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Teaching Military Geography Through GIS: Re-evaluating the Defense of Revolutionary War West Point

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TEACHING MILITARY GEOGRAPHY THROUGH GIS: RE-EVALUATING THE DEFENSE OF REVOLUTIONARY WAR ERA WEST POINT

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1. INTRODUTION

Teaching the subdiscipline of military geography as an applied field can be greatly enhanced by the use of Geographic Information Systems (GIS). Battlefields of the past can be visualized and explored in the present using the robust suite of tools available in GIS. The ability to analyze the terrain through GIS and understand how military planners used key terrain features to their advantage is a powerful pedagogical tool for instructors of military geography courses. One way to employ GIS as a teaching tool is in the context of "GIS staff rides".

Staff rides are traditional practical exercises that military leaders use to engrain critical lessons learned from historic battles. A staff ride includes a brief literature study of a specific battle and culminates in a battlefield walkthrough by the junior and senior leaders of a military organization. Leaders (the teachers) guide their subordinates (the students) through the sequence of the studied battle, prodding them to analyze decisions made during the din of battle on the very same ground on which the battle was fought. In the teaching of planning and conducting land warfare, these exercises are enormously useful in understanding the importance of terrain in battle among other things. This paper examines how we use GIS to enhance this type of experience for rising military leaders soon to graduate from the United States Military Academy at West Point, New York.

Prior to graduation from the academy and subsequent matriculation into the officer corps, both Geography and GIS majors complete a capstone military geography course. The purpose of this course is to provide the young leaders an integrative geographic experience – making the subject matter relevant while using the modern tools of the trade. Because the course is integrative in nature, it draws together all the geographic skills and knowledge the students have learned in their respective curriculum. All students in the capstone course have also taken a basic GIS course and are familiar with the principals of geographic information science. Therefore, we can easily incorporate GIS analysis into several military geography case studies. One such study involves the military geography of West Point, the oldest continuously occupied fort in the United States and an especially convenient local resource for teaching students the subject matter.

West Point played a crucial role during the American War of Independence because of its geographical site and situation. Located along the west bank of the Hudson River in the Hudson Highlands region, this fort occupied a dominating strategic position overlooking a sharp bend in the river. The "river" adjacent to West Point, more correctly thought as an estuary and interestingly the southernmost fjord in the northern hemisphere, offers commanding high grounds above the banks. During the war, the Hudson River-Lake Champlain corridor was a vital north-south artery for transporting British troops and supplies from New York City to Canada (Crackel, 2002; Galgano, 2004; Palka, 2004). Furthermore, the river essentially separated the New England colonies to the east from the mid-Atlantic colonies to the west (Galgano, 2004). Controlling key river crossing points in the Hudson Highlands was crucial as the majority of colonial troops during the Revolutionary War came from New England (Boynton, 1863). West Point was thus a critically strategic location during the war. The Continental Army immediately recognized the significance of the terrain and began to fortify the area early in the war (Miller *et al*., 1988).

One of the key learning objectives of the West Point case study is for the student to understand that as a result of terrain and resources, the river was defended not with one immense fort but with an array of complementary fortifications (Fig. 1). Furthermore, a massive 65 ton steel chain was strung nearly 500 meters across the river to further deter and impede the movement of ships. Fort Clinton, the linchpin of the system, overlooked the steel chain across the river and was protected by Fort Putnam which occupied high ground to the rear or one kilometer southwest of Fort Clinton. In addition, numerous supporting redoubts were strategically placed along the river and on high ground to cover likely British approaches by land (Galgano, 2004) (Fig. 1).

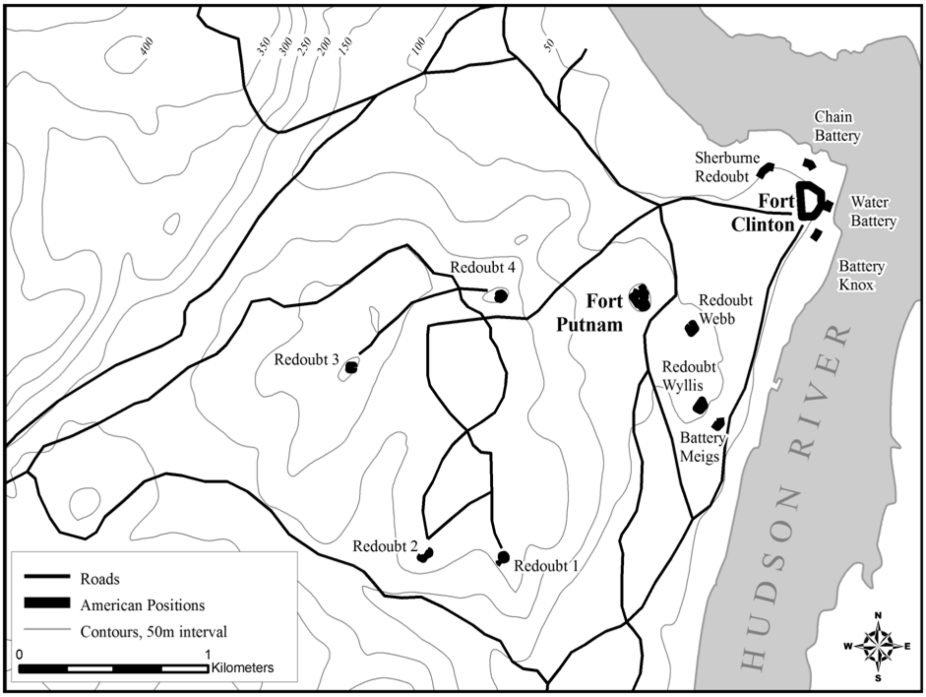

FIGURE 1
WEST POINT FORTIFICATION NETWORK

Fort Putnam is the most well preserved fortification and exists on prominent terrain overlooking the campus. Fort Clinton, on the other hand, is difficult to distinguish because it is poorly preserved and is therefore often forgotten in history. As a result many students and other visitors hold the common misconception that Fort Putnam was the central fortification in the West Point defensive strategy, when in fact Fort Clinton was the primary fort defending the river. The visualization capabilities and powerful spatial algorithms of GIS provides a mechanism for students to explore and analyze the West Point fortifications and find out for themselves the logic of this defensive system and the primacy of Fort Clinton.

Through the use of GIS, students come to understand the different roles of Fort Clinton and Fort Putnam by analyzing the visibility from each fort and also analyzing each fort and redoubt's susceptibility to being engaged from surrounding high ground. The savvy student realizes the logic of covering the high ground; however, there are areas of high ground that are not protected by a redoubt in the system of defenses. To help students explore this aspect of the fortification network, we provide a least-cost path algorithm which considers potential British infiltration routes into the rear of the fortification network from a landing point south of West Point. The least-cost algorithm primarily considers topography, specifically the slope gradients to be encountered by marching armies. A higher-cost path is considered a high-friction surface and would be significantly steep in gradient. Lastly, we ask students to consider where one additional redoubt could be located. Using all the tools available to this point, they analyze the fortification system and propose a location for an additional redoubt. In this way, they begin to see for themselves the interconnected nature of the fortification system. This type of self-discovery process, often referred to as "active learning", is the teaching strategy employed during this project.

Active learning involves teaching techniques where the students must read, write, discuss topics, or conduct problem solving (Bonwell and Eison, 1991). A significant amount of research suggests that active learning methods are a powerful technique for student learning (Bonwell and Eison, 1991; Nilson, 2010). Saville *et al*. (2005) conducted a study using various teaching techniques and concluded that participants utilizing active learning methods performed significantly better on evaluations than those that were given instruction using other methods. Continued research by Saville *et al*. (2006) compared active learning types to lecture at the graduate-level as well as undergraduate level and found active learning techniques resulted in higher exam scores and that students preferred active learning to standard lecture practices. With this approach in mind, we present the students with a problem (how to fortify West Point) and ask them to come up with their own solution using GIS as an analytical tool.

2. IMPLEMENTING THE STUDENT ACTIVE LEARNING METHOD

Terrain structure played a pivotal role in the establishment of this defensive network. In this project, students are asked to conduct a detailed military analysis of the West Point terrain. The GIS exercise illustrates the importance of this terrain through a variety of visualization techniques, including line-of-sight (LOS), an algorithm that depicts the effectiveness of plunging artillery fire, and least-cost path analysis. Specific questions are asked and all the data necessary for the analysis are given to them. Map products requested in the final report include: a reference map of West Point and the area fortifications, Fort Clinton and Fort Putnam LOS analysis maps, Fort Clinton and Fort Putnam plunging fire analysis maps, a British path analysis map, as well as some similar products for the surroundings redoubts. Because much of the area analyzed via GIS is located on the West Point campus, the students are able to ground-truth their GIS products in the field by comparing their results in the computer lab to the actual terrain, which has seen only subtle change since the Revolutionary War period.

2.1 VISIBILITY ANALYSIS (LINE-OF-SIGHT)

Consistent with its Appalachian setting, the topography in and around West Point is mountainous and is often referred to as the Hudson Highlands incised by the Hudson fjord. Given this amount of relief, it is important for students to explore the different visibility characteristics of the forts and redoubts. Students are provided a digital elevation model (DEM) of the region and the locations of the forts and redoubts. With this data they employ a standard LOS analysis for various locations with an emphasis on Forts Clinton and Putnam. The key learning objects is for the students to come to realize that Fort Putnam does not have good visibility of the Hudson River whereas Fort Clinton does.

2.2 PLUNGING FIRE ANALYSIS

Students continue their exploration of the West Point fortification system by calculating the ability of an enemy positioned on overlooking high ground to fire down into a fort or redoubt. This type of artillery employment is known as plunging fire. This ability of a position to achieve plunging fire over a fort or redoubt is a function of the relative height, the

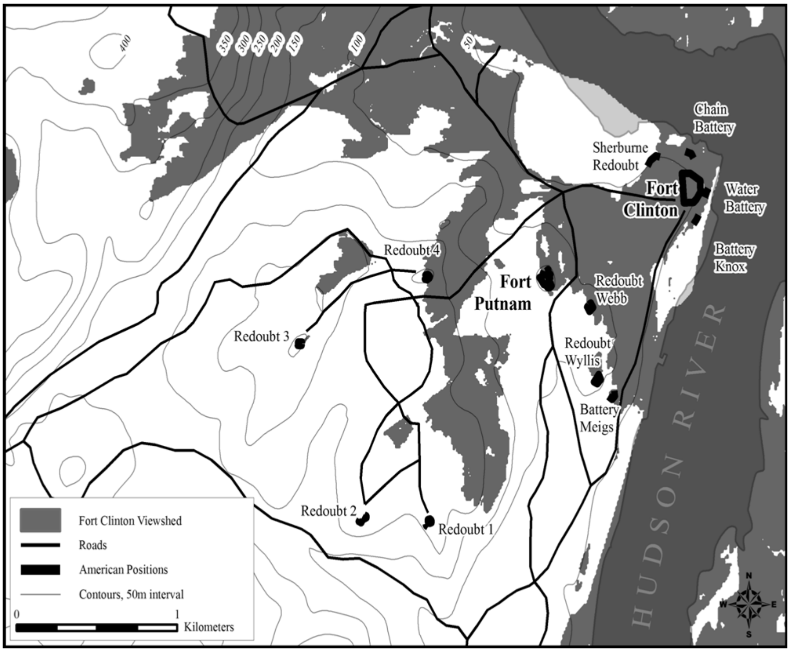

FIGURE 2
FORT CLINTON VIEWSHED

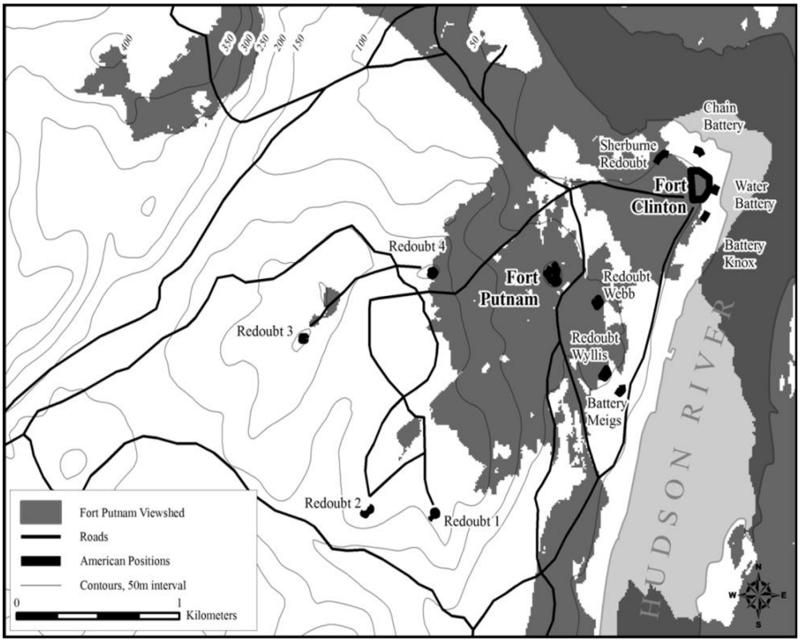

FIGURE 3
FORT PUTNAM VIEWSHED

distance between the two positions, and the wall height of the fort or redoubts. A custom tool was developed that allows the students to determine what locations on the battlefield can achieve dangerous ‘plunging fire’ effects into that respective fort.

The key learning point in this portion of the case study is for the students to determine that Fort Putnam is occupying the most prominent and dangerous high ground overlooking Fort Clinton. Moreover, the perceptive students should continue their analysis and use of this custom tool to analyze what terrain can achieve this plunging fire effect into Fort Putnam, and then realize that redoubts were built at those locations as well.

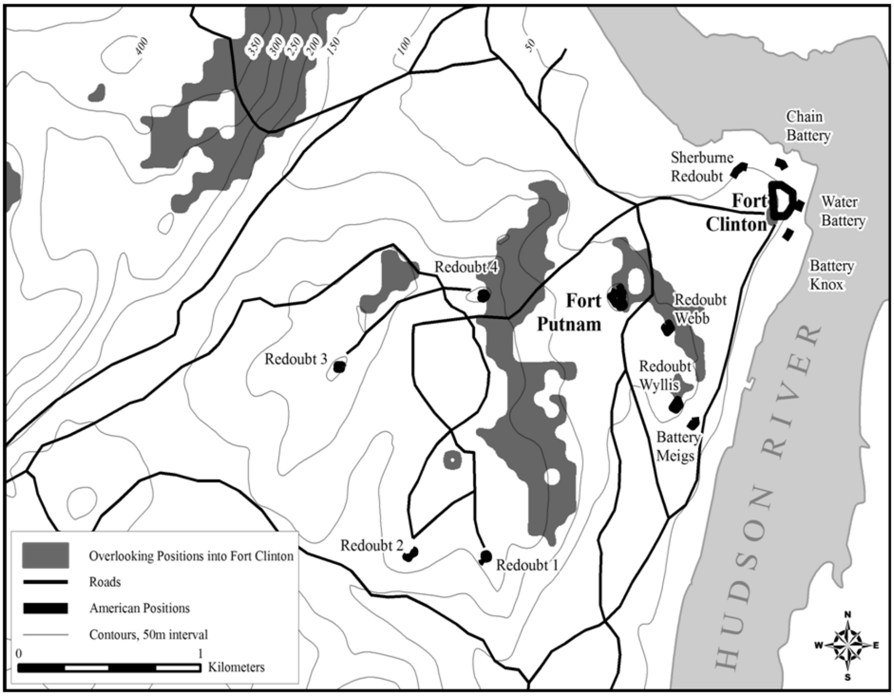

FIGURE 4
OVERLOOKING POSISITONS INTO FORT CLINTON

2.3 BRITISH PATH ANALYSIS

The students are asked to consider a scenario in which the British land south of West Point and an attempt to take the fortification system from the rear. The question for the student to consider is what possible routes the British could take, how long would it take for them to travel these routes, and how effective were the fortifications against this option.

The students are provided a simplified *friction surface* that assumes a march rate of 100 meters per minute on flat open terrain. These rates are adjusted to account for variations in slope angles, stream crossings, and road networks. Using this friction surface, students run least-cost path algorithms from a possible British landing point to various forts and redoubts. The resulting product provides possible paths the British could follow to attack the fortifications.

A student example of a map predicting the routes British forces would take based off the developed model above is shown in Figure 5 below.

3. LEARNING OUTCOMES AND DISCUSSION

After students conduct the laboratory analysis and complete their write up reports, they are taken on a tour of the grounds of the West Point defensive preparations – essentially a scaled down staff ride. It is during this culminating phase where students recognize the value of their GIS laboratory work. They see for themselves the visibility afforded at each fortification and can look up at potential dangerous overlook positions. In this ground-truthing phase, abstract knowledge becomes concrete.

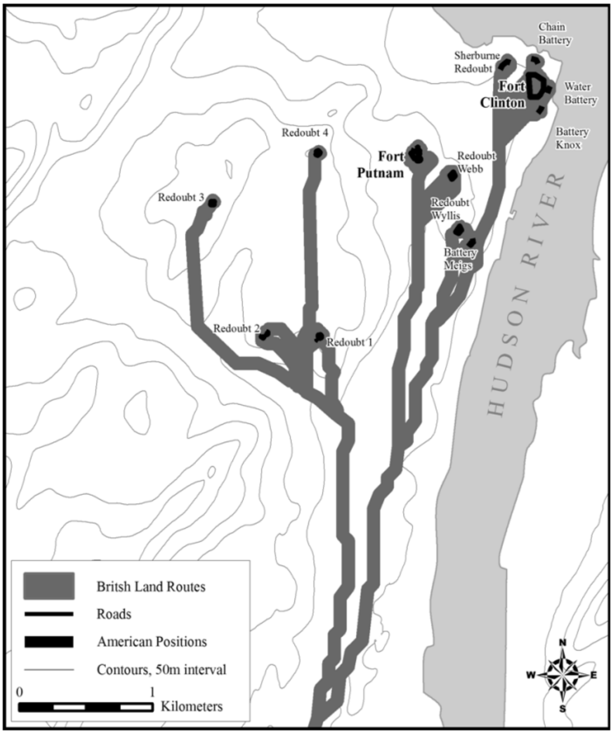

FIGURE 5
CALCULATED BRITISH OVERLAND ROUTES

Student reports varied in terms of their findings, but the active learning approach consistently proves effective in providing an opportunity for self-exploration and discovery. Through this hands-on exploration, the student becomes aware that Fort Putnam occupies the dangerous high ground to Fort Clinton's rear. In the same way, they come to realize certain redoubts occupy the high ground overlooking Fort Putnam. Moreover, students discover that the redoubts also helped to provide early warning of British forces attempting to infiltrate the main defenses of West Point. The terrain walk element of the project provides mixed results, as the area is heavily vegetated at present, whereas the forest was stripped in the late 1700s. Thus, the visibility from forts and redoubts is not as ideal today as it was in the Revolutionary War period. Nonetheless, line-of-sight at these fortifications was still good enough to illustrate the logic of the emplacement of the fortifications. Students did not walk all the routes of their proposed British paths to the fortifications, but they were able to visualize alternate routes on the installation proper that the GIS analysis did not propose. The limitations of a least-cost path analysis were evident in that it provided the most likely routes of advance, and not necessarily the most difficult or dangerous. Most students do an excellent job selecting an alternate position for redoubts that would cover other likely avenues of approach for British forces.

4. CONCLUSION

In this paper, a military geography project was described that uses GIS to conduct a modern analysis on the Revolutionary War West Point area fortifications. The positions were originally intended to reinforce the defenses designed to prevent British infiltration into the Colonial interior by way of the Hudson River. This particular exercise provides a unique perspective to the traditional staff ride in that it gives students the opportunity to analyze the battlefield through the lens of GIS prior to walking the ground. In the greater pedagogical context, it subjects the students to the active learning model previously described producing the desired deeper level of learning through application. The students are able to see how these same ranging and siting techniques can be applied in today's operating environment whether they are establishing a defensive position, a signal communication network or any other military application requiring a detailed terrain analysis. Moreover, the students are afforded the opportunity to realize the power of this spatial information tool which transcends the battlefield.

The use of all these diverse applications in GIS illustrates to the students the power of GIS technology and how it will be important to them in their military profession. In a relatively short time, most of these students will find themselves conducting detailed intelligence preparations of their "battlefields" or operating environments that they will not physically see as they conduct planning for a deployment to that area. West Point graduates who successfully completed this exercise are better equipped to reach for the geospatial information. These future army leaders gain a better understanding of the different GIS products available to them, as well as, the benefits and limitations of these GIS products their organization can use during the planning phase of an operation.

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