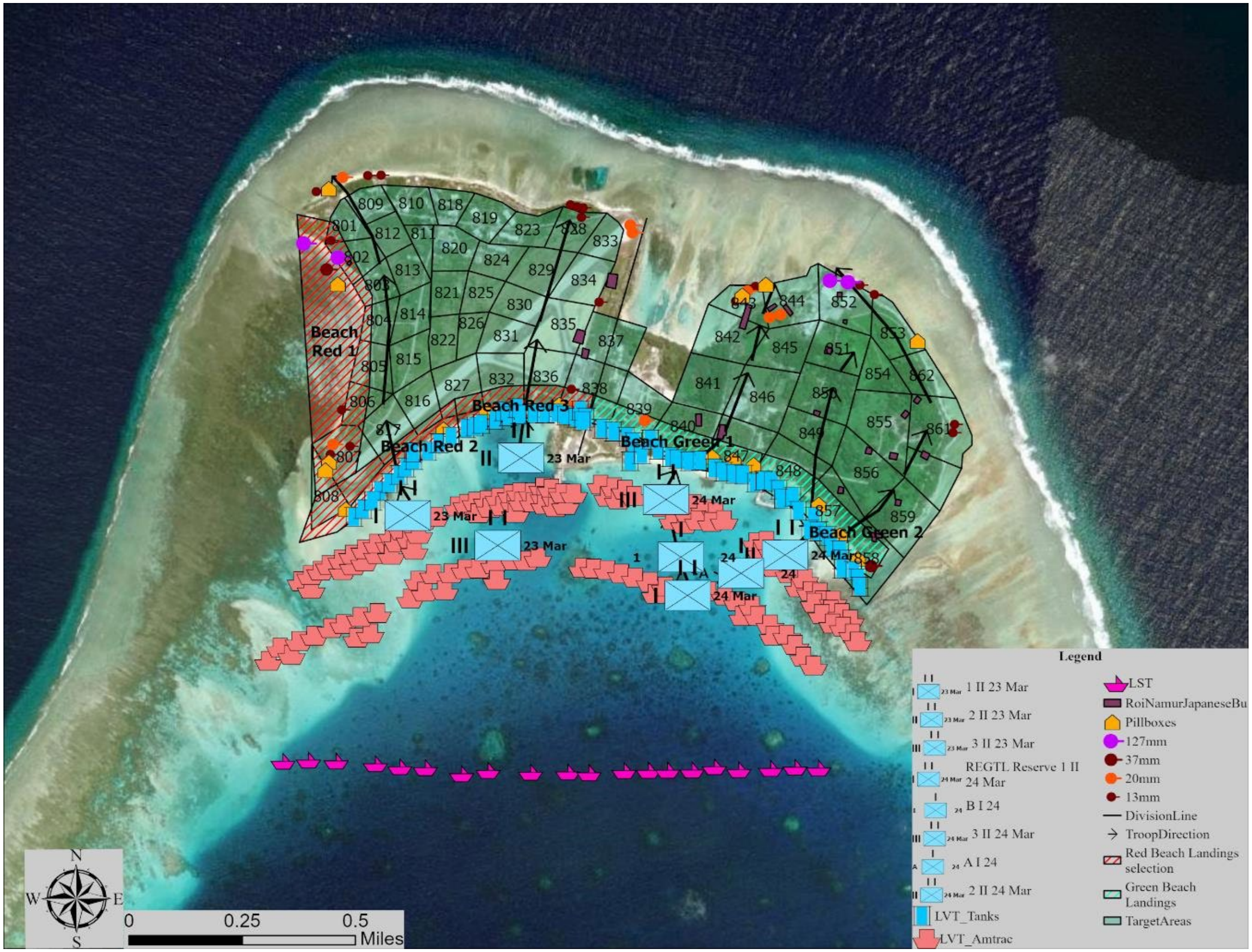

Figure 16 Map of all amphibious assault elements present at the Battle of Roi and Namur (Image created by Author).

For the next step in implementing all relevant items into the GIS project, Figure 17 showcases the track map of all areas traveled by USS *Hickox* (USS *Hickox* 1944:7). The overall track maps of all vessels present were defined through georeferencing. The process for plotting these track maps differed somewhat from earlier variables as rather than being large scale maps that entail points or lines, the results of georeferencing these track maps are presented as polygons whose area covers the entirety of all square mileage covered. The process for their creation is the same as the other in terms of georeferencing a historical image and then tracing relevant portion, but this type of plotting utilized polygons that required the outermost bounds of the travel paths to be traced. Rather than tracing each line and having that be the variable implemented into GIS, a polygon showing the overall area was preferred as the data that could be extracted from this type of file hosts more potential. The overall square area of traveled sea could be calculated.

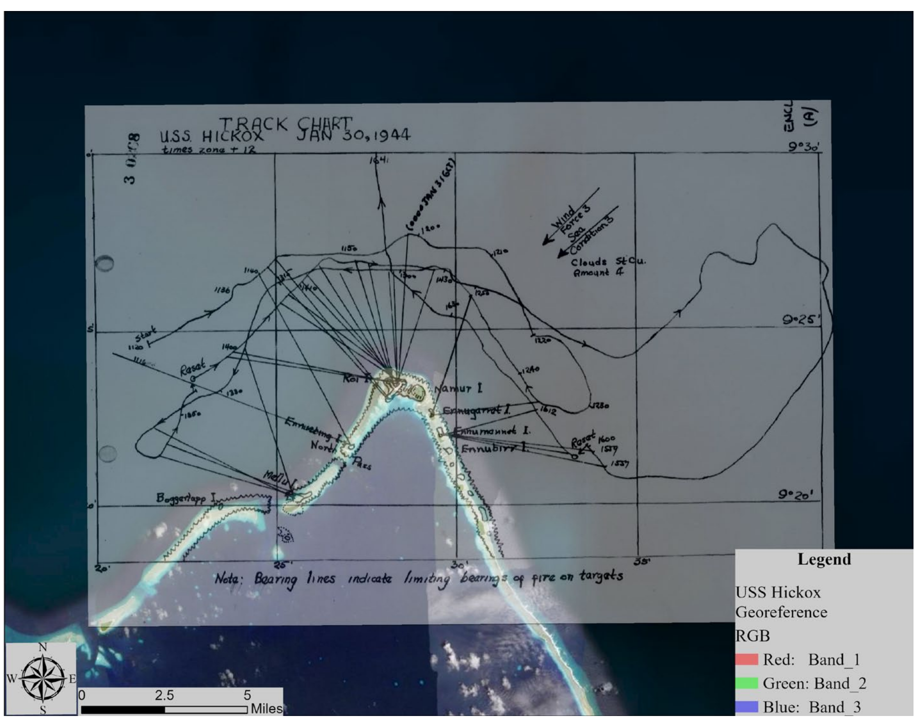

Figure 17 Image of a georeferenced track map of USS *Hickox* (1944) (Image created by Author).

Next, Figure 18 shows the area covered by all US naval vessels involved in the preliminary and continual bombardment of Roi and Namur. For this portion of the battle, several groups were host to support vessels. Throughout the historical record, there exists data related to individual vessels and corresponding track maps portray their movements. There also are reports that entail the larger groups for which multiple vessels were assigned. These reports have track maps showing the home vessel for the group, with all other related vessels following either behind or alongside it (Commander Task Unit 53.5.5 1944:6). There are several occurrences, however, where individual vessels from these groups received orders to split off from the main cluster to conduct a particular task. All possible portrayals of these instances are shown on this map, at this scale. This map does not depict the overall capacity and areas traveled by all US vessels participating in this battle, as carrier vessels and their corresponding supporting vessels exist at a much smaller scale. Although there are only six polygons that portray the area traveled by the bombardment vessels, they represent the overall grouping of both individual and assembled track maps from every vessel in attendance (CNSG 1994l:1-24).

Figure 19 shows the two larger carrier track maps and those of all the supporting vessels assigned to their group. These polygons are depictions of the greater areas traveled by all involved vessels at the smallest scale of the vessel track maps. These carriers and their supporting vessels were the primary naval support for *Operation Flintlock*. As it pertains to the Battle of Kwajalein Atoll, these representative polygons of the overall area traveled are only in accordance with this battle (CNSG 1994l:1-24). That is not to say these areas were the only ones traveled for the entirety of the Pacific Theater, but the general area is relevant to this study when bombardments were preliminary and concurrent. Both Figure 18 and Figure 19 were created through the georeferencing of historic maps of the flagships, such as USS *Essex* and USS *Intrepid* (USS *Essex* 1944:16-17; USS *Intrepid* 1944:16).

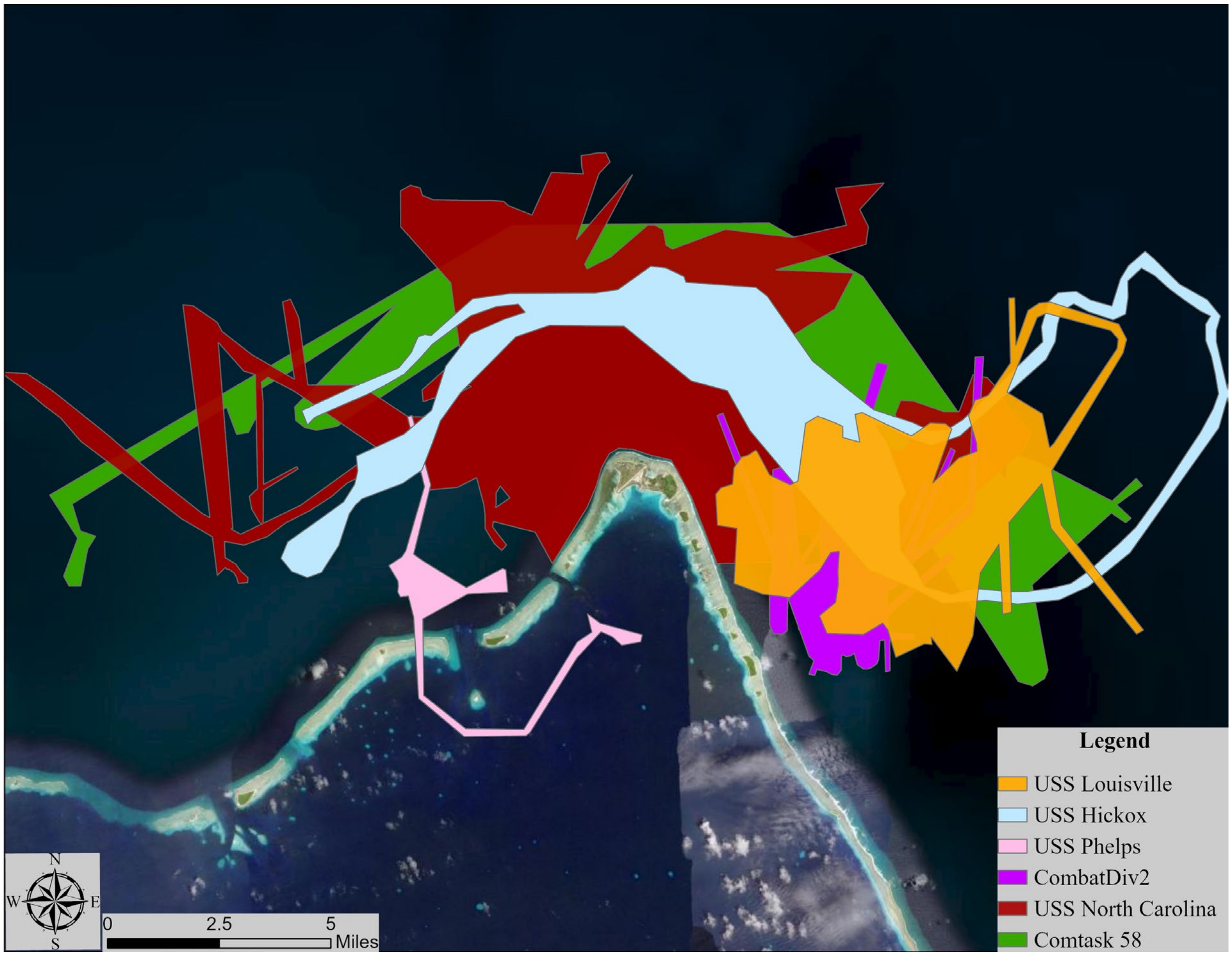

Figure 18 Map of the vessel tracks of all vessels involved in the preliminary bombardment of Roi and Namur (Image created by Author).

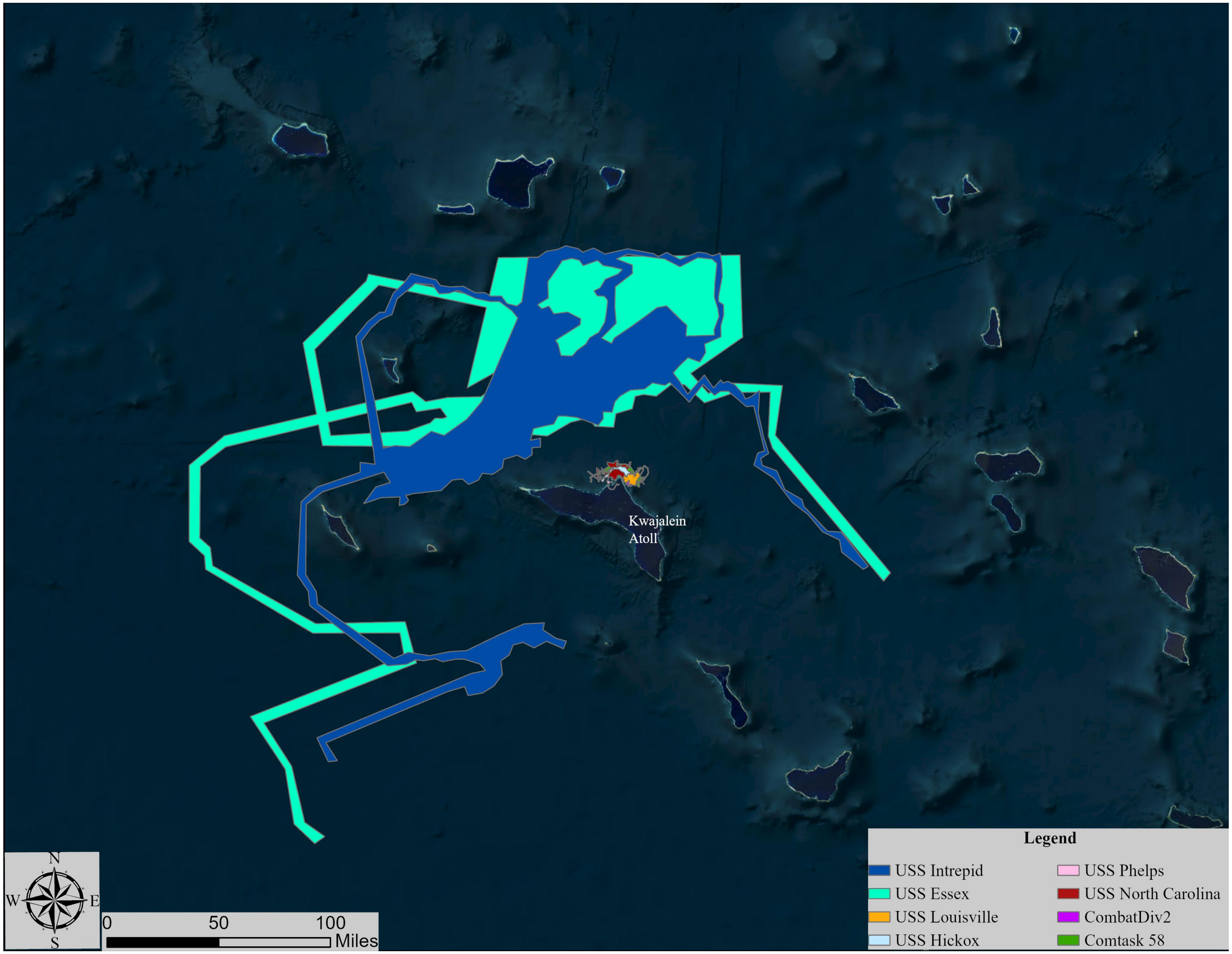

Figure 19 Map of the average area traveled of all flagship carrier vessels and their assigned support vessels (Image created by Author).

In Figures 20 through 24, the processes used to create the polygons that are representative of the average effective ranges of each variable in question are shown using the Buffer tool. The premise for this creation of points is quite simple following an initial understanding of what the tool does. Following the input of a desired layer for which the average effective range is created, the value of that effective range must be input in the “Distance” field. The “Dissolve Type” should have the “Dissolve all output features into a single feature” option chosen to ensure that all polygons will merge, rather than appearing independent of one another. These steps must be applied to every element that has some form of average range that can be visually represented through GIS. This representation is important as it is the last implementation of available data that does not require any further analytical processes: these polygons are still independent sources of data that by themselves are simple. Without the utilization of various data analysis processes, these ranges are like the other showcased variables since they are host to a swath of information and statistics but hold the potential for great data outputs.

First, Figure 20 depicts the effective ranges of every element involved in the Battle of Roi-Namur as they pertain to the amphibious assault and subsequent capture of the island. The effective ranges of every caliber gun at the Japanese defensive positions are also included in this map. The largest range depicts the overall effective half-range of the most common types of aircraft used for the assault on Roi and Namur. Since the average effective range of these aircraft was approximately 1,000 miles, the distance created from one point of the carriers to the edge of the created polygon is 500 miles. This is to show the relative maximum range these aircraft could travel from a carrier while still being able to return safely. Though this is not an occurrence that likely happened, it is important to note as this polygon is like the other classifications of created polygons in this map which showcase the effective range of a component. All other ranges pertain to the average effective range of each caliber weapon used, be it anti-aircraft guns or the guns mounted on LVTs (Eastern Mandates Campaign 2004:169-202).

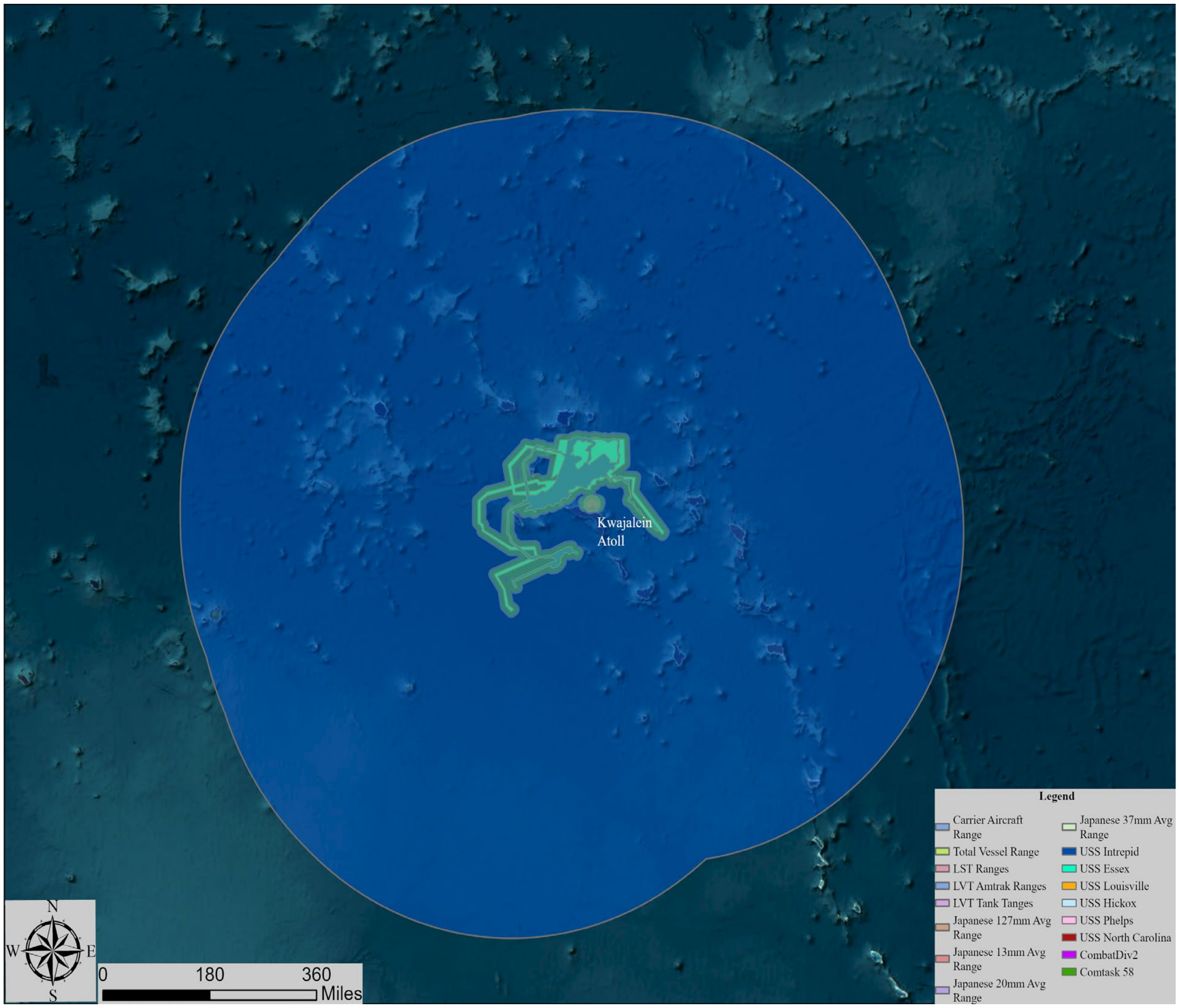

Figure 20 Map of all ranges for every component involved in the Battle of Roi and Namur (Image created by Author).

Figure 21 represents the next level of maximum range for participating variables involved in the Battle of Roi-Namur. The green polygon displays the average effective ranges of the most common caliber of gun present on all vessels, not just the bombardment vessels. The average effective range of the common calibers used was 15,000 yards, which is what this representative polygon displays. Both the carriers and bombardment vessels, such as battleships and destroyers, had an array of different calibers on their decks, but for the purposes of this study the average, most common caliber was used to account for variation among the types of vessels. Carriers, battleships, and destroyers have different purposes; thus, they also have various calibers of weapons. The shape area represents the overall average effective ranges of artillery for each vessel (Eastern Mandates Campaign 2004:183).

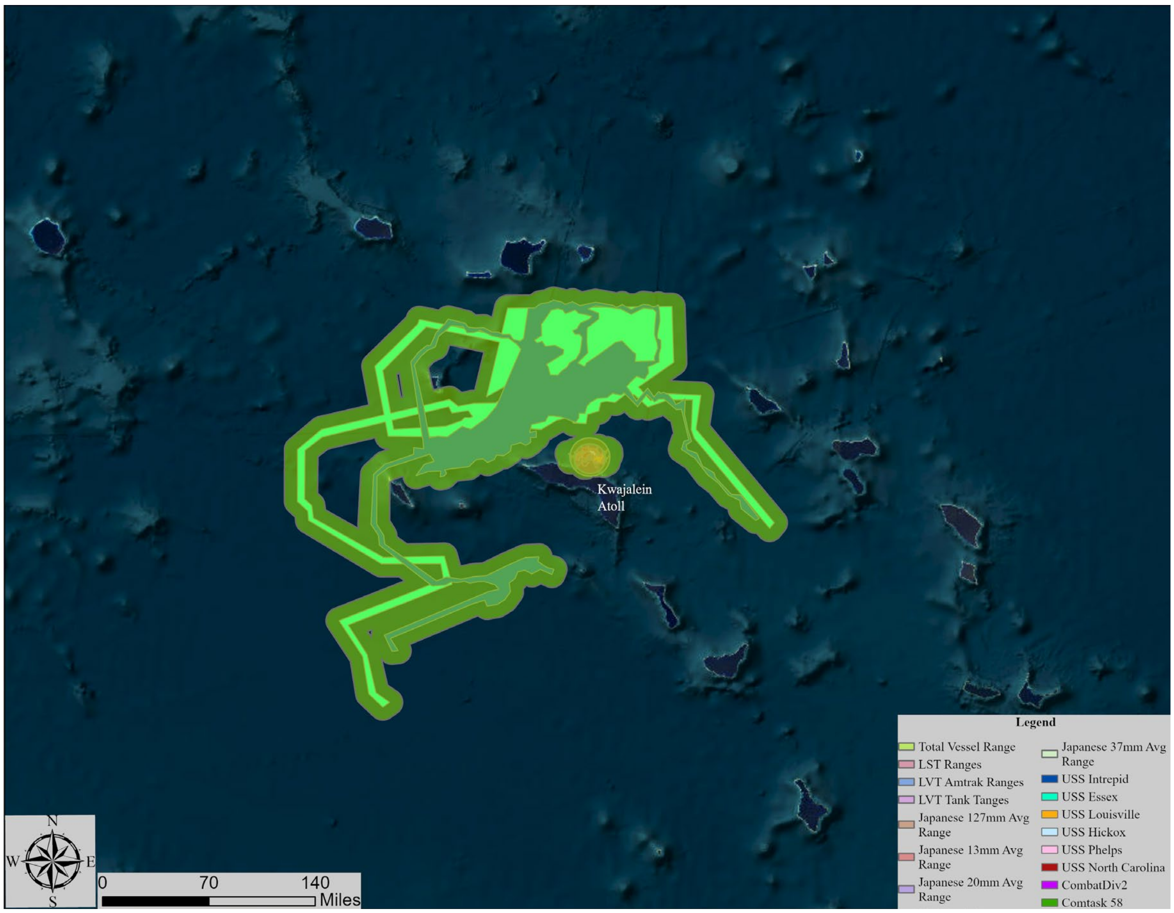

Figure 21 Map of the ranges of all calibers of weapons present at the amphibious assault of Roi and Namur (Image created by Author).

The overlapping nature of all calibers of guns present at the Battle of Roi-Namur is depicted in Figure 22. All bombardment vessels and subsequent components of the battle are visible. The next largest range is that of the four Japanese 127mm anti-aircraft guns positioned on the island. Though their primary purpose was to defend against aerial attacks, they were also used to fire upon naval vessels. For the purposes of this study, an average effective range of

22,000 yards for that caliber was used to create this representative area for their reach (Campbell 1985:192). Although there were of course variations of just how far that caliber could fire accurately, the range for the caliber showcases just how dense the overlap of caliber ranges was throughout the battle.

The next largest range shown in Figure 22 is that of the guns equipped on the LSTs present at the battle. These vessels were equipped with 40mm guns that had an average effective range of 17,000 yards (Campbell 1985:147). Like the average effective range of the vessels used for bombardment, these vessels served multiple purposes. Their primary purpose was transporting LVTs and other amphibious assault vessels, but they were also equipped to defend themselves against enemy attacks and assist amphibious assaults through fire of their own. Rather than showing this level without the overlapping 127mm range, this range was depicted without its own independent image to aid in understanding the various “levels” of ranges. This, alongside the 127mm caliber and the ranges of the bombardment vessels, are visible at similar scales, though the next “level” of ranges are better viewed at a greater scale. Nevertheless, it is important to understand the scale of these ranges based on their intended purpose (Campbell 1985:142-192).

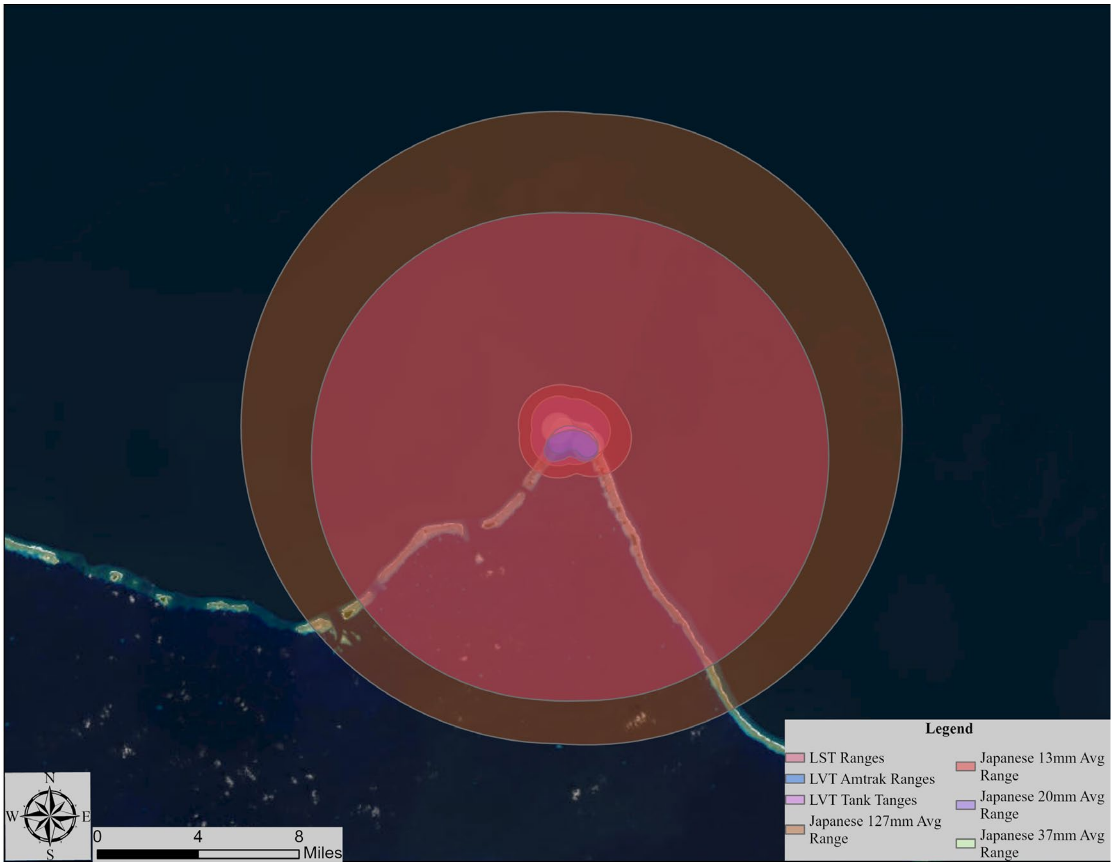

Figure 22 Map of the average ranges of Japanese 127mm guns, LST guns, and remaining weapons present on the assault of Roi and Namur (Image created by Author).

Figure 23 presents the next scale to show the areas of all effective ranges of each caliber weapon present at the Battle of Roi-Namur. The largest range area at this scale is that of the Japanese 13-centimeter (cm) guns. This caliber had an effective range of 2,500 yards and was used to defend against aircraft and ground assaults (Campbell 1985:191). This multipurpose caliber was positioned carefully throughout the island to ward off as many US attack types as possible. The next level of average effective ranges shown is that of the Japanese 20cm gun, which had an average effective range of 2,000 yards. Like the 13cm caliber, they were also used for aircraft defense. Though there were not as many 20cm guns present on the island compared to the number of 13cm, the emphasis the Japanese placed on defending the island against aircraft attacks is apparent.

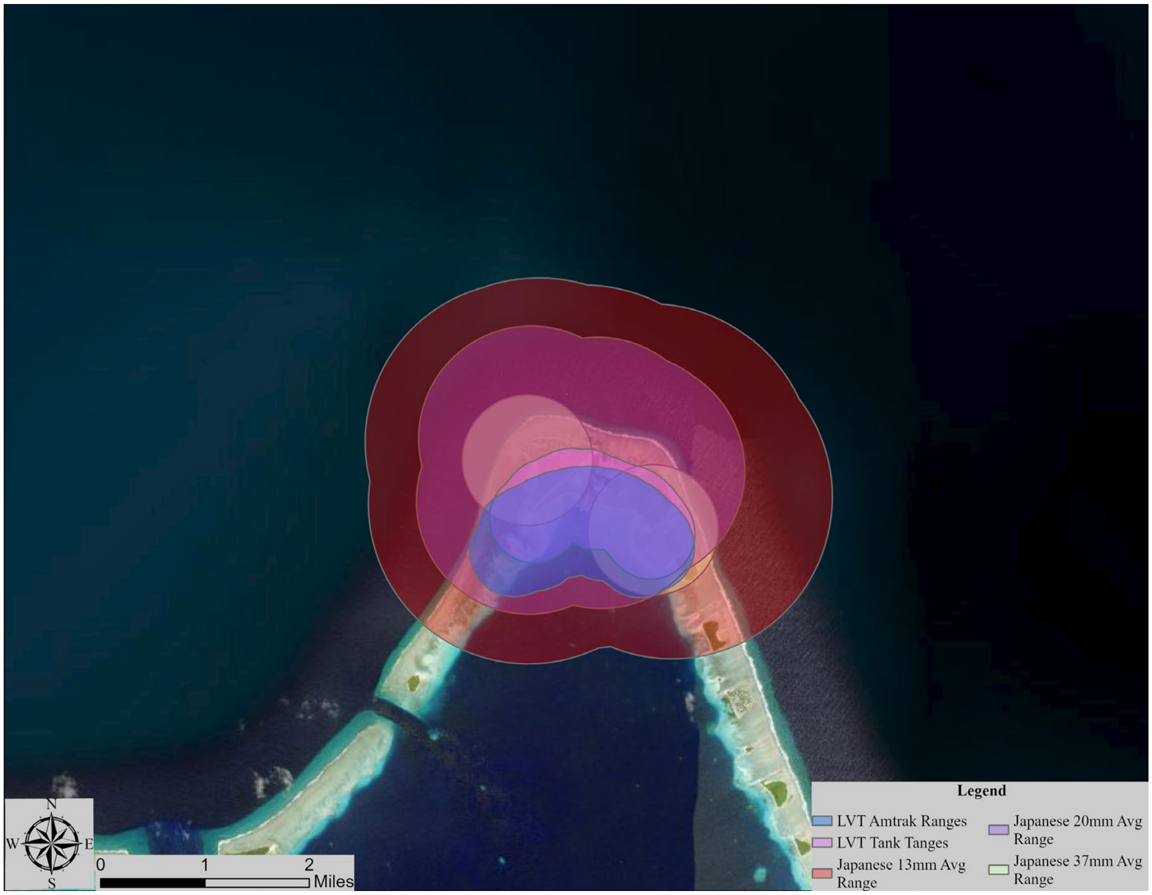

Figure 23 Map showing Japanese 13mm guns, LVT guns, and remaining weapons present at the Battle of Roi and Namur (Image created by Author).

The remaining average effective ranges of the gun calibers used for this battle are shown in Figure 24. The final Japanese caliber used at the battle was the 37mm gun. This caliber had an average effective range of 1,100 yards which was an anti-tank caliber. Two were present on the island at the time of the initial bombardment, placed in positions to effectively repel the US LVT (tank) assault. Placed on both sides of the island, the average effective range was clearly in mind when planning the defensive positions since the two long guns could cover most of the island against these types of assault. Nevertheless, they were not effective in saving the position as US forces quickly took control of the island (Campbell 1985:183).

The remaining ranges present in Figure 24 are the average effective ranges of the guns equipped on the LVT craft. Incredibly useful for the initial amphibious assault of the island, the tracks on LVTs allowed them to crawl up the beachhead to conduct the initial land-based assault on the Japanese defensive positions. The tank LVTs mounted 75mm guns with an average effective range of 750 yards. Amtrac LVTs were for carrying troops, so the caliber used to portray the average effective ranges was like those of infantry weapons. This resulted in an average effective range of 750 yards (Campbell 1985:142-192). By combining the most common infantry weapons and portraying their range through GIS, the overall areas the troops could fire upon is illustrated. Along with showing the average effective ranges, one option for further analysis of this data is to conduct a viewshed analysis. This would show a user based on the buildings present and the elevation of the island to know exactly what the troops were able to see. Unfortunately, this was not possible due to the lack of elevation data for Roi-Namur.

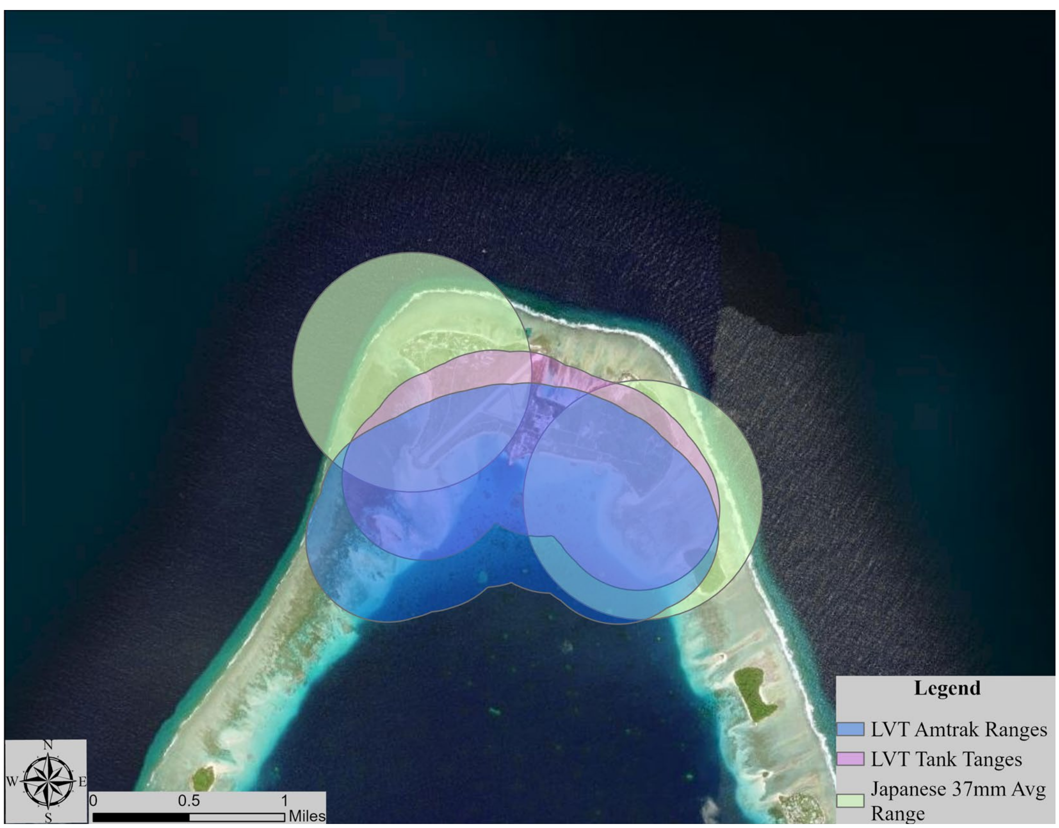

Figure 24 Map of the remaining average effective ranges of the calibers present at the Battle of Roi-Namur (Image created by Author).

Processes Used to Create Data Analysis Outputs

This section covers the steps and processes utilized to create all the maps and analytical processes. Following the overview of the entire dataset that has since been implemented into GIS along with the processes used to implement them into the software, the processes that were applied to the dataset to create meaningful results are considered. The results of those processes are not explicitly covered in this chapter, though the processes to create them are discussed. Each process employed several tools, and each tool had specific parameters chosen, for the sole purpose of creating data outputs that would result in the most meaningful results. This section will purely cover the methods used to create the assigned outputs, organized by the label of each overall output.

Levels of War Assignment

The first data analysis conducted for this study was the assignment of all variables plotted in GIS in accordance with the LOW framework. Up until that point, all variables were discussed, plotted in GIS, given the relevant data, and assigned based upon their category into the various levels of the LOW framework. To better understand the spatial relationship these components have to one another, all the levels must be visually represented through the means provided by ArcGIS Pro.

The most accurate way to visually represent each level as they correspond to its definition and accurately classify each element is through polygons that effectively “wrap” around the minimum boundary of all components. Several steps are involved to accomplish this, but the core premise revolves around the “Minimum Bounding Geometry” tool with the “Convex Hull” parameter. This tool essentially has the user select all desired variables and choose the correct parameters to create a polygon. The tool locates all the points chosen and creates a polygon that wraps around the overall boundaries of the plotted points so that the most efficient wrapping between the points is created. As shown in Figure 25, only the most external points are chosen to be waymarks along the new overall polygon. This in turn results in the overall most conservative spatial representation of the general boundaries or area coverage of a series of points.

For this study, the first data analysis output was created through the combination of all the vessel shape area polygons. Due to each polygon being an independent layer, all the vessel areas were first combined. It is also important to note that polygons are unable to be input into the “Minimum Boundary Geometry” tool; all desired points must first be turned into points. The first step in this process combined all the various vessel area layers through the “Merge” too, which ensured that all the layers depicting the overall track maps were merged into a single cohesive polygon. Following this, the newly created polygon was then inserted into the “Feature Vertices to Points” tool. This tool took an input polygon and separated it into various points based upon the parameter chosen. For the sake of this process, the “Point Type” parameter should be set to “All Vertices”. Following the application of this tool, a layer of points composing the vertices of the input polygon was created. This then allowed for the “Minimum Bounding Geometry” tool to be applied.

All the variables used throughout the amphibious landing and initial bombardment of Roi and Namur were associated with the tactical level. All the polygons existing within this level were subjected to the previously mentioned conversion process so that all the elements were in point format. Only then was the “Minimum Bounding Geometry” tool applied. The spatially representative tactical level, as it pertains to this study, was the result of this process. These processes were then applied to all the various levels. This resulted in every element being included in the LOW framework through its visual representation in GIS.

Range Intersections

The next type of data analysis created for the purposes of this study was the creation of maps portraying the overall areas of intersection between the average effective ranges of all US gun calibers. These outputs are important as they visualize the areas with the highest concentration of overlap between the various guns and capabilities of US forces. This allowed for a better understanding of what areas of the battlefield fall within the fields of fire of relevant vessels, which drives analysis regarding the most targeted areas of the battle. This data result also had a slew of statistical data backing it up, which also showed the vast scale of the Battle of Roi-Namur. Between displaying areas with the highest number of guns alongside having representative statistical figures demonstrating the vastness of the battlefield, these outputs were useful in extracting information out of the Battle of Roi-Namur than what was not previously known.

To conduct this data analysis, the core tool was that of "Tabulate Intersections". There were, however, a few processes undertaken before the tool was executed. The most important consideration for this process was to create a layer that combined all individual layers of ranges into a single layer, which was done through the "Merge" tool. Following the merging of all the effective ranges of all US components, all ranges existed within a single layer. Within that new layer's attribute table, the "Add Field" option was selected, and a new field labeled "Overlaps", with the "Data Type" option set to "Double". Following this, each level of overlap was assigned a quantitative value. The second outermost layer with the second largest range was assigned a value of 1, with the next range being set with a value of 2, and so on. With those edits complete, the "Tabulate Intersections" tool was run. The "Zone Fields" parameter was set to the new field that the user created. Ensuring all other parameters were correct, the tool was activated, and the output was a layer that showcased the overall intersections of each effective range. After the creation of this layer, various forms of data analysis were applied to it to determine the overall area square mileage of each level of intersection and percentages of overlap, as well as to visually represent areas that are the subject of the highest number of range intersections.

Kernel Densities

The third form of data analysis created for the purposes of this study was various density maps showcasing the areas that hold the highest concentration of variables throughout the battlefield. These maps are effective at showing the areas that were host to the highest concentration of all elements situated on and around Roi and Namur. For this study, two of these maps were created. The first is a kernel density map depicting all variables located on the island as well as the areas of travel for all bombardment vessels. This map served the purpose of showing the US plan of swarming Roi and Namur with a huge number of bombardment vessels and amphibious assault elements. This combination effectively secured the capture of the island, as showcased by this map. The other map represents the overall density of all US amphibious assault components alongside the archaeological points of dumped crafts and wrecked aircraft. Its purpose is to further the point of the previous map, while also serving as an aid for further archaeological survey. This map could assist research by revealing areas with the highest concentration of wreck sites for further study. Overall, the combination of these two density maps were useful visual aids for showing the high-density composition of all elements present during the Battle of Roi-Namur while also providing site predictive models for potential archaeological survey.

The process required to create both maps was quite similar. The steps needed to create these maps revolve around the “Kernel Density” tool. Before this was completed, a few processes were applied to all elements implemented into this type of map. The first step was turning all the polygons or line data into points. This process followed the same steps described previously, wherein the "Feature Vertices to Points" tool was used in previous data processes. Once all elements of interest were turned into points, they were merged using the "merge" tool for accessibility of the tool. Again, the process was the same as previously mentioned. A new field was created named "Count". This ensured that all points had an equal weight when being implemented into the tool. Once all elements were converted to a single layer point type, the new layer was input into the "Kernel Density" tool. The "Population field" parameter required the newly created field be chosen and the remaining parameters were altered to best suit visual needs. After the tool was executed, the symbology was edited to ensure the number of fields was appropriate. After appropriate tweaking, the final data resulted in a map showcasing the overall concentration of all chosen components in a pleasing and easy to understand manner. The transition of density colors was smooth but distinct.

Bombardment Concentrations

This format of data analysis was one of the most interpretation-heavy processes that was conducted for this study. The process consisted of the creation of three maps; a map depicting the concentration of Japanese defensive positions; a map showing the bombardment targets symbolized to show the intensity for each section fired upon; and a final combination of the two. The combination map is where further data analysis could be conducted, though the analysis outputs are not backed in statistical figures. It instead holds much value for interpretation of an overall battlefield and how it pertains to the output that surfaced from the map. This process shows the overall bombing frequency each area of the islands endured based on the number of times a bombardment strike occurred. This process also resulted in a visual representation of the overall concentration of all Japanese defensive positions that shows the areas with the highest density of fortification. The combination of these maps elucidated the purposes behind the bombardments while also showing more about the overall results.

This process consisted of two main methodologies to achieve a desired result, with a final overlay of the results. To create the map showcasing the overall density of all Japanese defensive positions, the same processes of using the “Kernel Density” tool were utilized. All components of the Japanese defensive positions were turned into point layers, and then combined into a uniform layer. A value of 1 was assigned to each component, wherein it was then applied to the tool. The output was then altered to ensure the maximum clarity was visible. This resulted in a kernel density map of all Japanese defensive positions. The other variable for this process involved the creation of a map showing the frequency of fire each defined section of Roi and Namur endured. In the original layer that consists of all the sections defined by the US military subject to bombardment, a new field was created titled “Frequency”. Primary sources that detail the number of times each section was scheduled for a bombardment by each involved vessel were used to populate this newly created field. Following with the input of all appropriate data, the layer was copied and pasted into the table of contents to ensure that the original layer of the bombardment section's symbology was not altered. After the layer was pasted, the symbology was edited wherein the “Primary Symbology” setting within the “Symbology” tab was set to “Unclassed Colors”. An appropriate color scheme was then selected so that the desired number of classes were visible. This resulted in the layer showing only the areas targeted by bombardments, with the colors representing the concentration of fire. Finally, the Japanese defensive position kernel density layer was placed below the newly symbolized frequency of fire targets. The transparency of these layers was then altered to best portray this information.

Encroachments of Levels of War

The final data analysis process created through the utilization of ArcGIS Pro for the scope of this study was one wherein input geospatial data from primary sources was used to better understand the Battle of Roi-Namur alongside the fundamental nature of the LOW framework. This process is perhaps the simplest but has the most important repercussions with regards to how the LOW framework is viewed. Less of an intricate process requiring tools, models, or scripts, the analytical process used to extract as much interpretation and information from the LOW framework and the scope of this study was mere placement of variables. Given that all the levels that pertain to this study were created as spatial representations that adhere to the variables input into GIS, they were then used to view the overall battle in multiple ways. By controlling the placement of visible variables, these newly created representations of the LOW allowed for further interpretations of the battle. The following discussion consisting of these processes will also surface potential issues existing within the categorization process of the LOW framework, or lack thereof.

Conclusion

This chapter explained the production of all the maps pertaining to the Battle of Roi-Namur as they relate to the study. The acquisition of the relevant data and the processes used to create each of the maps were described. All data pertaining to this study was visually represented, and the way they were extracted from primary sources and inserted into GIS to visually represent them was established. Also provided were descriptions of the visual representations of the data alongside an assessment of the information that resides in each variable's attribute table. Overall, this chapter displayed all visual representations of each component of the Battle of Roi-Namur and provided a platform for analytical processes.

Chapter 6: Analytical Results of the Battle of Roi-Namur

Introduction

This chapter focuses on outputs created by the various data analytical processes applied to the variables taken from primary sources. Alongside various tables and graphs that consist of a collection of all statistical figures from the battle, GIS analysis was applied to provide further context and information on the elements observed. Overall overlap and square mileage of the various ranges of guns used, the spatial representation of the LOW, areas of fire, concentration of Japanese forces, and the creation of various point density maps are the main results derived from these data analytical processes.

The results derived from this study focus on various aspects of the Battle of Roi-Namur, with each output revolving around the topic at hand. This produces multiple formats of data derived from the initial input of all components of the battlefield. The format of this section consists of highlighting all forms of data outputs, alongside a description of what is being shown. The data processes used to create the various forms of outputs are discussed, as are the actual results. This section also covers the efficacy of the various data formats as they pertain to the overall scope of the research questions established in Chapter 1. The next chapter holistically views the thesis data and evaluates the questions initially posed.

Levels Of War Assignment

The first form of data analysis for this thesis entailed visually representing all levels of war. To do this, polygons took the form of the overall area covered by each level. The creation of visual representations of the various levels of a LOW framework was incredibly useful in visualizing the concept. Prior to this, no conflict was classified to the LOW framework and then visually represented for the purpose of data analysis. Following this, even more information was derived, such as the overall square mileage of each level and the percentage of overlap each level had within the next largest, as well as the determination of how these levels interact with the physical values implemented into GIS.

The overall geodesic area of the strategic level as it pertains to the classification of the LOW of the Battle of Roi-Namur is depicted in Figure 25. This level included an overall total of 15,346,936 square miles. For this study, the strategic level consists of the entire Pacific Theater of WWII. This general area covers the physical areas between and from Hawaii, Papua New Guinea, Polynesia, Japan, and various areas of the Aleutian Islands. Though the area is massive compared to the overall area of the operational and tactical levels as it pertains to this study, the strategic level of this study covers the entirety of the area where any type of military conflict or consideration existed.

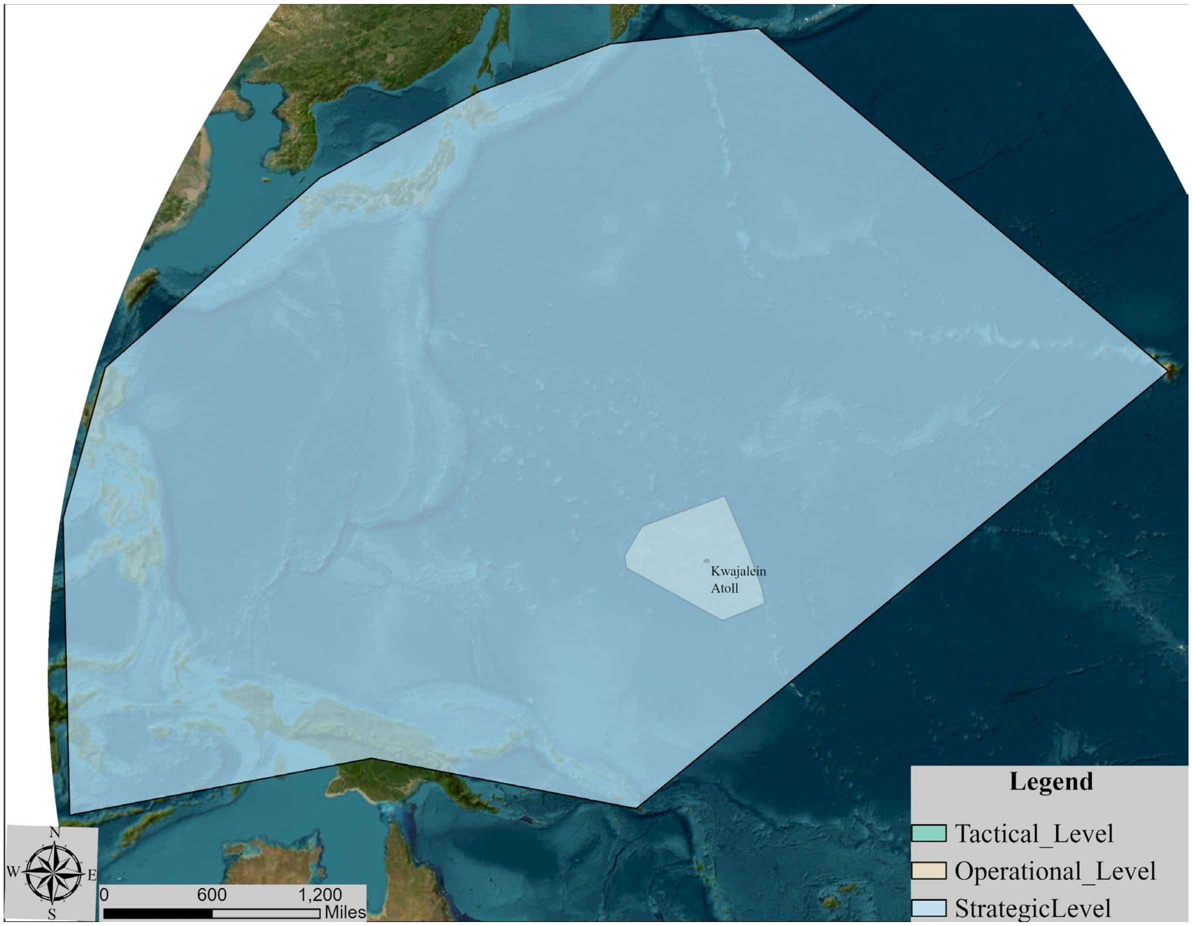

Figure 25 Map of the strategic level of war as it pertains to this study (Image created by Author).

Figure 26 consists of the operational level of war as it pertains to the Battle of Roi-Namur. For the scope of this study, the operational level consists of the range for *Operation Flintlock*, which was the US codename given to the plan to take and utilize the Marshall Islands as a staging ground for further intrusion into Japanese territory. The overall geodesic area of the operational level for this study includes 325,907 square miles. The entirety of the Marshall Islands is covered within this representative polygon, as the primary goal of *Operation Flintlock* was to secure the region. The LOW framework does not specify the classification of how items are categorized, be it spatially or theoretically. Thus, this serves as a prime topic of discussion in the next section as it pertains to levels. The spatial locations of the variables reside within the realm of their respective level, though further analysis covered expands and questions this concept.

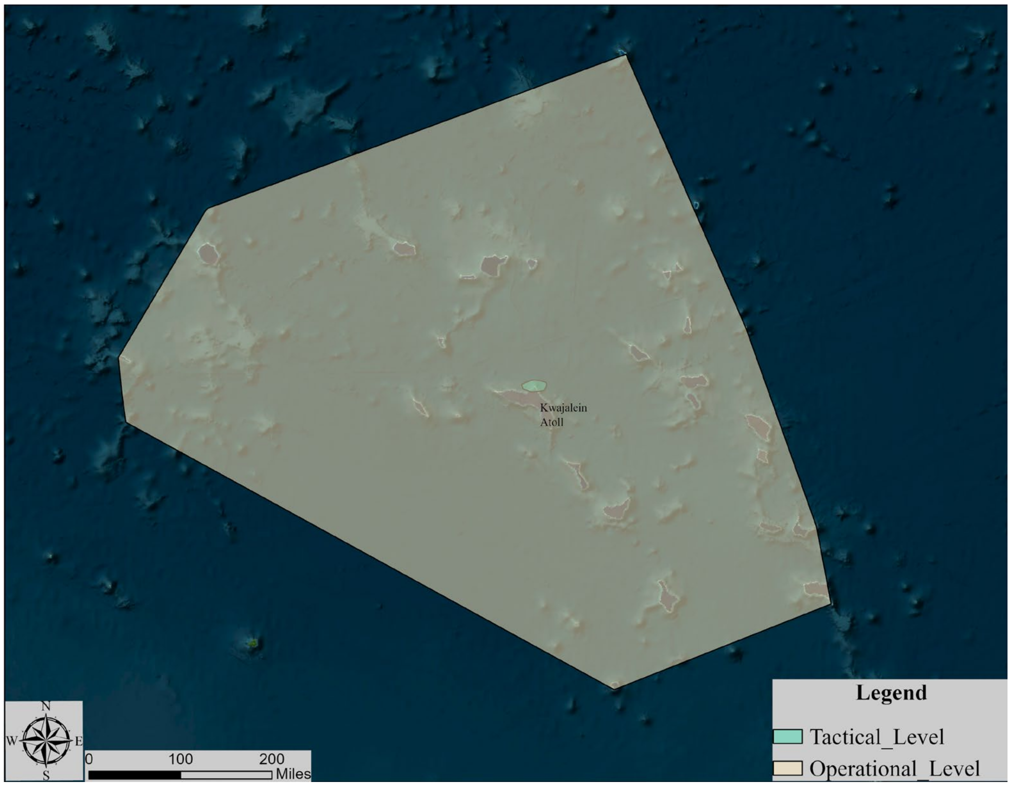

Figure 26 Map of the operational level of war as it pertains to this study (Image created by Author).

The tactical level of war as it pertains to the Battle of Roi-Namur is illustrated in Figure 27. To conduct an analysis of the most conservative estimate of the overall shape area of the tactical level of the Battle of Roi-Namur, only the area composed of the active bombardment vessels and the components within that area were considered. Though the carriers in the vicinity were also part of the tactical level as it pertains to the assault and bombardment of Roi-Namur by expediting and serving as the base area for the launch and recovery of the various aircraft, the carriers and related support vessels in that area were also part of other tactical levels that focused on other targets of *Operation Flintlock*. Nevertheless, the tactical level as shown in this representation holds a total geodesic area of 272 square miles. Kwajalein Atoll has multiple tactical levels of conflict that were conducted at the same time as this battle, but this study solely focused on all components within the battle of Roi-Namur. Thus, the creation of visual representations of the assigned LOW as they pertain to the Battle of Roi-Namur established new information that had not been created in other studies. The resulting polygons also provide a fusion of added insight into the battle that set up even further analysis.

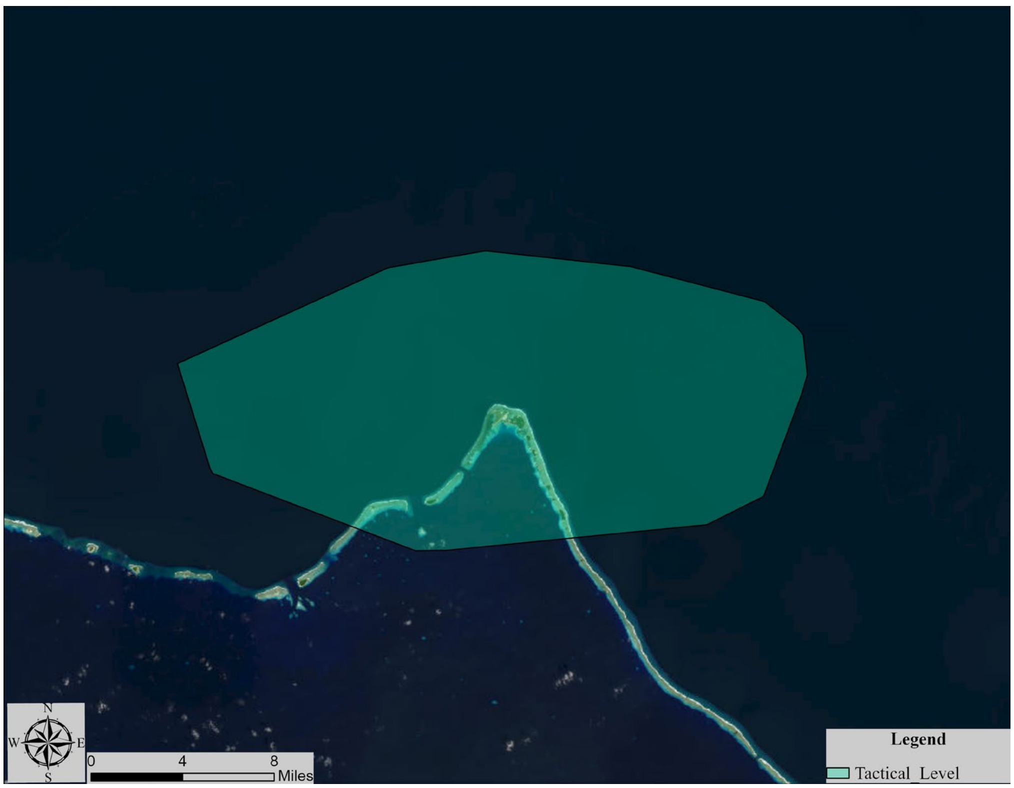

Figure 27 Map of the tactical level of war as it pertains to this study (Image created by Author).

Range Intersections

Figure 28 - Figure 30 all consist of the overlapping ranges of the calibers for guns equipped on US vessels involved in the amphibious assault and bombardment of Roi and Namur. Figure 28 highlights the largest overall segment of overlapping ranges of US vessels. The lime green polygon denotes the overlapping ranges with the overarching ranges of the two carrier vessels. It is important to note that aircraft range was excluded from this portion of the analysis

as it encompasses the entirety of the Marshall Islands; rather than including it to boost the number of overlaps, it was omitted. Nevertheless, the first layer marks the initial range overlap of onboard guns from all the US vessels present. The next level of intersection is shown in Figure 29, with LST ranges intersecting bombardment gun ranges. Finally, Figure 30 displays the final levels of the intersection of the average effective ranges of guns used in the battle. All visualized representations of intersections contribute new information regarding the overall capabilities and the US intention for tactical placements of involved vessels. Through the observation of these levels of intersection, the tactical implications behind vessel placement became clear.

Figure 28 Map showing all counts of intersecting ranges of US calibers (Image created by Author).

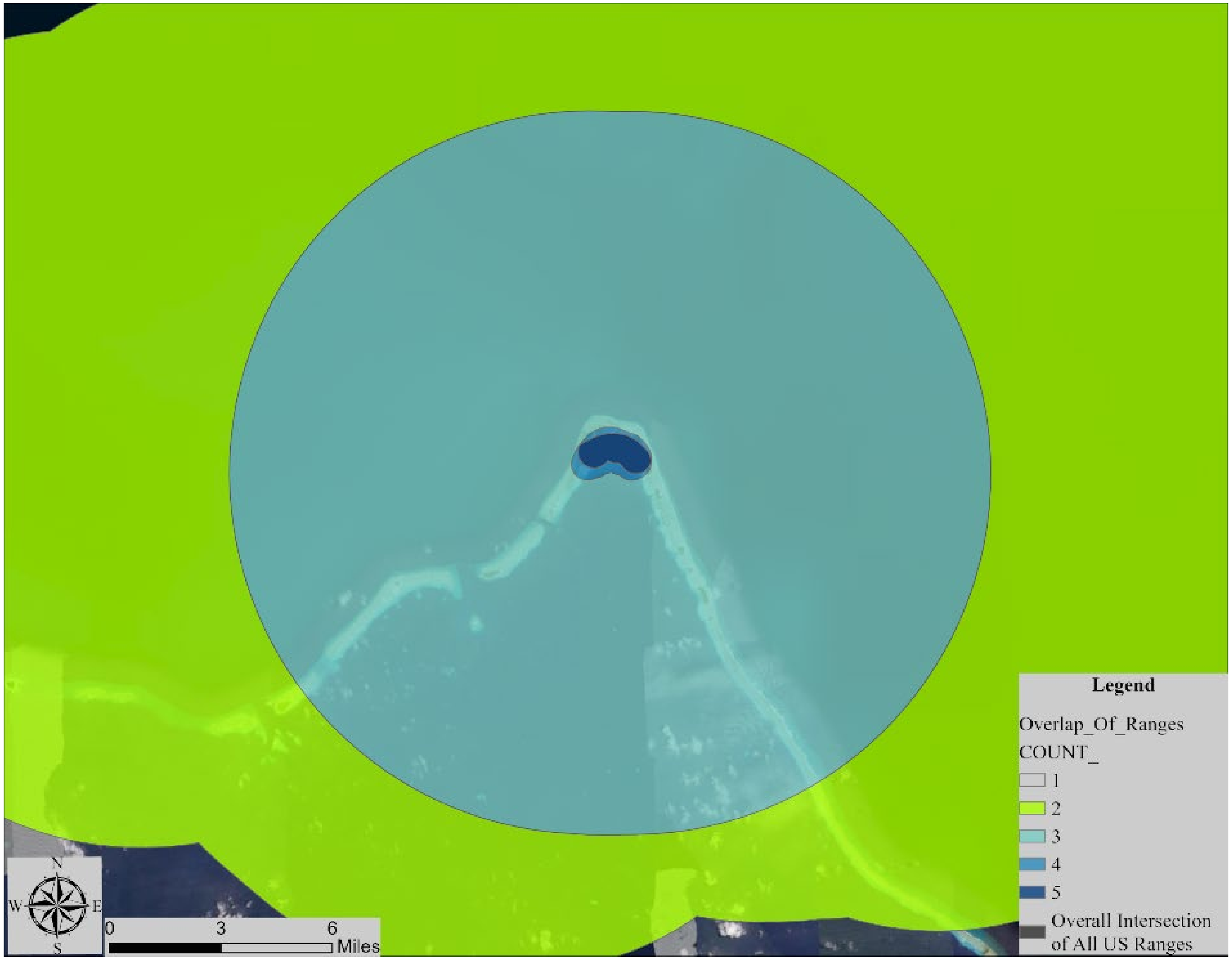

Figure 29 Map highlighting 3 levels of intersecting US ranges (Image created by Author).

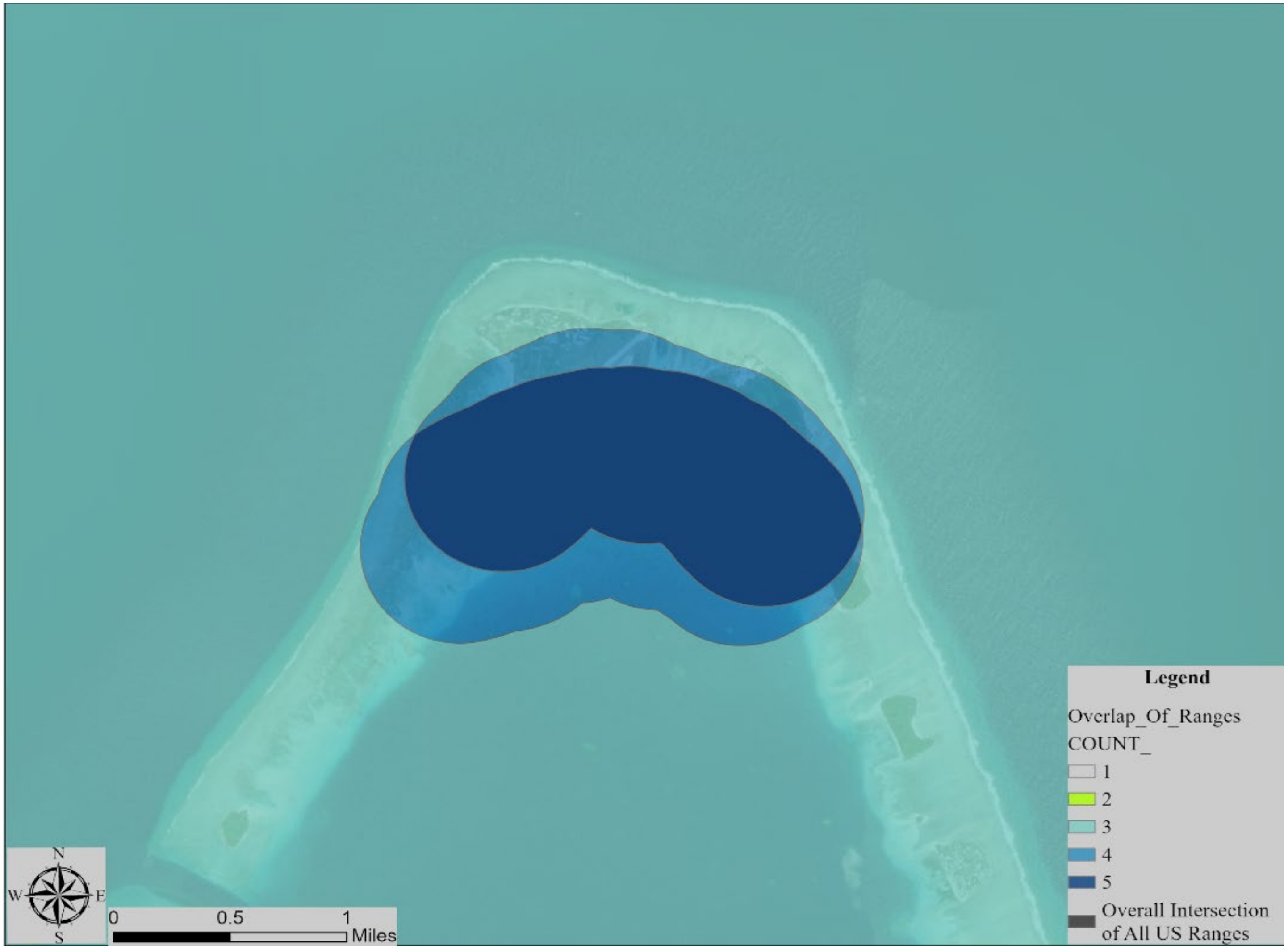

Figure 30 Map of 5 counts of intersecting US ranges focused on Roi and Namur (Image created by Author).

Kernel Densities

Through the utilization of the previously created points, two forms of density maps were created. Figure 30 portrays a kernel density map of all physical components that made up the amphibious assault and initial bombardment of Roi-Namur. The overall positions of the bombardment vessels that surrounded Roi-Namur were included in this analysis to show the highest concentration of all relevant points. Were the carrier positions to be included, the overall concentration of the density map would be lessened, thus providing a suboptimal output.

Figure 31 is representative of all active components of this battle regarding geospatial positions. Through this point density map, the overall concentration of variables is densely focused on and around the immediate vicinity of Roi and Namur. The legend depicts values relative to the number of points that make up the overall composition of all present variables. The count of these were classified, and figure 31 depicts the overall density of variables present at the battle. The higher the concentration of points in an area, the darker the purple color is. Due to the highest concentration of variables existing in this layout, the lessons learned from previous battles, such as the Battle of Tarawa, are readily apparent. Total bombardment and swarming of enemy positions were the key takeaway from Tarawa that was applied to the Battle of Roi-Namur. This raster map showcases this in action and offers definitive proof that not only were past lessons heeded, but they also visually represent the success of the tactics employed. Thus, through the deployment of a vast number of elements to the small islands alongside initial and recurring bombardments, Roi and Namur were successfully taken.

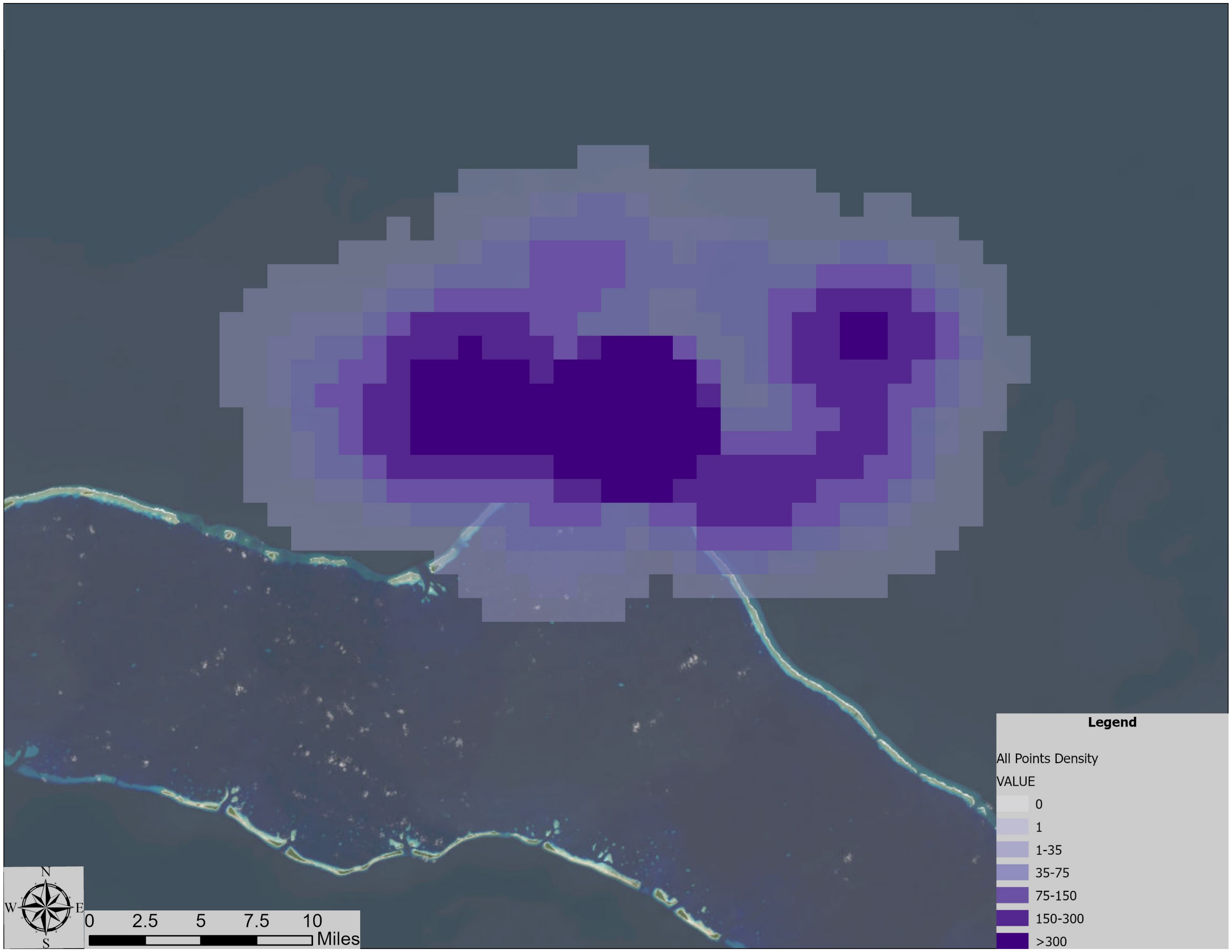

Figure 31 Map of kernel density analysis of all bombardment and amphibious assault components of the Battle of Roi-Namur (Image created by Author).

Figure 32 represents a point density map of the physical components that comprised the amphibious assault and subsequent archaeological remains at Roi and Namur. This map provides a more detailed look at the areas of highest concentrations of variables present on and around Roi and Namur. Included in this kernel density map are the Japanese defensive positions, the US landing vessels, and sites of wrecked and dumped aircrafts. The areas of highest concentrations of variables provide a comprehensive look at the archaeological context of the area. The higher the concentration of points, the color representation will be darker. Clusters of focused concentrations denote sites that may pose the greatest potential for archaeological material, such as the areas of dumped aircraft and amphibious vessels. This would greatly facilitate future studies taking place on and around the islands.

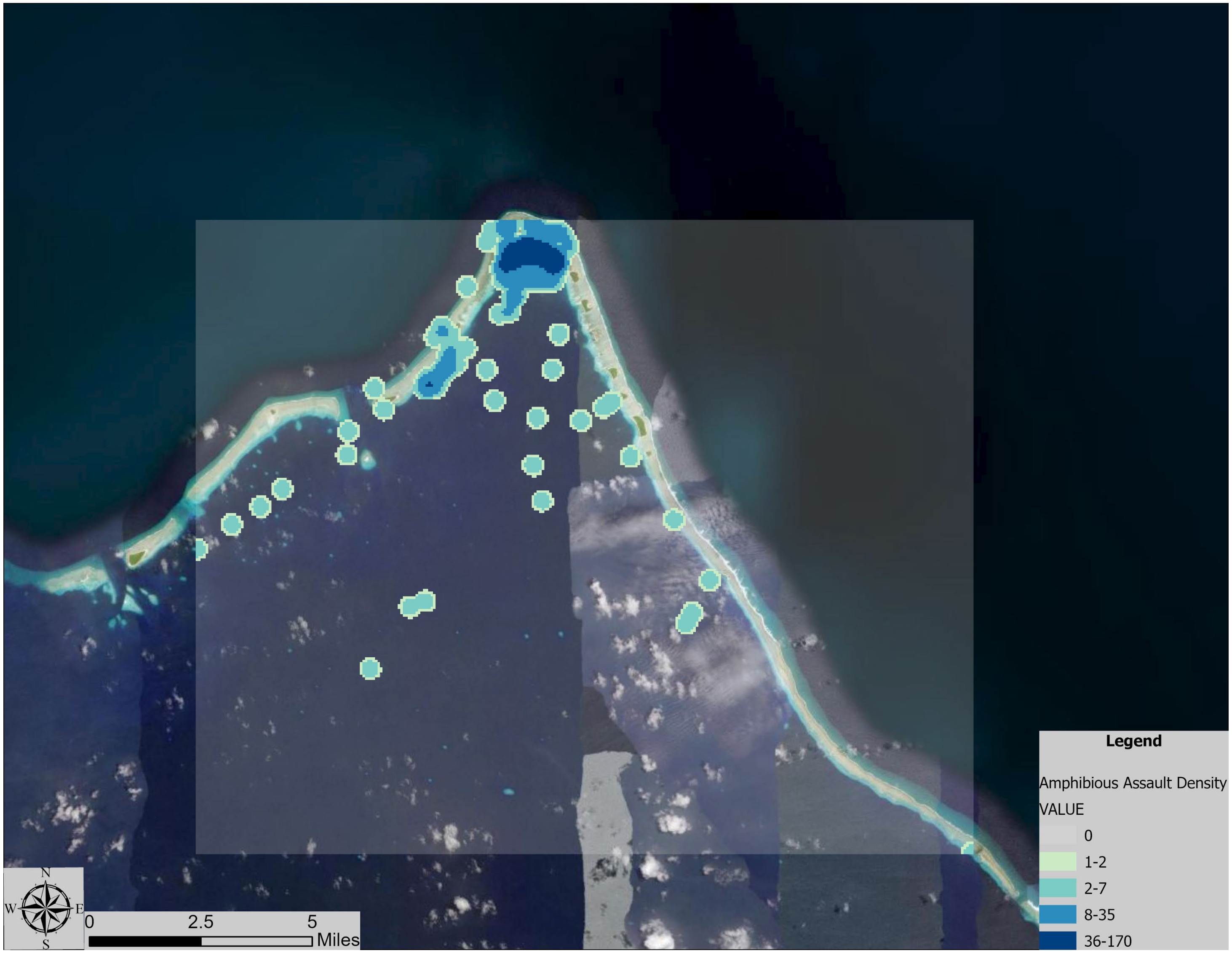

Figure 32 Map of kernel density of all components of Roi and Namur amphibious assault including wreckage and dumped vessels from post-battle operations (Image created by Author).

Bombardment Concentrations

A useful form of data analysis in battlefield archaeology is that of field of fire concentration analysis. This essentially considers specific areas of bombardment or other forms of attack. This type of study is useful for showing areas of concentrated attack and allows for better understanding battle progress and how the tactics used affect archaeological context. Although reading historic reports that describe targeted areas of a battlefield in comparison to other locations provides context, visualization of such data is often of more value. In the instance of the Battle of Roi-Namur, primary sources list the vessels tasked with targeting specific areas of the islands. All vessels involved in the bombardment kept extensive records detailing each target fired upon along with the time and number of shells fired (USS *NORTH CAROLINA* 1944:32-42). Such detailed information allowed for the application and execution of a field of fire concentration analysis which resulted in a better understanding of not only areas of concentrated fire, but also the reasoning for them through the analysis of Japanese defensive positions. The following figures depict various ways of portraying the data. Figure 33 displays the overall density of all Japanese defensive positions located on Roi and Namur through the use of kernel density analysis. For this map, the density concentration is represented by the frequency of Japanese defensive positions present. The more occurrences of Japanese defensive positions present, the darker the purple will be. This information is then enhanced in Figure 34, which highlights those areas according to the highest concentrations of fire by US forces. Figure 34 is represented in a different manner than the other analytical maps, as rather than utilizing a density analysis tool, the frequency of fire is represented through the symbology of the bombardment targets field. The higher the frequency of fire upon a zone, the darker red it is.

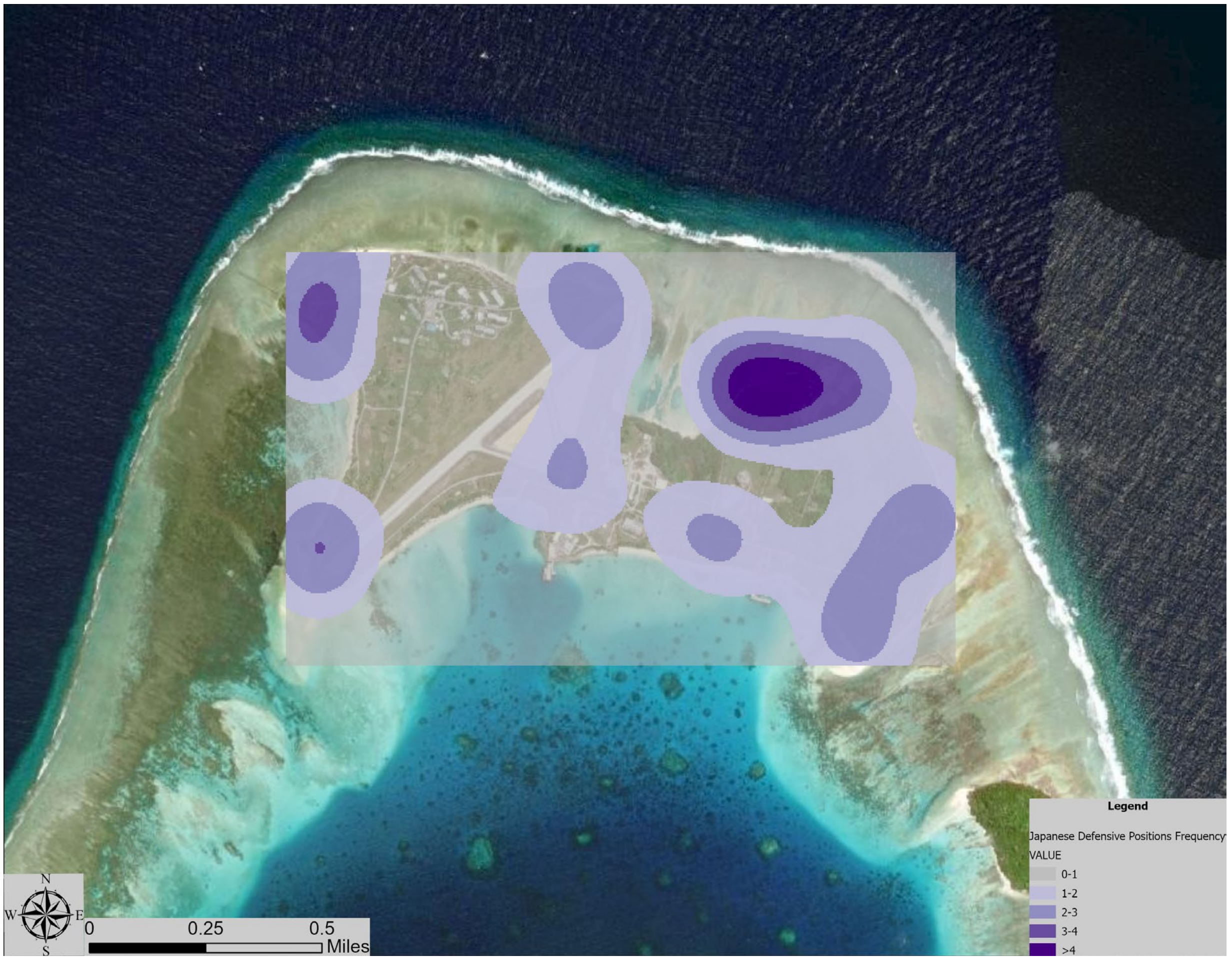

Figure 33 Map of density of Japanese defensive positions on Roi and Namur (Image created by Author).

Figure 34 Map of bombardment frequency of targeted zones on Roi and Namur (Image created by Author).

Through various analytical processes, the resulting data precisely shows which of the island's Japanese defensive positions took the greatest concentrations of fire. Comparing the concentrated fire for a previously assigned section of the island to the density map of all Japanese defensive positions (pillboxes, defensive buildings, and gun emplacements), provides further understanding of the development of the battle (CNSG 1944e:58).

Combining the two maps results in Figure 35, which shows the concentrations of fire overlayed on the highest concentrations of Japanese defensive positions. This map vividly shows the effectiveness of these well-planned bombardments. Though the island was essentially leveled by the frequency of fire, Figure 35 suggests that most initial bombardments targeted areas of highest Japanese concentration to facilitate the planned amphibious landing. Areas with less

Japanese defensive positions had very little fire concentrated on them. As this was a goal of the assault plan, the field of fire analysis clearly illustrates its successful execution. The results from the analysis also indicate that some areas of the island were largely ignored by US forces. Records indicate a rough estimation of Japanese occupation concentrating on the island of Namur (7^{th} Infantry Division 1944:7). This, alongside the spatial results, suggests that US battle planners relied on such reports to target Namur more intensely than Roi. It is important to note that while the results are based on the aforementioned information and spatial data, other forms of data may be missing from the dataset which could skew the information. Overall, the data portrayed in Figure 35 provides further insight into the tactical efficacy of the various plans and their effective execution.

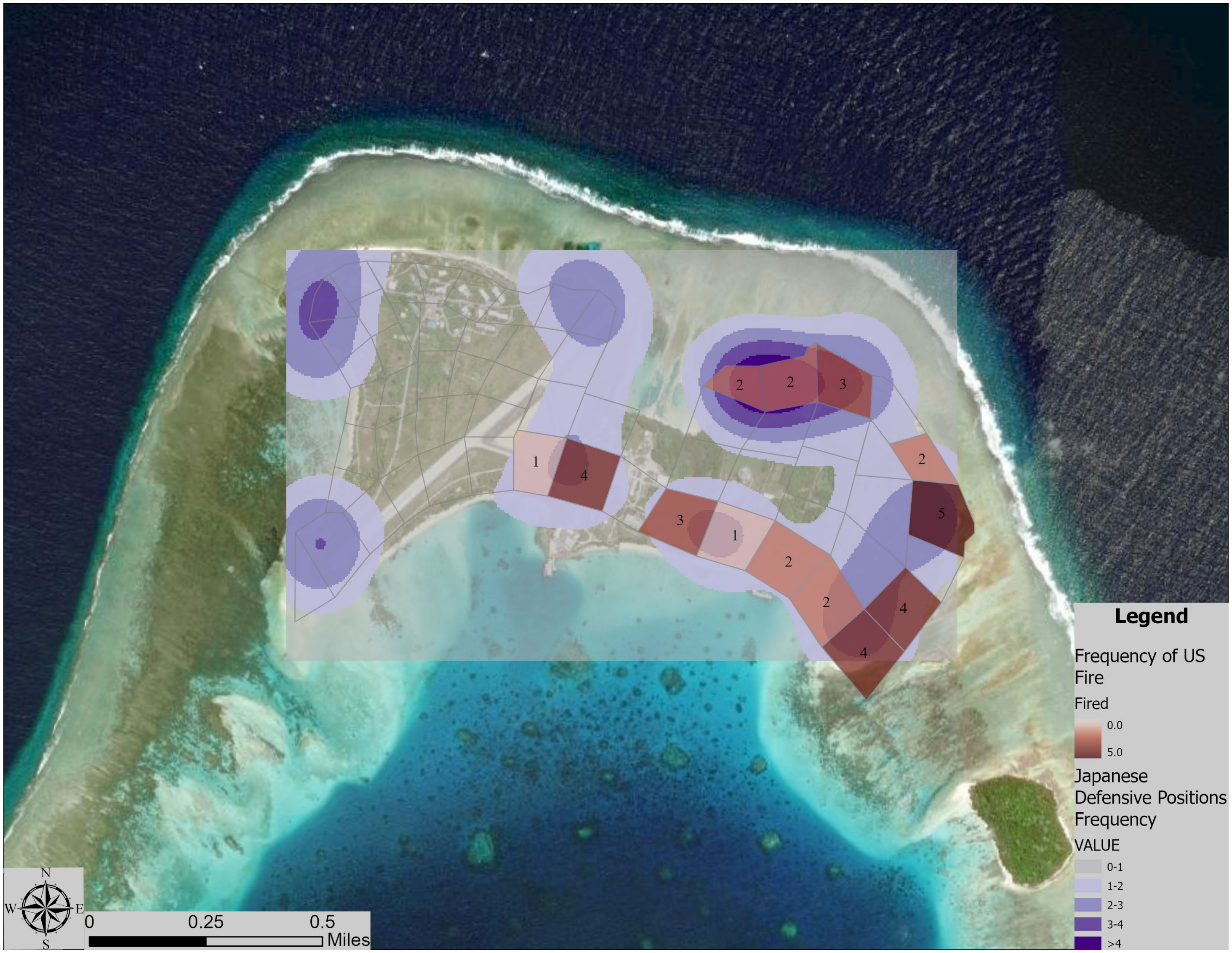

Figure 35 Map showing the density of all US targeted bombardments combined with the density of all Japanese defensive positions on Roi and Namur (Image created by Author).

Encroachments Of Levels of War

Perhaps the most interesting results gained through the various data analyses of this study are the previously illustrated ranges for the strategic and operational levels of war juxtaposed with the overall ranges of aircraft ranges used for this battle. Figure 36 depicts this analysis and suggests that although aircraft were implemented for the tactical level, their overall effective range (approximately 500 miles one way) surpassed the boundary of the operational level. The effective range of the carrier aircraft encroach upon the spatially represented strategic level. This in turn means that the overall range of those planes exists within the tactical, operational, and strategic levels. This presents the opportunity to discuss the inherent nature of the LOW framework and the importance of spatial location in the overall understanding and classification of the various levels.

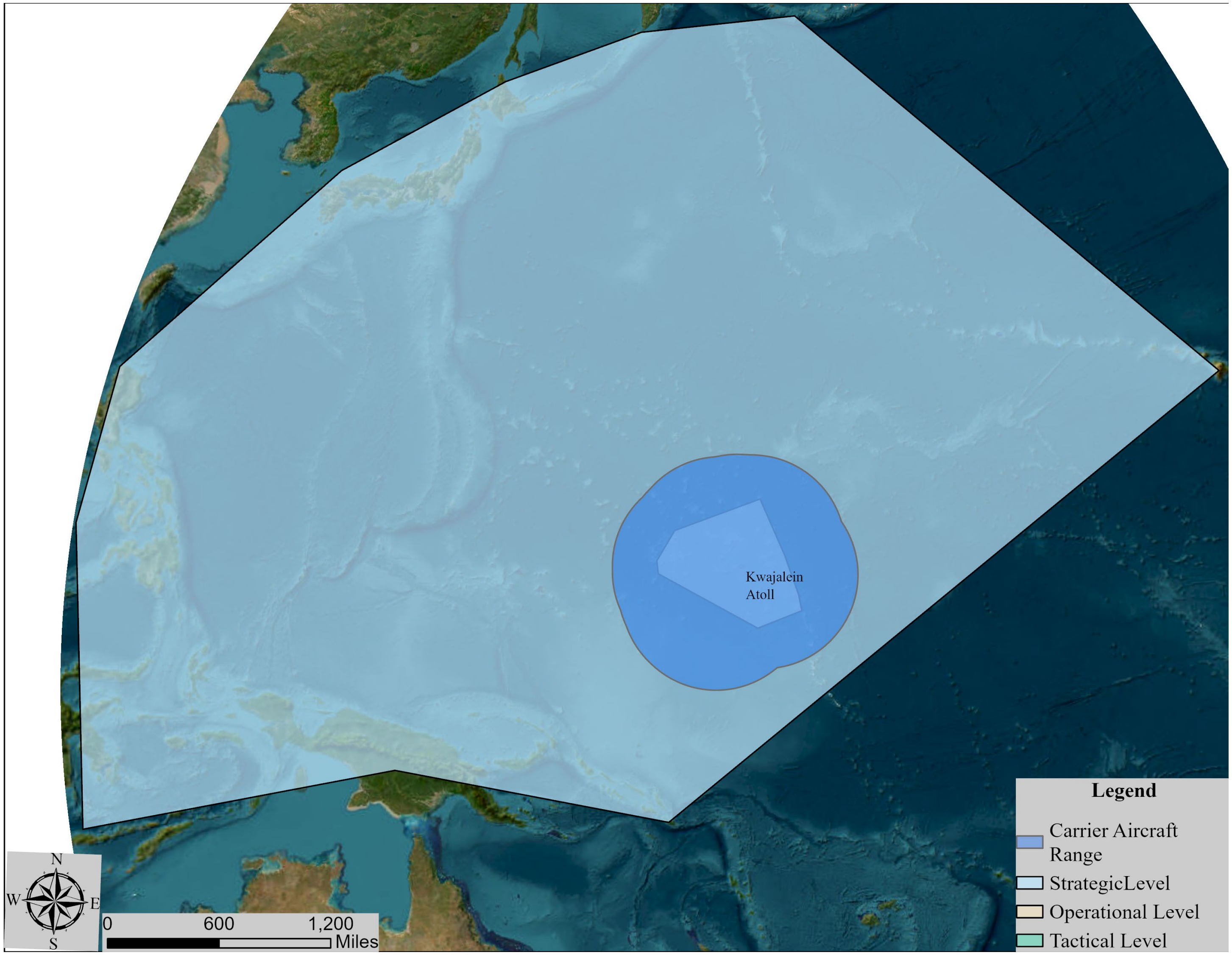

Figure 36 Map of US aircraft travel ranges encroaching the visual representation of the strategic level of the Battle of Roi-Namur (Image created by Author).

Figure 36 also brings to light an inherent issue within the LOW framework. Though described as being a tool to segment components of a conflict, the way in which that occurs is not clear. For the scope of this study, two of the components exceed the overall limit and classifications of the variables. The most obvious is that of the overall effective range of the aircraft launched from carriers. By encroaching upon all levels, the spatial position exists within all levels of war, yet was initially considered to be part of both the tactical and operational level due to the inherent purpose of the carriers and aircraft at the battle. By exceeding the boundaries of the operational level, it creates a conundrum that sparks discussion of the need for explicit defining parameters. The physical position of variables needs to be considered when determining what level it belongs to. Points exist both within the framework of the LOW, as well as outside of defined parameters. Overall, this suggests that the process of defining variables within the LOW framework should be reevaluated.

The other form of information that exists within the geodatabase is that of archaeological locations. All located wrecks and dumped vessels exist within the archaeological record and were created either at the tactical level or at the strategic level. Wrecks that formed whilst the battle was raging are part of the tactical level as they were directly involved in the fighting. Wrecks that were dumped into the lagoon post-battle fall within the strategic level since the act of cleaning up and expediting the departure of an occupied territory exists to fulfill the overall closure of the conflict and its constituents. By discarding the wrecks into the lagoon so the troops occupying the atoll can depart, the dumping itself falls under the umbrella of the strategic level.

Conclusion

The interpretative maps and representative images created for this thesis contribute to the overall analysis of the Battle of Roi-Namur. By extracting vital information from known data sources and applying analytical methods through GIS, new visual perspectives were gleaned. The impact of this study for future archaeological surveys around Roi-Namur is significant, as the representations of fields of fire and the high concentrations of lost and dumped vessels could be used for site predictive modeling. Overall, the incorporation and analysis of different datasets helped to better understand the wealth of information present within the primary sources pertaining to the Battle of Roi-Namur, as well as the Pacific Theater of WWII.

Chapter 7: Conclusion

This study views the Battle of Roi-Namur through the Levels of War framework, while using GIS as an analytical platform to acquire further insight into the conflict. Archival and archaeological datasets comprised the bulk of the information detailing the events of the battle. The combination of those methodologies was applied to determine if consideration of the LOW and GIS in tandem would elicit previously unknown information. Ultimately, this study highlights both expected and unexpected considerations regarding the battle, with visual representations of the battlefield aiding in its overall analysis. Each analytical methodology resulted in new data and further interpretations of the Battle of Roi-Namur. As such, this research holds great potential for helping to easily consider vast amounts of data to provide straightforward analyses and predictive models.

The theoretical principles of the LOW framework allow for a segmented view of the conflict. When combined with a multiscale approach of incorporating all relevant data, it becomes a powerful tool for visualizing each of the levels. The analytical processes performed within GIS were possible through this clear format of organization, with the results tying back to the original principle of interconnectivity described in the LOW framework. Thus, the overarching goals of this study were holistically satisfied through the combination of LOW and GIS analysis.

To establish the goals of this study, the historic and archaeological record were considered and that information available became the foundational dataset for the study. All individual components utilized for later assignment in the LOW were first established. This allowed for the introduction of the theoretical frameworks of battlefield archaeology and LOW, which are core concepts for this study. Following this, the incorporation of historical data into

GIS was carried out, wherein the bulk of the analytical processes occurred. Through this amalgam of data creation, manipulation, and execution of relevant tools, the questions established at the beginning of the thesis were all sufficiently answered. Ultimately, this research resulted in a unique analysis for the Battle of Roi-Namur. The merits of GIS application in battlefield archaeological studies are seen in the variety of analytical processes utilized and the visual representations produced.

The use of GIS visualization through a multiscale approach and LOW analysis provided new insight and further illumination into the Battle of Roi-Namur. Throughout the thesis, a range of maps, charts, and graphs were created as outputs of various analytical processes (Sanchagrin 2013:44-65). All these products provide visual representations of previously unplotted information. This was preceded by the creation of new methods of viewing, interpreting, and understanding the logistics and tactics employed at the battle. And while more research would likely provide further information to consider about the battle, the results of the study offer a cohesive combination of methodologies that enhances understanding of the events and outcomes of the conflict.

LOW analysis and the GIS multiscale approach derived pertinent information regarding the efficacy of the tactical plans utilized by Allied and Japanese forces at the Battle of Roi-Namur. Throughout the various methods employed, several analytical processes resulted in the clarification of the inner workings of the US bombardment plan of Roi and Namur in relation to the overall density of Japanese defensive positions. This explicitly covers the tactical side of the battle within the visual representation shown through GIS. Though the tactical plans of US and Japanese forces are present in nearly every aspect of this study, the explicit extraction of further information from the bombardment concentration analysis is clear. US forces focused most of their bombardment efforts to target the areas with the highest concentration of Japanese defensive positions on the South side of Namur to ease the amphibious invasion of US landing forces on both islands. The results of this data analysis prove that the utilization of a GIS analytical approach alongside a LOW framework can derive pertinent information regarding tactical decisions.

The processes outlined in Chapter 4 are directly conducive to understanding the role of GIS in visualizing historic records pertaining to the Battle of Roi-Namur. Throughout the various maps and images created for this study, the utilization of historic records was georeferenced in GIS to input information as accurately as possible. Though some information was inferred, such as when plotting variables drawn from written primary sources into GIS, several other forms of data were conveyed through historic maps, such as the track maps of all US bombardment vessels and the positions of the US plan of amphibious assault (USS *Hickox* 1944:7). By georeferencing those images and utilizing written data from historic sources, the historic record was incorporated into GIS. The way each portion was implemented and visualized depended upon the data's format. Though the historic record can be visualized in several ways, this thesis provides a new technique for bringing them to life in ways previously not applied to the Battle of Roi-Namur.

Finally, GIS was shown to be useful in aiding the analysis of archaeological data pertaining to the Battle of Roi-Namur. The maps and results created for the scope of this thesis entail a large swath of information pertaining to archaeology, such as utilizing kernel density analysis to find areas of higher concentrations of dumped sites. Areas of high concentrations of Japanese defensive positions, in conjunction with bombardment patterns, also highlights areas of potential survey due to the possibility of buried archaeological material. All this data is representative of the archaeological record of the battlefield. Within these maps lies the overall concentration of the areas for lost or dumped vessels or aircraft. As such, the density of the areas that hold the highest concentration of sites provides a valuable tool for future archaeological surveys. Other maps of the battlefield also provide insight for archaeological research, such as field of fire concentration maps that portray the areas most impacted by bombardment. These areas can be indicative of unexploded ordinance or wrecked Japanese defensive positions both on land and in the water that have yet to be identified. Thus, all the maps created hold merit for future archaeological studies given the depth of information each provides.

Conclusion

Through its goal of determining the efficacy of combining GIS visualization through a multiscale approach with the LOW framework for the Battle of Roi-Namur, this thesis resulted in the creation of a multifaceted discussion of the battle. This combination of methodologies provided new ways of viewing information and enhancing previously known data. The results offer a new approach to understanding battlefield analytics and provides a platform for cataloging data that will collectively provide further comprehension of conflict sites. The geodatabase created from this study produced a methodological approach of extracting previously ignored information from the battle alongside furthering the potential for its future application. Though it is easy to focus on the results this combination of methodologies provides, it is important to emphasize the avenues of further understanding the approach could initiate.

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