2001

Archaeological Application of the Metal Detector

Wayna L. Roach
College of William & Mary - Arts & Sciences

Recommended Citation

Roach, Wayna L., "Archaeological Application of the Metal Detector" (2001). *Dissertations, Theses, and Masters Projects*. Paper 1539626294.
https://dx.doi.org/doi:10.21220/s2-jnkc-qy07

ARCHAEOLOGICAL APPLICATION OF THE METAL DETECTOR

A Thesis

Presented to

The Faculty of the Department of Anthropology

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

by

Wayna L. Roach

2001

APPROVAL SHEET

This thesis is submitted in partial fulfillment of

the requirements for the degree of

Master of Arts

Wayna L. Roach

Wayna L. Roach, Author

Approved, April 2001

Dennis Blanton

Marley Brown III

Kathleen Wheeler

Kathleen Wheeler

Director

Independent Archaeological Consulting, LLC

DEDICATION

To my parents who never said I couldn't, and to Alyssa and Boo who always said I could.

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ACKNOWLEDGMENTS

The author would like to thank Professor Dennis Blanton for generously allowing the first metal detector field trials and for his guidance throughout this project. I would also like to express gratitude to Professor Marley Brown III for his helpful criticism and timely advice during the process. I am deeply indebted to Dr. Kathleen Wheeler for her insightful comments and enthusiasm for the project. All of the field trials in New England were conducted under Dr. Wheeler as part of larger projects under her direction. I also need to thank Ellen Marlatt for assisting with all those technical details and I want to extend a special thanks to Peggy Marlatt who graciously provided me with room and board during my defense.

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ABSTRACT

Metal detectors are widely viewed by professional archaeologists with much disdain and distrust. The widespread destruction of historic sites has become so intimately associated with these machines that most archaeologists want little or nothing to do with them. Yet the metal detector operates on many of the same geophysical principles as other remote sensing devices used frequently by archaeologists. And when compared to other remote sensing devices, the metal detector is less expensive and yields results that are easier to interpret than many other methods.

Metal detectors operate by producing a signal that is affected by metallic objects within its range. Although detectors vary, modern detectors are designed to be easy to use and give dependable results despite changing soil conditions. A few archaeologists have been using metal detectors at sites across the United States and in the United Kingdom. The results of these surveys serve to illustrate how metal detectors can be used for archaeological survey and the positive effects of their implementation.

As a way of supporting and advocating the professional use of metal detectors on archaeological sites, a series of field trials were conducted in the eastern United States. The results of these surveys were used to develop general rules that can be used by archaeologists to guide further use of metal detectors as remote sensing devices.

ARCHAEOLOGICAL APPLICATION OF THE METAL DETECTOR

Introduction

The mention of metal detectors for some people immediately conjures the image of the hobbyist with headphones, combing the beach for old coins or lost jewelry. Others imagine a darker picture - that of the illicit digger using a metal detector on sensitive archaeological sites in order to find artifacts for resale on a lucrative market. In either case, metal detectors are strongly associated with amateurs and hobbyists, and in the archaeological world, the machine is well known as a tool used by those who wish to enhance personal collections or line their pockets. This unfortunate association has succeeded in camouflaging a machine that could be very useful to the professional archaeologist.

Metal detectors as an archaeological tool are widely viewed by the professional community with much disdain and distrust. The stigma is so strong, some archaeologists would rather do almost anything than resort to the use of a metal detector on a site. Yet the metal detector operates on many of the same geophysical principles as other remote sensing devices used frequently by archaeologists.

Despite this fact, the metal detector has never been one of the standard tools of the archaeologist. Much information has been recovered through standard methods of surface collection and subsurface testing, and these methods have reams of professional writing to detail their correct implementation. Archaeologists are inculcated with the standard methods that have been proven effective for finding sites and recovering artifacts. To use metal detectors appears to some, to be indulging in the use of a toy and most professionals see no need for it.

This thesis seeks to explore the concept of the metal detector as a remote sensing device that has been underutilized by archaeologists. The introduction is an assessment of the current status of the metal detector and the reasons professional archaeologists neglect their use. In Chapter 2, a review of established remote sensing tools will be undertaken in order to give background to the discussion of the metal detector. Remote sensing devices discussed in this chapter include aerial photography, thermal photography, digital imagery, resistivity and conductivity, the use of magnetometers, and ground penetrating radar.

Chapter 3 extends the discussion of remote sensing by introducing the metal detector as a remote sensing device. This discussion will include a description of the metal detector's basic components, and an explanation of the electronic principles upon which it operates. This chapter will also specify the advantages that may be gained by using metal detectors during archaeological survey.

There are already a few archaeologists who have incorporated the use of metal detectors in their testing strategies, and Chapter 4 will outline their work. The most well known example is the use of metal detectors by archaeologists working at the Little Bighorn Battlefield in Montana during the 1980s. However, the use of metal detectors on historic and prehistoric sites began in the 1940s and has been implemented in the United States at sites in Wyoming, Texas, New Jersey, West Virginia, and also in Canada and England.

Chapter 5 will suggest a methodology to be implemented when using a metal detector. The methodology is based in part on field trials conducted for this study.

I hope to demonstrate that the metal detector is a good tool put to a bad use. The damage done to archaeological sites by hobbyists with metal detectors has successfully sullied the image of these machines. Moreover, hobbyists are common in all parts of the nation and many archaeologists have had unpleasant encounters with them. Together these factors create a strong association of the machine with amateur work and the disturbance of sites. Yet all the damage done does nothing to change the fact that the metal detector is a remote sensing device that can indicate the presence of metal artifacts without disturbing the soil. Archaeologists should bear in mind the fact that shovels are just as necessary to looters as a metal detector and archaeologists would never think of abandoning the use of shovels. The key is how the tool is used, not the tool itself.

Chapter I

Remote Sensing

In his book titled *Archaeology*, David Hurst Thomas defined remote sensing as "The battery of nondestructive techniques used in geophysical prospection used to generate archaeological data without the need for excavation" (Thomas 1989). In less technical language, remote sensing is one way of gathering information about a site without actually doing any digging.

Although remote sensing techniques are in frequent use today, prior to World War II, remote sensing methods were generally of a primitive nature and only rarely utilized. In the 1890s General Pitt-Rivers, an early archaeologist, commented that pounding the ground with the flat side of a pick head could indicate features. He described "...the sound produced by hammering on an excavated part is much deeper than on an undisturbed surface" (Clark 1990: 11). Though quick and simple, it is easy to see that the utility of this method would be limited.

Another early method with less limited application is aerial photography. Aerial photography was developed during the American Civil War when photographs (newly developed technology) were taken from hot air balloons (more newly developed technology). During World War I, many aerial photographs were taken in Great Britain and it was at this time that people realized these photographs were revealing more than the enemy's position. Old roads, trails, and walls appeared in shallow relief (Sever 1995).

These features were readily seen in an aerial photo, yet difficult or impossible to see on the ground (Scollar et. al. 1990).

Another method that developed rather early on was phosphate detection. During the 1920s in Scandinavia researchers discovered elevated levels of phosphate in the soil was an indicator that human or animal waste products had been deposited at a site in the past. These elevated levels are not achieved by limited usage, but develop when a site is occupied or re-occupied for some time. In this way, elevated phosphate levels can be an indication of prolonged occupation of a site (Lambert 1997). This particular method is still in common use today.

However, all of these methods were truly in their infancy before World War II. It was only in the late 1940s and 1950s that remote sensing methods were recognized to be useful for archaeologists' work. It was also at this time that many of the electronic and mechanical military technologies developed for World War I and II became available to the scientific community. The improvements in technology, coupled with a growing sophistication and professionalization of archaeology created a surge in the application of remote sensing methods to archaeological survey.

This movement was brought on in part by Gordon Willey and his original use of aerial photographs. Willey's settlement survey in Peru is perhaps one of the best examples of the use of aerial photographs as a method of detecting sites. With the help of J. A. Ford, Willey's fieldwork was conducted in 1946; their aim was to carry out a systematic search for sites throughout the Viru Valley in Peru. Willey hoped to cover the vast area not on foot, but by air, and through the subsequent examination of black and white photos. From this survey, Willey hoped to discover a large number of sites and develop theories about human settlement patterns in this part of Peru. This was a new avenue of archaeological research, and the sheer size of the project necessitated the use of these survey methods. Once a site had been tentatively identified from the aerial photo, a more traditional visit was made on foot or by vehicle. Willey used this method with great success, even creating site maps from the aerial photos before going into the field (Willey 1974).

Since then, remote sensing methods have been used with increasing regularity and success. Earthworks are commonly surveyed with resistivity meters that measure the degree of electrical resistance in the soil; when the results are plotted, virtual pictures of underground ditches, bulwarks, or walls appear (Scollar et. al. 1990). All this is possible without disturbing the site itself, which is sometimes necessary on protected sites or landmarks (Coles 1972). Magnetometers, which are capable of detecting magnetic areas in the earth, are widely used as well, often to record the remains of thermal features, such as hearths and kilns (Clark 1990; Goodman, Nishimura, and Yamamoto 1994).

In the United States, these methods became a part of the 'New Archeology' movement, when archaeologists hitched their trade to the hard science wagon. The movement was typified by interdisciplinary efforts aimed at understanding the processes at work on archaeological sites, and the almost obsessive compulsion to measure all that could be quantified. Typically, remote sensing devices helped archaeologists figure out where sites were located by measuring various qualities inherent in the soil. These qualities included how well or how poorly soil would conduct electricity, or how quickly radar waves would bounce back when sent into the ground. Based on scientific procedures borrowed from other disciplines, archaeologists were putting the gains of science to work for them.

Remote sensing devices were also time and effort saving machines that could, in certain ways, take the place of shovel testing. They could sometimes give a better picture of what lay under the surface than excavation. In addition, they could be implemented more quickly than the physically demanding exercise of shovel testing.

In today's "post-processual" or "post-post-processual" world, remote sensing has continued to enjoy common application. In fact, remote sensing may be considered more useful today than ever, due to increasing pressure to get the most archaeological bang for the tax or grant buck. Methods of remote sensing, when applied to a site prior to excavation, allow archaeologists to focus limited resources. Furthermore, in a time of increasing conservation and curation costs, it helps to learn as much as possible can about a site while at the same time generating a minimum of material.

Remote sensing methods and benefits

Remote sensing methods, varied as they are, can generally be divided into two categories. These are geophysical surveys and chemical surveys. Geophysical surveys take advantage of natural properties of the soil and the materials within it to learn about a site. These surveys involve an electronic device of one type or another that sends and receives a signal. The process of sending and receiving a signal is carried out at regular intervals as the machine moves along a grid superimposed on the site. The signal is recorded, printed on paper or a computer screen, and interpreted by the operator. Surveys of this type are capable of detecting underground features such as graves, tombs, tanks, walls, and ditches. Ground penetrating radar, magnetometry, and conductivity and resistivity measurements are all examples of geophysical surveys (Barker 1995).

Chemical surveys are quite different from geophysical surveys. These studies involve collecting soil samples from a site that are subsequently tested for specific chemical components. These tests are conducted based on the premise that when certain activities occur for a period of time in an area, the chemical make-up of soil is altered in specific ways. Therefore, the presence of certain chemicals or elements can be indicative of the past occupation of a site. The success of these surveys depends upon the types of soils present and the relative concentration of the chemical or element in the soil. Examples of chemical surveys include testing for phosphate to detect the presence of organic wastes, calcium to indicate past food residues and burials, or mercury which can indicate the occurrence of fish harvesting and consumption (Dincauze 1976; Lambert 1997).

The type of survey selected is usually based upon the specific needs (and budget) of the project. No matter which methods are employed, the benefits are always multiple. First and foremost, remote methods of surveying a site can provide valuable information while destroying virtually none of the site. During standard excavation, although archaeologists attempt to record everything, it is obviously not possible to preserve every detail. By its nature, excavation is a process that cannot be replicated or repeated. Most of the soil will be discarded after being combed for cultural materials. Usually only samples are taken of abundant materials and artifacts like charcoal, bricks, and coal. With remote sensing, the quandary over what to keep and what to throw away is eliminated. Moreover, when excavation is undertaken, subsurface features can be specifically targeted for excavation with a minimum of disturbance to the rest of the site.

In cases where sites are large and complex or time constraints severe, remote sensing can help prioritize one portion of the site over another. A quick survey can reveal areas more likely to have archaeological features, and work can be concentrated in those areas. Remote sensing may also be used to help decide where to hold field school excavations, or where to concentrate a season's work in an on-going project (Sheets and McKee 1994).

In some cases there may be barriers or prohibitions on excavations at sites that can be circumvented by remote sensing. In these areas, remote sensing makes it possible to detect features without digging. Geophysical surveys are easily conducted on churchyards, historic landmarks, or areas already under urban development, such as roads or parking lots. In this way, these areas may be tested for the presence of subsurface features without impacting sensitive resources or disturbing paved surfaces (Bjornstad 1998; Wheeler 1998).

Remote sensing methods are generally quicker than standard excavation techniques. Although contingent on the size of the site, most geophysical surveys can be completed in a day or two, or even a few hours. Therefore, not only do these methods help archaeologist target features when they dig, these methods make it possible to gather information about the entire site more quickly than could be accomplished by digging (Kruckman 1987; Scott and Fox 1987).

Remote sensing surveys may also detect features that would be missed by standard excavation procedures. This is related in part to the fact that remote sensing surveys are usually applied to a whole site, while time constraints mean hand excavation can only be applied to a certain portion. Unexcavated areas are terra incognita without remote sensing, and even large features could go undetected. Chemical surveys can reveal certain activity areas such as animal enclosures, human living areas, or fish processing areas, even when no archaeological features can be found. For these reasons, remote sensing is actually capable of drawing a more complete picture than excavation, and can detect features that might be missed otherwise.

Geophysical remote sensing methods

There are several geophysical sensing methods commonly applied to archaeological sites. A discussion of the principles of each method, reliability and relative cost to the archaeologist are outlined below.

Aerial photography

From the first photographs taken from a hot air balloon during the American Civil War, aerial photography has reached new heights so to speak, from thermal imagery to the latest pictures captured from satellites in orbit around the planet. Today, archaeologists have the pleasure of choosing a photo type from a whole range of possibilities.

Despite the availability of more sophisticated images, black-and-white photographs can still be useful for detecting sites on the ground. Black-and-white photographs are cheaper than other types of images, and generally do not need computer enhancement or other specialized equipment in order to be useful to the archaeologist. Balloons, blimps, helicopters, and airplanes are used to fly over a site or area for photographic purposes. The amount of detail desired, the wind conditions, and availability determines the type of aircraft used. The height at which the photograph is taken depends on what degree of detail the archaeologist needs and upon the size of the site (Meyers and Meyers 1995).

However, archaeologists do not always have to personally arrange for the photographs to be taken. Black-and-white images for most of the United States and selected portions of the world are currently available on the web at www.terraserver.microsoft.com. The user can simply type in the name of the area of interest and an image is quickly displayed. These photos are courtesy of the US Geological Survey and can be magnified to a scale of 1 inch = 100 meters. They may also be printed for the viewer's convenience.

Aerial photos are able to show subtle topographical details not visible from the ground surface. Slight changes in topography when seen from the air can indicate the presence of mounds, earthworks, and old roads or trails. Aerial photos may also show thick vegetation or darker soil patterns indicating the presence of enriched soil, often associated with animal or human organic waste products. Old Roman roadways in Europe, ancient cities in the Middle East, and mound sites in the Ohio and Mississippi River Valleys in the United States are examples of sites that have been discovered through aerial photography (Scollar et al. 1990, Sever 1995).

Thermal images

Thermal images depict in color the slight differences in temperature over the surface of a site. Temperature differences may signal the presence of underground features since the flow of heat is affected by soil anomalies (Clark 1990). Features, such as ditches, walls, or pits often appear hotter or cooler than their surrounding soil matrix (Gibbons 1991).

Plants give off heat too, so that areas with lush vegetation may also be distinguished in these types of photographs. Since archaeological sites often have enriched soils that allow such growth, those areas with dense plant growth may also indicate the presence of an archaeological site. Thermal images are frequently used by archaeologists working in Mesoamerica as aids in detecting ancient sites from the air despite dense jungle cover (Gibbons 1991).

Unlike a regular photograph captured with a camera and printed on paper, a specialized scanner is necessary for detection of slight temperature differences over the surface of a site. To convert the resultant data to a picture, a computer is also part of the necessary assemblage required to produce a thermal image. Unfortunately for the archaeologist with a small budget, these sensitive scanners are very expensive. Therefore, this type of survey may not be feasible for every site, or the archaeologist may need to contract for an outside expert to conduct this type of survey. Using an expert cuts the cost for the archaeologist; however, scheduling and availability of such a specialist may present its own problems.

Digital Imaging

Digital imaging is a newly available resource for the archaeologist interested in remote sensing. Digital images are produced by satellites in orbit around the earth. These satellites record the full range of electromagnetic energy emanating from the earth, capturing not only the visible spectrum, but also the invisible portion including ultra-violet and infra-red. When the full spectrum can be captured, details that were not previously apparent can be seen (Limp 1993, Wiseman 1996).

In 1972, the first satellite was sent into orbit specifically to capture images of the earth. It was called LANDSAT, and it was the beginning of a new era in aerial photography. At first, a resolution of 80 meters was the best that could be achieved; however, later satellites improved upon that, and today resolution levels of as little as a few feet are possible (Sever 1995; El-Baz 1997; Kennedy 1998). Better resolution meant smaller objects could be detected, and the more useful these images became to archaeologists. Some of these images, when studied by archaeologist revealed ancient trails and roads (Archaeology Newsbrief 1993b). Satellite images are being used to find original Anasazi roads at Chaco Canyon in New Mexico (Joyce 1992), footpaths in the Tilaran area of Costa Rica (El-Baz 1997), and lost cities in the Peten region of northern Guatemala (Sever 1995).

With the exception of sensitive military sites, archaeologists can obtain photographs for anywhere on the globe. In 1995 President Clinton declassified hundreds of thousands of satellite images taken by the Central Intelligence Agency in the 1960s and 1970s (Kennedy 1998). By doing so, he made satellite images relatively cheap and easy to obtain. Satellite imagery is also becoming an option for the archaeologist interested in aerial photographs of sites. These images are available and may be ordered from the U.S. Geological Survey for a minimal cost ($14 U.S. in 1998 from http://edcwww.cr.usgs.gov/) (Kennedy 1998: 555).

Soil resistivity

Soil resistivity involves measuring the relative ability of particular soils to conduct electricity. To conduct this process the operator inserts metal rods into the ground, between which an electrical current can flow. Once the current is generated, the degree of flow through the soil between the probes can be measured. The depth to which the current penetrates is governed by the distance between the electrodes and will be approximately 1.5 times greater than the distance between electrodes. Standard spacing between electrodes ranges from 0.3 meters to 1.0 meter (Dolphin n.d.). This process is carried out repeatedly along designated transects until the total area has been tested.

Once the survey is complete, a computer converts the relative resistivity measurements into an image. The strength of the electrical current passing between the probes is affected differently by dissimilar soil conditions, so that changes in the soil across the site can be detected through this type of testing. The image created by the computer is composed in varying shades of gray with low resistivity in lighter shades and high resistivity in darker shades (Scollar et al. 1990).

The resistivity method has been used successfully to detect ditches and pits filled with a matrix different from that which surrounds them (Weymouth 1986; Bevan 1995). Resistivity is also a very effective means of mapping subsurface stone features since stone is highly resistant to electrical current. If they are not buried too deeply, the stone footprints of former structures are readily detected with resistivity testing (Scollar et al. 1990; Candansayar and Basokur 2001).

Drawbacks of this method are related to climactic conditions and soil types. Because water is an excellent conductor of electricity, temporarily or permanently saturated areas are not well suited to these types of surveys. In addition, the archaeologist would do well to schedule this type of survey during the traditionally dry periods for the locality of the site. Soils that tend to retain moisture, like clay, may never render easily interpreted results, dry or otherwise (Clark 1990).

Prices for purchasing these machines vary, but prices begin around $1500 (Dolphin n.d.). Obviously, these machines are less expensive than a thermal scanner, but may still lie outside the price range of many small project budgets.

Magnetometers

Magnetometers are designed to detect slight magnetic anomalies lying beneath the surface of the earth. Many slightly magnetic features were created when temperatures at a high level were sustained in a concentrated area for a period of time. For this reason, kilns, ovens, hearths, and other thermal features can be detected by using a magnetometer (Bevan 1983, Weymouth 1986). Areas of relatively higher magnetic susceptibility are most often presented in iso-intensity contours, which are line drawings with those areas with the same readings connected by a line. On an iso-intensity drawing, magnetic anomalies will appear as tightly spaced lines or concentric circles (Bevan 1995, Scollar et al 1990). Some archaeologists also use images that are depicted in shades of gray, arguing that the magnetic results are more easily interpreted visually in this format (Silliman, Farnsworth, and Lightfoot 2000).

The magnetometer enjoys a high degree of popularity with archaeologists because it has proven quite successful in detecting the types of features mentioned (Tabbagh, Bossvet, and Becker 1988; Chavez et al. 1995). Magnetometers are also used on underwater sites from Maine to Greece to pinpoint the location of a ship prior to excavation (Parrent et al. 1991; Archaeology Newsbrief 1993a, 1995). Magnetometers have also identified Neolithic house floors that were subjected to burning (Bevan 1995) and large fired-clay hearths dating to 500 to 1500 A.D. in the Amazon (El-Baz 1997).

Magnetometer surveys can be affected by large metal objects nearby such as automobiles or large metal tanks, or even small metal objects very nearby like metal eyelets on the operator's boots. Metal artifacts in the soil appear as very strong magnetic features and may completely mask less magnetic features nearby. Igneous bedrock inclusions or outcroppings that have been heated to a high temperature have magnetic properties and produce results that can mimic the presence of features, due to their inherent magnetic properties. Though the survey method requires only that the machine be carried over the site in repeated linear transects, the susceptibility to interference may require more than one attempt to get a good reading.

The cost of purchasing a magnetometer in 1998 ranged from $6,800 to $23,500 (Silliman, Farnsworth, and Lightfoot 2000). Due to the cost of the instrument, the archaeologist can consult an expert or rent a magnetometer. But even rental charges can be steep, costing up to $105 a day plus a one-time $95-210 fee for the most expensive model magnetometer (Silliman, Farnsworth, and Lightfoot 2000).

Ground penetrating radar

Ground penetrating radar (or GPR) is a more recently developed technology than either resistivity or magnetometry and was first used for archaeology in 1973 (Scollar et al. 1990). It operates similarly to the aforementioned devices in that it sends a signal into the soil and measures the way the signal is reflected back.

The GPR unit functions as transmitter, receiver, and recorder, which are all contained within a metal box-like housing. Readings are taken by simply dragging the unit across a site along a previously imposed grid. As it moves, it sends out radar signals and the medium below reflects them back, where they are recorded as digital information.

The resulting signals, or in this case echoes, are rendered for the interpreter as dark bands on a computer screen or paper printout. The unit can record signals from several different strata in one location, so that each echo is rendered as a separate dark band. The frequency, regularity, and spacing of these bands are then analyzed for evidence of anomalies. GPR surveys are a very effective means of detecting voids under the earth's surface such as buried gas tanks or tombs. GPR signals are also affected by soil anomalies such as grave shafts, and objects made of metal, stone, brick, or wood (King, Bevan, and Hurry 1993; Black 1998). In addition, unlike most other remote sensing techniques, the absolute depth of soil anomalies or objects can be determined based on the relative amount of time it takes the radar signal to return to the antennae (Conyers 1999).

Under optimal conditions, the application of ground penetrating radar can yield very accurate predictions about the subsurface features. Advances in computer technology allow the received radar signals to be manipulated in three-dimensions, which can aid the detection of features in difficult to interpret areas (Meats 1996; Conyers 1999). Some very good results using ground penetrating radar have come from sites in Japan (see issues 36, 37, 38 of Archaeometry). Though it has been used with varying degrees of success elsewhere, the results in Japan have been consistently clear. This is apparently due to the types of soils present in that country, to which ground penetrating radar can be quite sensitive.

In general, these types of surveys are done by a special consultant, who is paid a fee to do a survey of a site for an archaeologist and interpret the results. The machines and computers necessary for the survey are expensive with prices beginning around $10,000, putting these machines out of reach for many archaeologists. In addition, the ambiguous dark wavy lines that comprise the results of a GPR survey are extremely difficult to interpret, and a fair amount of experience is necessary for reliable interpretation of the results.

All of these remote sensing methods have been used with varying degrees of success for the last decade or more. However, none of these devices can pinpoint artifacts the way a metal detector can. In addition, historic sites that contain a large number of small metal items cannot be surveyed with magnetometers that are designed to detect much smaller nonmetallic magnetic anomalies. For this reason, although magnetometers have been used on historic sites, the areas surveyed were either determined to contain little or no metal artifacts based on prior *metal detector* surveys (Silliman, Farnsworth, and Lightfoot 2000), or were found to give unreliable results due to the number of metal artifacts in the soil (King, Bevan, and Hurry 1993). Metal detectors can also be used in wet areas that are not easily tested with resistivity methods. When these factors are considered, it becomes apparent that metal detectors are actually remote sensing devices that fill a void since they can detect artifacts and indicate features on sites where other methods would be ineffective.

Chapter II

The Metal Detector

Due to the commercial market that exists for many metals, a machine that could detect the presence of metals was a long sought after device. Alexander Graham Bell attempted to develop a metal detector as early as 1881. When President James A. Garfield was shot doctors hoped Bell could locate bullets in the dying President's body. Bell's attempts were unsuccessful and President Garfield later died of his wounds (Garrett 1998).

Other early metal detectors were developed during the 1920s and 1930s as a by-product of aircraft directional technology. During the 1920s, Dr. Gerhard Fisher obtained the first patent for radio direction finders for aircraft. Pilots soon discovered, however, that in areas with high metal or ore deposits, the radio direction finders did not operate properly. Once Dr. Fisher figured out that the directional electronics were picking up the metal deposits, he decided the malfunction could be used to develop a metal-finding device. In 1937, Dr. Fisher patented one of the first metal detectors, the Metalloscope (Fisher Research Laboratory n.d.). The Fisher Research Laboratory remains one of the leading manufacturers of metal detectors in the 21st century.

In 1925 a metal detector was developed for companies that wished to deter tool theft among employees. Developed by two German physicists and installed at the main doorway, the gateway possessed an electromagnetic field and was equipped with sensors that could detect changes in the field caused when metal objects passed through it. The device was sophisticated enough to be set to ignore small objects such as coins or keys (Garrett 1998).

In the 1940s and 1950s portable metal detectors began to enjoy some public recreational use but were fairly large since they were built using bulky vacuum tubes. With the invention of the transistor, metal detectors became more streamlined and easier to use. Several manufacturers began to market detectors, each adding their own improvements to the metal detector design. In the 1980s the microchip was incorporated; this time the patent was developed by Charles L. Garrett, maker of Garrett Metal Detectors (Garrett 1998). Today, metal detectors are truly sophisticated metal sensing devices, capable of determining metal type, depth, and the probable identity of sensed objects.

Metal detectors have been used to find coins, gold, buried pipes, metal in sawmill timber, land mines, and hidden weapons (Fisher Research Laboratory n.d.; U.S. General Accounting Office 1996). Metal detectors are in fact one of the main tools used to locate land mines by the U. S. Government (U.S. General Accounting Office 1996). Before conducting utility work, construction companies often conduct a search for buried utility lines using metal detectors. Sawmill timber is searched with metal detectors for wire and nails that can ruin expensive saw blades. Industrial food producing plants use metal detectors to ensure metal is not incorporated in packaged food. Construction companies use metal detectors to trace wiring and locate nails holding important structural elements in buildings (Garrett 1998). Perhaps the most frequent use of metal detectors today is by law enforcement and security personnel as they search for hidden weapons.

Modern metal detectors fall into three general categories; industrial metal detectors, security metal detectors, and hobbyist metal detectors. Industrial detectors are mounted on a horizontal axis with a handle at the top; these detectors are used primarily to locate underground utility pipes, conduits, or buried property markers. Security detectors are most often hand-held instruments used by law enforcement or security personnel to search for concealed weapons.

Although industrial and security metal detectors are quite useful in their specific capacity, they are generally not well suited for archaeological endeavors. As a result they will not be included in the ensuing discussion. On the other hand, the hobbyist metal detector is highly adaptable for use as an archaeological tool and will be the focus of this chapter.

The overall appearance and operation of the hobbyist metal detector is the same regardless of the manufacturer. The basic components of these metal detectors are the search coil, the shaft, a connecting cable, and the control housing (Figure 1). Each of these components is discussed below.

Search coil

The search coil is a flat disc at the terminal end of the metal detector that sends and receives electromagnetic signals. The search coil is composed of a plastic or fiberglass cover containing two separate loops of wire. These loops are known as the transmit and receive windings, and they act as antennae for sending and receiving electromagnetic signals. The search coil varies in size and shape and may take the form of a solid disc or an open ring with the standard being a round, 8-inch, solid coil. Variations include 4-, 7-, 10-, and 15-inch sizes, and an elliptical shape instead of round.

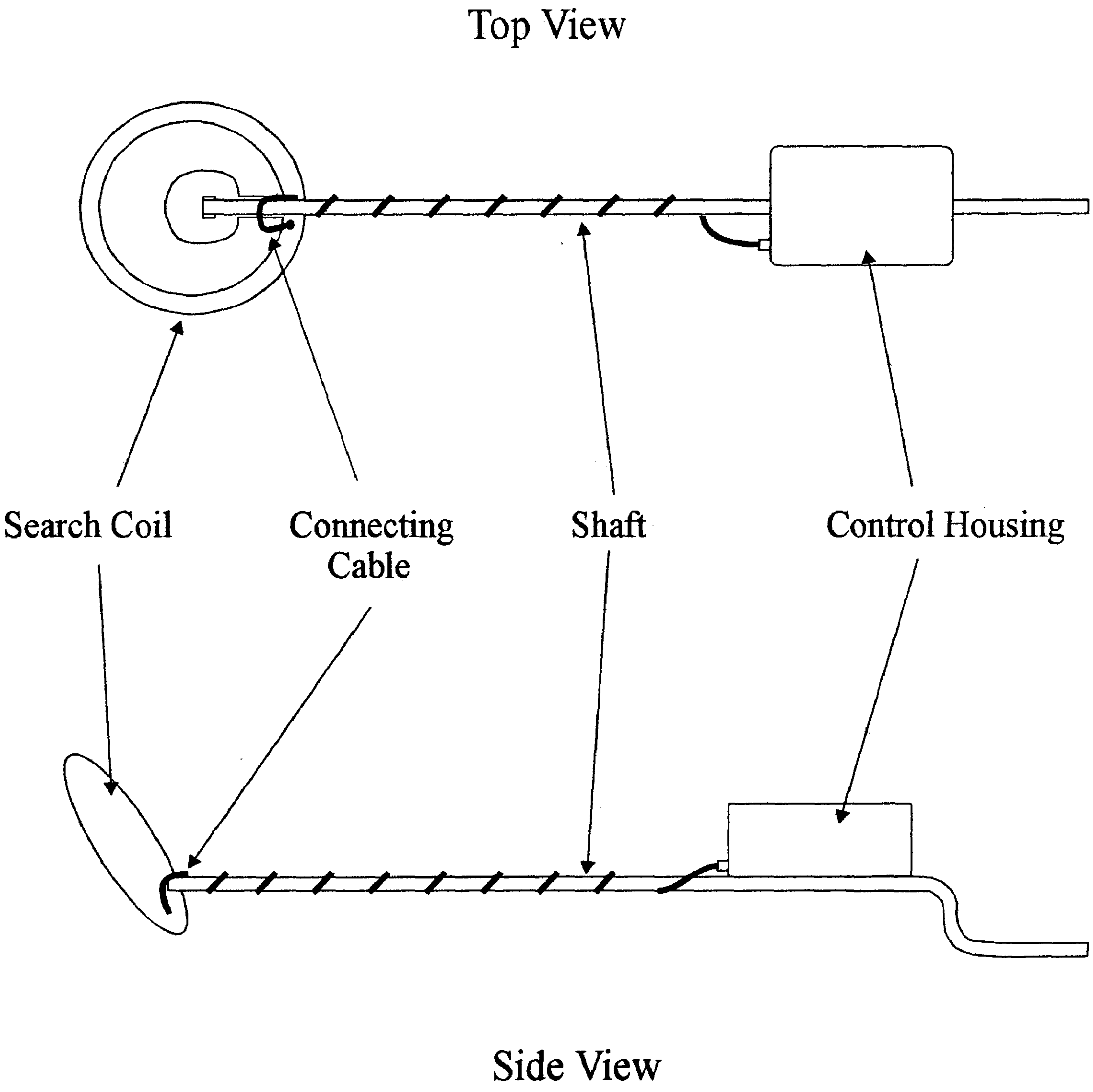

Figure 1. The basic components of the metal detector (after Connor and Scott 1998).

Smaller coils make it easier to search tight spots and are better at pinpointing metal targets, while larger coils cover more area at once and detect metal at a greater depth. Solid coils are easier to use in brushy areas as an open coil will snag on branches.

Control Housing

The signal the coil sends is generated in the control housing. This portion of the metal detector sits at the opposite end of the machine from the search coil where the operator can easily adjust settings. The control housing contains circuit boards, the power supply, target indicators, signal meters, speakers, and sensitivity and power controls with which the metal detector may be equipped.

When the machine senses metal, the detector can alert the operator in a variety of ways, with all signals appearing or emanating from the control housing. The metal detector may emit an audible tone through the speaker indicating metal has been detected, or the detector may be equipped with a meter that gives a numbered reading when metal is detected. The detector may also have a target identification system that actually tells the operator whether a nail, bottle cap, or silver coin has been detected.

The control housing also holds the power supply for the metal detector. A rechargeable battery pack is supplied with some models, while others operate on one or more regular batteries. Most models can operate at least 8 hours with out changing batteries, some models can run on a battery pack for up to 70 hours (Fisher M-Scope catalog n.d.).

Since the control housing contains most of the sensitive workings of the machine, it is usually not waterproof unless specifically designed for underwater use. However, the rest of the machine is submergible, and for this reason the control housing is sometimes detachable. In this way, the operator can carry the housing on their hip or shoulder while the rest of the machine is used in the water. Carrying the control housing also lightens the machine so it can be used with one arm for longer periods with less fatigue for the operator.

If the machine produces an audible tone, a headphone jack is usually located on the control housing as well. Using headphones requires less energy and extends the life of the battery.

Connecting cable and shaft

A sealed cable connects the control housing and the search coil, relaying signals between the two components. The cable wraps around the shaft as it makes its way down from the control housing to the coil. All of these components are attached to the shaft, which terminates in a handle for the operator. The shaft is adjustable for the height of the operator and is usually composed of some light substance such as plastic or fiberglass that keeps the machine from being too heavy and awkward to operate.

The design of the shaft is such that it creates the feeling that the metal detector is an extension of the arm. Modern detectors usually have a grip located slightly before the end of the shaft, with the end forming a half-circle that fits behind the wearers arm between the wrist and elbow. This design results in a handle that is roughly Z-shaped and allows the weight of the machine to push against the wearer's forearm instead of being totally supported by the wrist. Since most units weigh less than 5 pounds, the light weight coupled with the supported design allow an operator to work all day with a minimum of physical fatigue.

Operating Principles

Metal detectors operate on the premise that an electrical current can produce an electromagnetic field. When metal objects enter the field they induce small changes that are in turn sensed by the metal detector (Rowan and Lahr 1995; Kraus and Rokycany 1996).

The electromagnetic field originates in the control housing where a current is produced utilizing the batteries or battery pack. The current flows down through the connecting cable and into the search coil. Inside the coil are loops of wire, known as the transmit and receive windings. The transmit winding emits an electromagnetic field that extends both above and below the search coil in an elliptical shape. The elliptical electromagnetic field has the same diameter as the search coil but is slightly elongated so that it can penetrate to a depth that is slightly more than the diameter of the coil into the ground. Therefore, the depth at which the detector can sense metal is directly related to the size of the search coil. A 4-inch coil generates an elliptical field with a diameter of 4 inches and a length of about 5 inches, while a 10-inch coil has an elliptical field with a diameter of 10 inches and a length of about 1 foot. Detection at depths greater than 1 foot can be achieved with the industrial detectors due to the fact that they generate their electromagnetic field in a different configuration than the hobbyist machines (Garrett 1998).

When the electromagnetic field encounters a metal object, the object itself absorbs a portion of the energy and small "eddy" currents appear on the surface of the object. Although metals are generally good electrical conductors, they all display a certain amount of resistance to electrical flow. This resistance is always the same for each metal, and therefore can be used to identify the metal. The slight delay between the time the transmit winding sends out its magnetic field and a current appearing in the metal target is called phase shift (Rowan and Lahr 1995; Garrett 1998).

Once an eddy current appears in the metal object it can then be detected by the receive winding. The metal detector has built-in mechanisms that convert the demonstrated phase shift to a metered or numeric reading or to an audible tone, depending on what the machine is designed to do. Some detectors have a meter that shows the received signals as a numbered display. The number shown in the display will indicate the type of metal detected. Others have a built-in target identification system so that the received signal is interpreted as a particular metal or object by the machine. For example, the target indicated might be made of iron or zinc, or it may be a 1 cent or 25 cent piece. In many cases, visual displays are accompanied by an audible tone. Depending on the type of metal detected, the tone can be softer or louder, and higher or lower in pitch.

The metal detector's ability to sense metal is greatest when the metal falls directly below the search coil and well within the generated electromagnetic field. However, if the target is just barely within the electromagnetic field, it will give a fainter signal. This results in softer, weaker audio signals and can cause the target identification system to switch erratically between identifications.

Metals of all types can be detected, from nails and bullets to jewelry and tinfoil. Metal types may be identified either by the strength of the signal or by the target identification built into the metal detector. The strength of the eddy current is a function of how well the metal conducts electricity, and the size of the object. For example, iron gives a strong, low tone when detected, while precious metals give weaker, higher tones.

Many hobbyists or “coin shooters” choose to completely tune out iron tones and focus on the higher tones, in hopes of retrieving only coins and precious metals in this manner.

Advantages and Disadvantages of Using Metal Detectors

The metal detector is a familiar and common device, unlike the remote sensing devices discussed in Chapter 2. It is not unusual to find metal detectors under the Christmas tree, and there are probably hundreds of thousands of hobbyists using metal detectors today. Several companies specialize in the production and promotion of metal detectors; Garrett Metal Detectors, Fisher Research Laboratory, Nautilus, Tesoro, and Whites are just a few of the leading manufacturers producing metal detectors. Since their market is almost wholly composed of hobbyists, these companies emphasize the ability to detect ‘treasure.’ In the store, the salesperson will describe how deeply the machine can detect coins; on the box the advertising language will forecast the ‘treasure in your backyard.’ Peruse a catalog of metal detectors from any manufacturer and the ads describe machines that will find “deeper, more valuable items other detectors can't”(Whites catalog, n.d.).

The link tying metal detectors and "treasure hunting" together is a very, very strong one. Almost everyone is familiar with metal detectors and what they do, but most people do not associate them with professional archaeology. Many professional archaeologists consider this a serious disadvantage as it causes archaeologists who use metal detectors to look like amateurs; or worse, to be indistinguishable from looters.

Metal detectors are unique in that rather than detecting differences in the soil that *may* indicate features or sites, metal detector readings always indicate artifacts (except in rare cases when natural gold or copper nuggets exist). This ability is exactly what makes it a favorite with the public at large. Detecting all metal objects can be seen as a disadvantage in that the artifacts detected may not be from the period for which the archaeologists is looking; they may be bits of tinfoil or soda cans. If modern trash is abundant at a site, an archaeologist can quickly become overwhelmed with hundreds of targets and no idea which indicate a site and which are incidental trash.

However, the ability to detect metal artifacts becomes a definite advantage on sites where there is little material other than that associated with the site under investigation. In these instances, every reading becomes an important artifact that contributes to the overall understanding of the site. Metal detectors have also proven useful in those instances when a site has been stripped of its overburden and only features remain. A metal detector can help locate features and metallic objects within the feature.

Compared to other remote sensing devices, the metal detector is relatively cheap. Depending on the maker, these machines can be as low as $50 for a small Radioshack metal detector, or $1219.95 for a top of the line Fisher CZ-20 submersible salt-water detector (Fisher M-Scope catalog n.d.). Because they operate on the same electromagnetic principles, the expensive machine will generally not detect any deeper than the $50 machine. However, the control box will have more knobs, and it may be able to identify the target and estimate its depth. A more expensive model may also be able to tune out specific metals, important for the treasure hunter looking for gold coins, but not as important to the archaeologist. Of course, the $1219.95 Fisher CZ-20 is also specially equipped to operate underwater at depths up to 250 feet.

A dependable metal detector with an 8-inch coil and a meter or target identification system costs around $200. For the purposes of general archaeological survey, the ability to discriminate, tune out, or determine exact depth are not very important capabilities. Therefore, archaeologists could expect to pay about $200 for a machine that would help them find sites and delineate intra-site concentrations of artifacts. For archaeologists who need to discriminate between metal types due to modern trash or to search for specific diagnostics, a slightly more expensive machine, around $400 might be useful. In either case, metal detectors are available at a price much lower than most other remote sensing devices.

Metal detectors can be useful on all types of sites, from nearly all periods. Even prehistoric sites can benefit from metal detector surveys. Magnetometers are commonly employed remote-sensing devices that detect slightly magnetic anomalies such as hearths, kilns, or burned structural features. Unfortunately, actual metal items skew the readings obtained from such a survey. In order to eliminate unwanted interferences, metal detectors are used to rid the site of bottle caps, tinfoil, and other modern trash that disrupt magnetometer readings.

Some archaeological professionals criticize the use of metal detectors based on the fact that a significant portion of the artifacts from a site are composed of non-metallic materials such as ceramic, brick, and bone. However, these professionals should consider just how much of a typical artifact assemblage is made up of metal items. From hairpins to straight pins, to nails, knobs, plows, buttons, wheels, bolts, hinges and knives, the list of metal items commonly found on archaeological sites can go on and on. Often, iron nails are the most common artifacts in an assemblage. Nails, along with other metal items, are deposited in meaningful patterns, just as ceramics and bone and other items are. If the metal is detected, then the patterns inherent in their deposition will also be detected.

Most historic sites do contain substantial amounts of metal; it is a common component of domestic trash and architectural debris. Moreover, metal often occurs in conjunction with other types of artifacts including ceramics, faunal material, window glass, and brick. Due to the substantial amount of metal in historic artifact assemblages, it seems that the metal detector is well suited for historic archaeology. Metal detectors can be used to identify metal loci and perhaps define patterns in the distribution across a site. In addition, nails can be crucial when attempting to identify where buildings once stood. Linear scatters of nails and wire can indicate fence lines, while outlying clusters of nails may signify outbuildings.

Since so many archaeological surveys today are carried out with less than the optimal amount of time, metal detectors are a quick way to survey large areas. They can make sure that a survey with shovel test probes did not miss small discrete loci, or clusters separated some distance from the main site.

Metal detectors are also especially useful on sites where most of the diagnostic materials are metal, such as military and battle sites. At these sites materials such as ceramics, bone, or bottle glass are often found in low quantities, while metal artifacts like bullets, spent casings, buckles, badges, and gun parts are plentiful. The metal artifacts are the most important portions when it comes to identifying a site as a military occupation as opposed to a domestic or industrial site. Unfortunately, hobbyists have extensively searched many military and battle sites with metal detectors, who have preferentially removed the metal diagnostics. Therefore, if an archaeologist approaches a military site without a metal detector in hand, they will be working under a serious disadvantage, and may be unable to accurately identify the site through shovel testing alone (for examples demonstrating these points refer to Chapter 4).

Metal detectors are generally easy to use. There are a few simple operating skills that have to be learned, but they are quickly mastered. The skills necessary include learning how to turn on the machine, how to set volume and discrimination for ground interference (if its not automatically set), and learning how to recover the metal target once identified. These techniques take no more than a few hours or at most a day to master.

The results of using a metal detector are immediate, and consist of: positive reading -- metal exists, or no reading -- metal does not exist. In contrast to the results from most other remote sensing methods, the results of a metal detector survey are simple and straightforward with absolutely no manipulation of data required.

Chapter III

Past Applications of Metal Detectors in Archaeology

Early on, there were many who realized the metal detector was a made-to-order tool for locating a variety of metal objects. As advances in technology made metal detectors smaller and more accurate, public interest grew. By the 1960s and 1970s metal detector manufacturers were mass-producing the machines for recreational detectorists (Whites n.d.; Garrett 1998). Archaeologists were by no means unaware of the detector, and by the 1980s, some professional archaeologists were ready to say they would not want to conduct a large-scale excavation without a metal detector (Gregory and Rogerson 1984: 184). However, these archaeologists are the exception, and today most professional archaeologists are still not comfortable using metal detectors.

The stigma attached to metal detectors originated during the years it first gained popularity with the general public. Hobbyists used the machine to search for and recover buried metal objects. Sometimes those objects were scattered change from a beach, but they were just as likely to be bullets from a Civil War battlefield. Many sensitive archaeological sites were practically destroyed by hobbyists with detectors (Hicks 1996, 1997; Tarler 1999). At the same time, archaeologists were just beginning to use remote sensing methods such as resistivity and magnetometers with a primary purpose of locating subsurface features, not individual artifacts. By the 1980s and 1990s when archaeologists realized how useful metal detectors could be, the machine was firmly established as a tool for hobbyists and amateurs looking for "buried treasure."

Despite general reluctance on the part of professional archaeologists, the use of metal detectors on archaeological sites can be documented from the 1950s to the present. In most cases, the metal detectors are actually operated by volunteers and not the archaeologists in charge of excavation. This is due in part to the fact that many volunteers can cover a large area more quickly than a single operator. However, it is a common belief held by archaeologist that the metal detector is too complicated to be operated by a novice and takes years of experience to use; therefore, volunteers with experience are called in to survey the site. In light of the actual ease with which most modern metal detectors may be operated, the latter reason is no longer true.

Military battlefields were among the first to receive the benefit of professional metal detector survey because so many of the diagnostic artifacts are metal. However, over the years metal detectors have been used at many types of historic sites, both domestic and military, and also at prehistoric sites. In general, any site containing metal artifacts can benefit from inspection with a metal detector.

Some of the first documented work took place on the site that would become the model for archaeological application of metal detectors. The Custer Battlefield, today known as the Little Bighorn Battlefield in Montana, was subjected to professional metal detector searches as early as 1958. The work was conducted by Don Rickey, military historian, and Robert Bray, Smithsonian archaeologist. Don Rickey was looking for firing lines on the battlefield in hopes of reconstructing the battle, and he assisted Robert Bray who wanted to check a particular area of the battlefield for subsurface artifacts prior to the construction of a blacktop path (Connor and Scott 1998). Don Rickey was also the first to survey the Wagon Box Fight site in Wyoming with a metal detector between 1956 and 1958, more than thirty years before the Wyoming State Archaeologist would perform a metal detector survey there.

In truth though, during the 1950s the use of metal detectors by archaeologists was limited. During the late 1960s and 1970s the professional use of metal detectors began to rise, seeing use on both historic and prehistoric sites. Archaeologists at the University of Winnipeg in Canada used metal detectors in an attempt to locate prehistoric sites containing copper artifacts. The University utilized a metal detector in an attempt to relocate the Jansson site, thought to have been eroded away by the time of the survey in 1969. Unfortunately they had no success in relocating the site (Steinbring 1970). However, in 1979, Henry Iwacha, a volunteer working for the University of Winnipeg, used a metal detector at the LM-8 site in Winnipeg to locate a large copper nugget and an Old Copper harpoon (Iwacha 1979).

The 1980s saw better metal detectors, and even greater use by archaeologists. Though earlier surveys consisted of general sweeps over the area of interest (Steinbring 1970; Iwacha 1979), surveys in the 1980s were more likely to have specifically stated survey and recovery methods (McLeod 1985; Scott and Fox 1987; Scott et. al. 1989; Legg and Smith 1989). By this time, a noticeable focus was becoming apparent as well. Due to the high proportion of metal artifacts and the general proximity to the surface, archaeologists were using metal detectors with increasing regularity for surveying battlefields.

The Wyoming Office of the State Archaeologist surveyed one of these battlefield sites in 1984. The Wagon Box Fight occurred in 1867 when Dakota Sioux and Cheyenne Indians mounted an unsuccessful attack against soldiers and civilians from Fort Phil Kearny. The soldiers, firing newly acquired breech-loading Springfields, took shelter within a circle of supply wagons for three or four hours until relief arrived. The site gained significance from the fact that the fight marked a turning point in solider morale in the U.S. Government's campaign against the Plains Indians. It was also the first time that the highly effective Springfield breech-loading rifles were used (Reiss and Scott 1984).

Accounts of the battle detailed the arrangement of wagons and events of the battle but could not pinpoint the exact location of the site. Through metal detector survey, archaeologists hoped to confirm the precise location of the Fight and also gain further information about events during the battle. This work followed earlier metal detector surveys conducted by Don Rickey in 1958 and S. W. Vaughn in 1967 (McLeod 1985).

Survey methods used at the Wagon Box Fight included total coverage of the area in question, with every target collected, but only the older, non-modern artifacts mapped. Tinfoil, soda caps, and other 20th century materials were removed from the site, but not recorded. McLeod reported that all artifacts were recovered within 15 cm of the ground surface. Three 1-meter square units were also excavated in those areas displaying the greatest concentration of metal artifacts with no additional artifacts recovered.

The 1984 survey, along with the earlier work, confirmed the location of the Wagon Box Fight by recovering cartridges, lead shot, and other metal artifacts dating to the 19th century arranged in a roughly circular shape. As a result of this work, archaeologists felt they were successful in pinpointing the exact location of the engagement and concluded that the Wagon Box Fight Monument properly marked the site of the battle.

Another military site subjected to metal detector survey during the 1980s was the Little Bighorn Battlefield., probably *the* most famous battlefield in the American West; as such it had long been the subject of archaeological study. Despite its legendary status, as of 1984 the Little Bighorn Battlefield had never been archaeologically surveyed in its entirety.

Archaeological survey has been one of the only avenues available for the investigation of the events of the battle since none of Custer's soldiers survived to describe the actions of the doomed men. Indian warriors who participated in the battle had been asked to tell their stories, but their accounts left questions about specific locations and also about U. S. troop movements. Archaeological investigation was undertaken as a way of reconstructing what happened on the day the Dakota Sioux wiped out Armstrong Custer and his detachment of soldiers.

During the 1984 survey and subsequent surveys, metal detectors have been the primary survey tool used on the battlefield, rather than more customary shovel tests. In several books and papers published about archaeological excavations on the site, archaeologists Douglas D. Scott and Richard Allen Fox detail the role that metal detectors have played in their survey of the battlefield (Scott and Fox 1987; Scott et. al. 1989; Scott 1991; Fox 1993). Neither Fox nor Scott comment in any length on the justification, merits, or drawbacks of the use of metal detectors. In 1993, Fox stated simply,

> "Based on the assumption that most battle artifacts would be metallic, or associated with metal objects, the survey methods emphasized the use of modern,

> hand-held metal detectors. The controlled, systematic use of metal detectors represents an advanced method for locating and illuminating artifact distributions at battlefield sites" (Fox 1993: 67).

Scott and Fox were following the precedent set by Don Rickey and Robert Bray when they used metal detectors on the battlefield in 1958. They were also well aware of the number of artifacts that had been found and removed from the battlefield by hobbyists, who searched the site to find battle-related relics for personal collections (Scott et al. 1989). Although items recovered by earlier professionals and relic hunters shed some light on the events of the battle, the lack of specific provenience prevented archaeologists from fully understanding the action that had deposited the artifact.

Due to the size of the battlefield (760 acres), the archaeologists knew that shovel testing the entire site was impractical. The methodology they subsequently developed and employed at the battlefield was elegant in its simplicity and effectiveness. It allowed for the survey, recovery, and recordation of thousands of artifacts with precise provenience. In 10 weeks, a single summer season, the entire site was subjected to metal detector survey and over 5000 artifacts were collected. And more than that, the exact location, depth, and orientation of each artifact had also been recorded (Scott and Fox 1987; Scott et al. 1989; Connor and Scott 1998).

The methodology used during the 1984 survey was as follows. In order to keep strict and reliable provenience of all artifacts, the site was surveyed and gridded out in 100-meter squares with a steel rebar stake placed at each grid point. Volunteers with metal detectors then walked along transects roughly 5 meters apart. Another volunteer followed a crew of detectorists, scanning the ground surface for artifacts and placing pinflags as metal targets were located. A second crew followed the metal detectorists.

The second crew uncovered targets but left them in place for the recording crew. The third and final team numbered, mapped, and bagged each target; regardless of age, all artifacts except glass, nails, and brick were collected from the site. Larger excavation units were placed over targets that were associated with leather, wood, or bone (Scott and Fox 1987; Scott et al. 1989).

As a result of the work carried out since 1984 with metal detectors, troop movements during the Battle of Little Bighorn are better understood and archaeologists can begin to compare the archaeological evidence to the accounts told by Indian participants. In addition, metal detector surveys have led to the discovery of the equipment dump created by those soldiers who cleaned up the battlefield, important because of the wealth of material it contained from the battle (Scott 1991). The researchers were also able to relocate the original graves of the fallen soldiers (Scott and Fox 1987; Fox 1993), and found more than a few human bones that had escaped earlier recovery efforts (Fox 1993).

Metal detectors were being used in Canada in the 1980s as well. The Cochrane site (EbLf-12) located in St. Peter, Manitoba was surveyed with metal detectors in 1983 as part of an attempt to educate both professionals and amateurs about the use of metal detectors on archaeological sites. Specifically, it was hoped that after working together on the site, each side would come to "understand the rationale and techniques used by the other party" (McLeod 1985: 20). The author felt if an understanding could be reached, some of the hostility and misunderstanding between the groups could be eliminated.

The Cochrane site was the known location for a number of 19th and 20th century structures, but it was also the suspected site for an 18th century fort. The site had been previously identified through surface collection and shovel testing but was endangered by severe erosion due to its location on the banks of the Red River.

Metal detector sweeps were performed at 1-meter intervals across an area 12 meters wide and 16 meters long. Each target located along a transect was exposed without disturbing its horizontal or vertical provenience, and mapped prior to its removal. At this site, all artifacts were recovered within 10 cm of the ground surface.

The majority of the material recovered at the Cochrane site consisted of late 19th and early 20th century domestic deposits related to the structures that once occupied the site. There were no 18th century materials recovered, indicating either the remains of the fort had previously eroded away, or that the fort had not been located within the survey area.

The author also felt that the dearth of understanding between hobbyists and professionals had been filled to some degree, stressing that relic hunters who participated realized that no artifacts of monetary worth were found at the site. In turn, the professional archaeologists were educated about the metal detector and the ways in which the machine could contribute to an archaeological survey.

Metal detecting in the United Kingdom was also becoming more common throughout the late 1970s and 1980s. In 1984, Tony Gregory and Andrew Rogerson published an article in the professional journal Antiquity in 1984 detailing the success they had experienced using metal detectors at two sites in Norfolk, England.

The first site was a large triple-ditched enclosure in Thetford, Norfolk that was in peril of being looted due to the nearby discovery of a treasure hoard. The second was in East Harling, Norfolk where a hoard of mid-eighth century pennies had been found. In both cases, the sites were located in plowed fields. The accepted procedure for excavation of plowed sites at that time was to remove the plow zone before beginning the actual excavation. At these sites, however, the plowzone was surveyed with metal detectors before any soil was removed. After being thoroughly searched, approximately 10 cm of the plowzone were mechanically removed and the area was surveyed again. This procedure continued until the entire plowzone had been searched and removed. Once excavation began below the plowzone, each identified feature was scanned for metal items before being dug.

At both sites, the majority of metal artifacts recovered were found within the plowzone with a metal detector. At the triple-ditched site, 104 of 126 metal artifacts (83%) were recovered from the plowzone (Gregory and Rogerson 1984: 182). In fact, items from the topsoil were the only evidence discovered indicating the site had been occupied during the late Roman period and would have escaped notice without the metal detector survey. At the penny hoard site, only 18% of all the metal objects were found in features; 25% were in the topsoil and would have been missed without metal detector survey (Gregory and Rogerson 1984: 183).

The authors stress the efficiency and effectiveness of metal detector surveys, stating that it cost two-thirds of one digger's salary for the whole project at the triple-ditched enclosure that covered 11 acres. Moreover, they state,

> "the metal-detector is more efficient than even the most experienced excavator in the recovery of metal-objects, and allows the recovery of a certain group of datable material even where sites area being excavated on the most selective basis" (Gregory and Rogerson 1984: 184).

By the 1990s, the metal detector had gained significant ground in the archaeological world. Archaeologists were becoming more and more likely to employ a metal detector at military sites, especially following the publication of the results of the work at the Battle of Little Bighorn.

In 1994, Douglas Scott published the results of survey work done at the Big Hole Battlefield, in southwestern Montana (Scott 1994). The Big Hole Battlefield is the site of one of the clashes between the U.S. Army and the band of Nez Perce Indians that attempted to escape U.S. prosecution by fleeing to Canada. The Nez Perce band was led by Chief Joseph.

The Big Hole Battlefield, like many other famous battlefields, had been heavily collected by several individuals. Don Rickey, Little Bighorn Battlefield Historian, searched a portion of in the late 1950s, recovering several cartridges and bullets. Between 1959 and 1964 the superintendent of the Big Hole Battlefield, Aubrey Haines, surveyed significant portions of the site, marking find spots with stakes bearing field numbers. These individuals recovered bullets, cartridges, buckles, and various other battle-related artifacts. However, as with the Little Bighorn Battlefield, despite multiple surveys, the Big Hole Battlefield had not been investigated in its entirety.

By employing the same methods used at the Little Bighorn Battlefield, over 1,000 battle related artifacts were recovered in 1992 from the 665-acre site, including a bayonet, a firearm, and a few belt knives (Scott 1994: 34). Not only were all of the battle-related components and battlefield limits recorded, but other components were also identified, including historic settlements, road development, irrigation, and artifacts related to the development of public interpretation of the site. Again, despite the acreage involved in the project, the survey was completed within a single summer season.

Palo Alto is another battlefield surveyed predominantly with metal detectors. In 1992, this site in southern Texas was investigated with the specific goal of determining where the U.S. and Mexican troops were positioned during the 1846 battle. Archaeologists hoped to locate troop positions so that the land could be purchased for the development of the area as a National Historic Site. Earlier efforts at locating the battle site had utilized a magnetometer; however, there were too many small metal artifacts for the magnetometer to be useful. Archaeologists concluded that metal detectors would be more appropriate for the survey.

Hand-held metal detectors, operated by volunteers, were used to sweep about 210 acres (Haecker and Mauck 1997: 131). Although this accounted for only 8% of the proposed 3,400-acre-park, previously conducted historical research had indicated the area surveyed was the most likely location of the battle. The method of survey, recovery, and recordation followed that established by Douglas Scott and Richard Fox at the Little Bighorn Battlefield. Analysis of 951 artifacts recovered during the 1992 and 1993 field season allowed archaeologists not only to locate the exact positions of the U.S. and Mexican troops, but also to revise official Mexican accounts of the battle.

The Mexican troops suffered between 200 and 400 casualties during the May 8 encounter, losing to the American forces that they outnumbered (Haecker 1996). After the engagement, Captain Jean Louis Berlandier, a Mexican officer, sketched a map of the battle, indicating that the Mexican troops had aggressively advanced in the last stages of the battle. Official U.S. accounts and sketches of the battle disagreed with the Mexican version, in that there was no Mexican advance and that the Mexican troops had in fact been driven to the southeast. The Berlandier map had been the most widely reproduced map, and the discrepancy between the two accounts had never been addressed.

At the battle site, metal detector surveys were conducted across the site. These surveys failed to find any Mexican artifacts in the area of the supposed advance. Instead, Mexican buttons, badges, and other accoutrements were found to the southeast of the position taken by the American forces. Moreover, a light scatter of Mexican artifacts was found to the north and east of the main Mexican position. American accounts describe a failed attempt by the compressed Mexican troops to move around the left side of the American line, which would have left just such a scatter of artifacts (Haecker 1996).

Although the author expressed initial concern that relic hunters had severely impacted the battlefield by removing hundreds of artifacts over the years, his work confirmed that there was still sufficient material to answer questions about the battle.

In addition to these famous battlefields, smaller Civil War sites all over the southeastern portion of the U.S. have been recorded specifically as a result of using metal detectors as a primary method of survey (Legg and Smith 1989; Jones 1998; Nasca et al. 1998; Harwood et al. 1999). Civil War sites are particularly easy to miss, as they are typically low in diagnostic materials. This is partly due to the fact that relic hunters have often removed many of the diagnostic items such as bullets, buckles, and military buttons. Shovel testing will often identify only a scatter of 19th century ceramics and bottle glass at these sites, which is interpreted as a domestic scatter not worthy of further testing. However, if metal detectors are brought to bear on these looted sites, military diagnostics can be found, especially because archaeologists often have the option of removing obstructing vegetation or working in open areas not as thoroughly hunted by relic collectors.

A case example will illustrate the fact that Civil War sites, significant ones, can be missed by standard subsurface testing methods. In 1994, a professional survey was conducted at the proposed Winchester Area Headquarters for the Virginia Department of Transportation (VDOT) in northern Virginia. As a result of that survey, two sites were identified. One was a prehistoric site determined to be potentially significant and the second was a 19th century foundation for a building that had been removed, deemed not significant. A peripheral scatter of historic artifacts was noted, but attributed to the 19th century domestic occupation. No artifacts definitively associated with the Civil War were found.

The next phase of excavation was carried out at the prehistoric site, the results of which indicated the site was neither stratified nor single component, and further study was not recommended. Based on these results, the VDOT proceeded with their development, and no further archaeological work was planned.

However, during this time, local relic hunters who had found artifacts in the area contacted both archaeologists at the site and the Virginia Department of Historic Resources (VDHR) in attempts to notify someone of their findings before the site was destroyed. Furthermore, one of the relic hunters had conducted historic research of his own and felt he had identified the site as Camp Mason, a Confederate encampment of Virginia troops during portions of 1861 and 1862.

This information persuaded Bob Jolley, a VDHR archaeologist to contact VDOT and present the relic hunters case that despite the results of the professional survey, a

Confederate camp was likely to be located at the site in question. The VDOT, although not technically required to allow any further archaeology, decided to let Bob Jolley and a handful of relic hunters perform metal detector surveys at the site. Furthermore, the VDOT also agreed that should the survey locate proof of a Civil War site, they would conduct further archaeological survey.

Bob Jolley and the relic hunters successfully located 1,200 metal targets. A random number of targets were excavated, yielding several Civil War diagnostics including musket balls, military buttons, a knapsack buckle, a cartridge box buckle, a piece of lead, and the tongue of a Confederate general service frame buckle (Jones 1998: 6).

In 1998, another survey was conducted by the William and Mary Center for Archaeological Research (WMCAR). First, the site was gridded into 10-m-squares and the 1,200 targets located by Bob Jolley and the relic hunters were recorded by counting the number of pinflags per 10-m-square. Then, the squares were numbered, and a random 25% sample was selected from which to recover the targets. After that, shovel test probes were dug and several 1-m-x-2-m units were excavated in those areas deemed to have the highest potential for subsurface features. Finally, mechanical stripping was conducted in selected areas where pinflags and subsurface testing indicated the potential for features was high.

This time, the survey confirmed that a Confederate military encampment was located at the proposed site of the Winchester Area Headquarters. WMCAR also identified a previously unnoted Early Archaic component and the occupation of the site by a regiment of the North Carolina infantry. The survey recovered 529 historic artifacts, but only 8% were Civil War diagnostic artifacts. Based on the low number of diagnostics found, it is easy to see how the site was missed by standard survey.

Civil War artifacts found during the WMCAR survey included .69 caliber musket balls, buck and ball shot, .69-caliber musket worm (for removing balls stuck in a barrel), and an old button dating to the Mexican-American War. These artifacts were taken as evidence that the site was truly a Confederate encampment because the men were equipped with outdated large-bore muskets and occasionally outfitted in old uniforms from the Mexican-American War some 20 years earlier. As a result of this project, the author concluded, "systematic shovel testing, even at relatively close intervals, is an inadequate method for identifying and evaluating [Civil War] resources" (Jones 1998:52).

A final example further illustrates the practicality of using metal detectors at domestic sites. In 1990 and 1993, metal detectors were used as part of a testing strategy at the supposed site of the ill-fated Donner camp in the Sierra Nevadas (Hardesty 1997). Although several written accounts exist to describe the terrible winter the Donner party spent in the mountains, the exact location of the camp was unknown, and the subject of long-standing speculation.

Excavations were undertaken in 1990 prior to the modification of public trails to allow handicapped access. Historical documents were consulted before undertaking excavation in hopes of finding clues about where specific encampments had been located. One family group spoke of placing poles around a large pine and camping under that makeshift shelter all winter. A tree that still bore visible charring on one side was thought to have been the tree mentioned in the account. However, excavation around the tree turned up nothing.

Discouraged with these results, the archaeologists decided to try something else and invited three volunteers to conduct metal detector searches of the general area. The volunteers walked transects 4 feet apart with archaeologists recovering each target. Using this method, two artifact clusters were quickly located and the remainder of the 1990 season was spent excavating these areas (Hardesty 1997: 65). Within these clusters, archaeologists recovered many artifacts dating to the period of the Donner party camp, including lead bullets, jewelry, ceramics, horse and ox shoes, cut nails, buttons, and glass bottle fragments. They also recovered an 1830 U.S. Liberty penny and an 1839 Isle of Man farthing (Hardesty 1997: 111).

The Donner party campsite is a temporary domestic site rather than a military or battle site. However, it serves to illustrate the point that the metal detector can be just as useful on a domestic site as on a military one. A significant portion of the artifacts recovered were metal, and in addition, the metal detector identified clusters that yielded ceramics, bone, charcoal, and glass bottle fragments, along with the metal artifacts initially indicated. Although Donald Hardesty did not indicate how deeply artifacts were detected, he did state that a deep-detector (two-box variety) was used on the site in 1993, and no further clusters were found.

Metal detectors are also beginning to see use in other settings. One example is underwater archaeology and the excavation of sunken ships (Parrent et al. 1991; Archaeology Newsbrief 1993a, 1995). Most sunken ships were constructed of wood and are difficult to date or identify based solely on the wooden structure itself. Therefore, identification of the ship rests on the successful recovery of the cargo and/or guns of the ship. Specific cargo items can tell archaeologists where the ship was from and who was aboard, while the guns, especially the cannons, often bear actual dates inscribed upon them. In order to find these types of metallic items, metal detectors and magnetometers are used initially to locate shipwrecks and then to prioritize work on large ships. Strong metal readings indicating the probable location of a ship and its cargo help underwater archaeologists make the best use of limited time and funds (Connor and Scott 1998: 79).

From prehistoric sites (Steinbring 1970; Iwacha 1979) to Civil War sites (Legg and Smith 1989; Nasca et al. 1998; Harwood et al. 1999) to domestic sites (McLeod 1985; Hardesty 1997), the efficiency of using metal detectors during site survey has been proven again and again.

Chapter IV

Methodology and Field Trials

From the earliest archaeological use of metal detectors until the present, methods of survey have slowly changed from adhoc and casual utilization to careful application as part of a thoughtful methodology. Instead of random sweeps with a detector over a site, modern survey methods proscribe searching along regular transects. Methods of recording the results often follow rigorous standards, with horizontal and vertical placement carefully noted.

Metal detectors themselves have become more sophisticated. Today, many models offer not only the ability to discriminate among metals, but to even choose a single metal type from a range of possibilities. The depth of the object may be indicated, and the metal detector may also indicate its precise identity. Underwater archaeologists have the option of using waterproof metal detectors to assist them in their work.

So how should an archaeologist approach a metal detector survey? Just as with traditional subsurface survey, there is no single answer to this question. One approach will not fit all situations, and the precise method must be tailored somewhat to each site. Archaeologists must exercise his/her own judgment about how to use a metal detector in order to best serve the archaeological resource. However, there are general rules that can be applied regardless of the site.

Methodology

A grid should be established at the site prior to the survey and should encompass the entire area to be examined. This will aid both in the execution of the survey and the recording of the results once the survey is complete. The manner in which the grid is marked on the ground will be decided by the size of the survey. A smaller site might be marked at every 5 or 10 meters, while a larger one covering several acres could be staked at 100-meter intervals. If the site is very large, labeling grid markers will aid in the process of recording horizontal provenience.

Next, regular transects should be carried out across the site. A single operator can conduct the metal detector survey and mark targets, but a second person who follows the operator and marks targets will speed up the process. The operator should keep a slow and deliberate pace to allow for maximum coverage of the area. The search coil of the metal detector should be kept even with the surface of the ground and as close as possible without touching it. Swinging the metal detector like a pendulum must be avoided as it causes the search coil to rise several inches off the ground at the end of each swing and reduces the metal detectors ability to penetrate the ground. The operator must physically swivel from side to side to keep the machine level along each sweep.

Each target indicated by the detector should be marked. Pinflags are the most commonly used markers, although the metal stems will set off the detector. The metal of the pinflag will only hinder the survey when targets lie very close together because the flags can be no less than the width of the search coil apart. If the survey methodology requires 100% recovery, an area with closely spaced targets would have to be surveyed more than once. However, if the survey is being carried out only to determine the location of the site boundaries and intra-site artifact clustering, flagging every target in a busy area is not necessary. The concentration will be apparent despite the spacing limitations. Another way to deal with plentiful, closely spaced targets is to set the detector to discriminate and tune out iron, as many diagnostics such as coins, bullets, and buckles are made of non-ferrous metals.

The archaeologist must at some point decide whether to discriminate between metal types. The decision to search for all metal targets or not will be based on the goals of the project and the number of metal artifacts at the site. If the aim of the survey is to locate artifact clusters, discrimination is not necessary and all metals should be included. However, should the project require the survey to locate particular diagnostic artifacts such as lead bullets, brass buckles, or spent cartridges the operator would be well advised to tune out all non-diagnostic metal types, especially iron.

When recovery of targets is part of the archaeological plan, the results of the survey help decide how many of the targets will be recovered. If there are hundreds or thousands of metal artifacts at a site, time or budget constraints usually force archaeologists to collect only a sample of the targets. On the other hand, if only a few metal artifacts are found, they may be easily recovered within the time available.

Again, if the goal is simply to define artifact patterning at a site, recovery of targets is unnecessary. Traditional subsurface testing carried out after the metal detector survey will gather a sufficient sample of the artifact assemblage, especially if the subsurface excavation is planned with artifact clusters in mind. However, if the aim is to locate specific metallic artifacts, then recovery is an integral part of the survey. Recovery is best done with a metal detector, rather than with a shovel and screen. With a metal detector, it will take less time to recover the target, and it can be left in place for recordation purposes if necessary.

If precise horizontal and vertical proveniences are important, recordation should involve a transit. Targets may be numbered sequentially, with a corresponding transit reading. If less precise methods are acceptable, the number of targets in a given area may be counted, for example the number of flags per 1-, 5-, or 10-m square. If recovered, the target should be bagged, and labeled with its unique identification information. It may also help to keep a running log in the field of recovered targets.

Finally, a conservation plan should be in place prior to the field survey if the project will include the recovery of a large number of the metal targets. As with many archaeological materials, metals often become very fragile when removed from their subsurface environment. Corrosion processes that were slowed by the relatively stable below-ground environment speed up when artifacts are excavated. Fragile metallic items may begin to disintegrate without proper support. Metal objects recovered from underwater or waterlogged sites may develop severe cracks if allowed to dry out. Lead, tin, iron, brass, and bronze are all subject to corrosion and will not survive in storage if left in an unconserved condition (Singley 1988; Cronyn 1990). In order to protect all of the information gained by the survey, time and funds should be dedicated to conservation at the outset of the project.

Field Trials

Several metal detector surveys were conducted as a part of the preparation of this thesis. The methodology described above was based in part on the results of personal experience with a metal detector in the field. Surveys were of 19th century sites only which was a result of site availability and should not be taken as an indication that the metal detector is best suited to sites of this period. A combination of domestic and Civil War sites were investigated during the 1999 and 2000 field seasons. Surveys were conducted primarily in New England, although the Civil War sites were located in Virginia (Figure 2).

In each case, survey was conducted with a Radioshack Discovery 2000 metal detector. This machine was purchased new in 1999 for roughly $200. It does not have the ability to search for a particular metal or determine the depth of a target. It does have a target identification system, and although it will not select a single metal type, it does allow discrimination against a range of metals. For example, all iron can be tuned out, but it cannot be set to detect only silver coins. Its has a 10-inch open search coil and uses two 9-volt rechargeable batteries as a power source. The batteries allowed me to operate the metal detector all day and could be recharged nightly. The 10-inch open coil was suitable for searching for small (½ - 1 inch diameter) metal items down to 6-8 inches, while larger (1 inch diameter and larger) metal items could be detected as much as 12-16 inches below the ground surface. Drawbacks included snagging the open coil on brush, and difficulties pinpointing targets in areas containing high numbers of metal artifacts.

Potential Civil War site, January 20-22, 1999

In advance of a road construction project, the survey of several acres near Suffolk, Virginia was undertaken as part of an agreement between the William and Mary Center for Archaeological Research (WMCAR) and the Virginia Department of Transportation

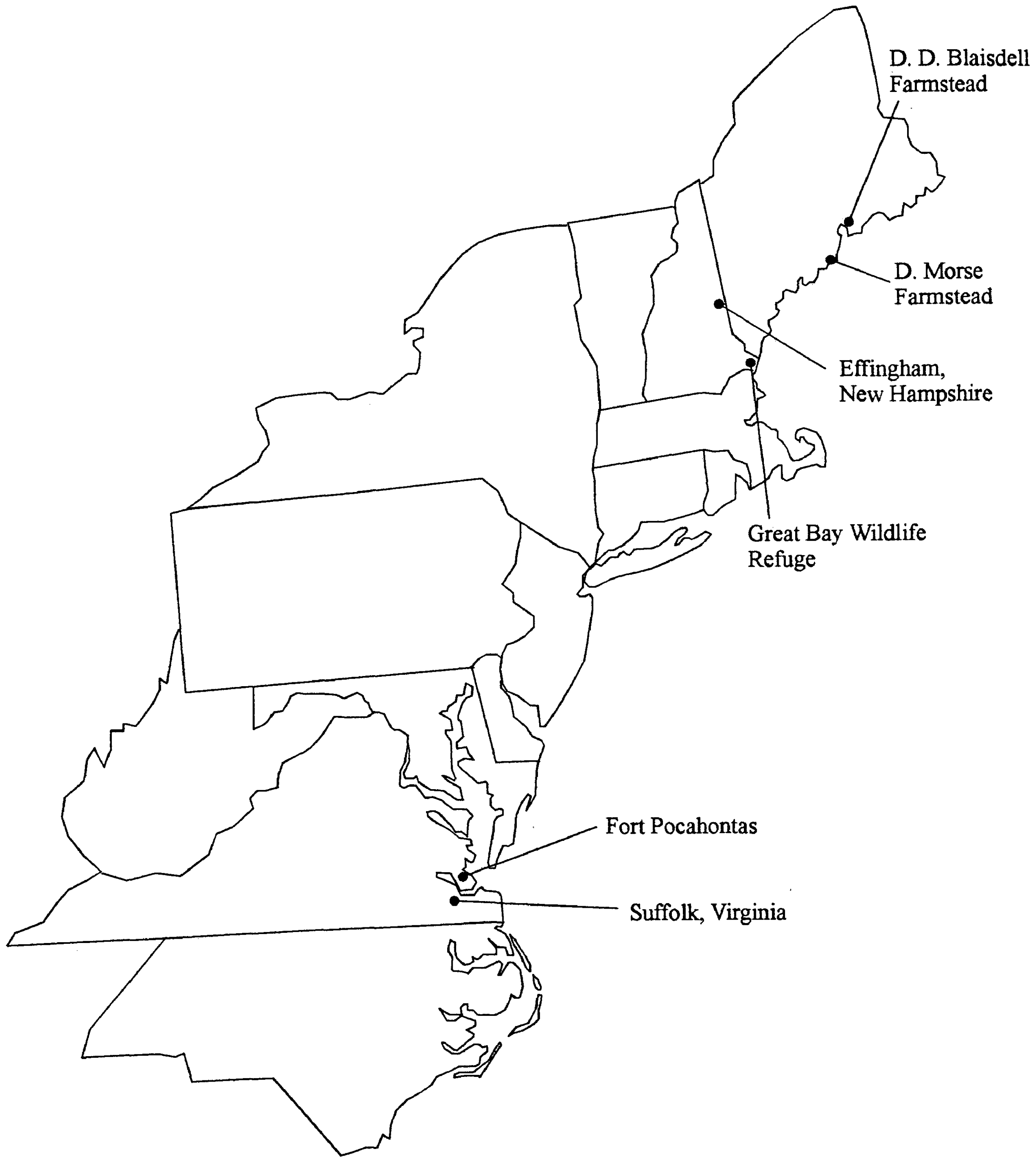

Figure 2. The location of sites surveyed.

(VDOT). The survey area lay partially in plowed field and partially in woods that were being harvested for timber. In the plowed field, a grid was paced off and metal detector sweeps were conducted along transects spaced approximately 5 m apart. Unfortunately, because the field was covered with corn and soybean stubble, the coverage was less than optimal because the search coil could not be held perfectly even with the ground surface. The soybean stubble was easier to survey than the corn, which could only be surveyed along each row between corn stalk stubs.

Since relatively few metal artifacts were found in the plowed field, archaeologists attempted to recover all targets. The rate of recovery for large targets was 100%. However, small targets were harder to locate and the recovery rate dropped. The method which seemed to work best was to pinpoint the metal target as precisely as possible, and then scoop out a minimum amount of dirt. The excavated soil was next placed on a bag placed flat in an area previously determined to be clean of metal. The dirt was divided into two piles, each pile scanned for metal, and the negative pile discarded. If neither pile gave a signal, the hole was searched and more soil removed. Even very small items were found using this method, including nails less than 2 inches long and ¼ inch boot tacks. The precise location of recovered targets was not recorded because the items recovered were all nails or machinery parts that were determined to be randomly scattered across the field. No Civil War diagnostics were found.

After surveying the corn/soybean field, two wooded areas that had been partially logged were also searched. Wooded areas were not subjected to strictly gridded transects, but rather the least disturbed portion of each was subjected to almost total survey. The open woods were easier to survey than the cornfield, as the only obstacles to the metal detector were fallen leaves, tree trunks, and occasional bushes. A railroad spike, a long bolt, and several shotgun shells were recovered, but no Civil War material.

Although no Civil War diagnostics were recovered, archaeologists did find something interesting in the final area. On a river terrace in the last wooded area, the metal detector located multiple targets. When archaeologists looked closer at the area, they found brick, ceramic, and shell on the surface. Although a dozen or more nails were recovered, they were without exception cut. The cut nails, coupled with the brick, ceramic, and bone indicated the survey had defined a 19th century domestic site.

Although no Civil War materials were recovered during the survey, it was clearly demonstrated that a metal detector survey could, by itself, identify a historic site. The detector registered nails from the long-vanished structure immediately. The presence of the nails made archaeologists look more closely at the area, causing them to discover other artifacts on the surface. In a matter of minutes, it was evident that we had located a site and that it dated to the 19th century.

Metal detectors had found the site much faster than shovel testing could have, and had given a more precise idea of where the site boundaries lay. Unlike traditional testing which is carried out at discrete intervals, metal detector transects are continuous across a site, allowing archaeologists could determine precisely where targets disappear, while at the same time noting density across the site. Shovel testing would still be necessary to gather information about site stratigraphy and to collect a representative artifact sample, but with some idea of site boundaries and intra-site concentrations already noted.

Fort Pocahontas, Spring 1999

The next field trial took place at Fort Pocahontas, a Civil War-era Union fort located on private property in Charles City County, Virginia. Archaeological investigations had been undertaken at the request of the landowner in preparation of the development of the site as a public attraction. The 1999 field season was the third year of investigations by WMCAR at the site.

General Edward A. Wild established Fort Pocahontas in 1864. He took with him Wild's 1st Brigade composed of the 1st, 10th, 22nd, and 37th Infantry U.S. Colored Troops along with part of the 3rd Division 18th Corps of the Army of the James (Nasca et. al. 1998). Because most of the troops stationed there were African-American, the Fort has presented archaeologists with an opportunity to investigate how African-American soldiers lived during the war, comparing their accouterments and living conditions to those of white soldiers.

In addition to the investigation of the way African-American troops lived, there were other lingering questions about Fort Pocahontas that WMCAR hoped to address. One of these questions had to do with a Confederate attack on the Fort that took place on May 24, 1864 (Nasca et. al. 1998). Rebel troops, led by Major General Fitzhugh Lee, attempted to overrun the Union position at Fort Pocahontas. The first Southern attack was turned back. Not to be so easily routed, the Confederates tried again, this time attempting to gain access to the barricaded Fort through natural ravines on the east side. This attempt was also rebuffed, and the Confederates were forced to admit defeat.

Earlier metal detector surveys at the Fort had located important archaeological deposits. Metal detector surveys carried out in 1997 and 1998 had revealed evidence of troop encampments in several areas outside the Fort's earthen embankments (Nasca et. al. 1998; Harwood et. al. 1999).

During the 1999 field season, survey was conducted in the ravines said to have provided cover for the Confederate soldiers second attack on the Fort. Methodology for the 1999 survey was not governed by strict transects. Instead, archaeologists attempted to narrow the amount of survey needed by assuming that the hillsides facing the fort would have absorbed many of the bullets fired at the Confederates as they were driven back for the second time. However, a thorough search of the facing hillsides of the eastern ravines was unsuccessful in locating any bullets or Civil War diagnostic material.

Having failed to recover a single bullet from the ravines traditionally held to have been used, the search moved to ravines on the north side, hoping the tradition could have misplaced the location of the second attack. Again, searching was done mainly on the facing slopes with hopes of recovering spent bullets that never found their Confederate targets. This time, two bullets were recovered, however, both were in perfect un-fired condition and were assumed to be simply lost by either Civil War soldiers or re-enactors who visit the site each year.

Despite negative results, the metal detector surveys were completed in only a couple of days. The same area would have taken a week or more for several teams to cover with shovel tests, with less total ground area examined. Further archaeological research will attempt to reconcile the negative archaeological results with the oral tradition concerning the Confederate movements in the ravines around the Fort.

The first field trial of the metal detector in New England occurred May 8-9, 2000 in Thomaston, Maine. At the time of investigation, the site in question consisted of a house and approximately 3 acres of land that were slated to be replaced by private development. The survey was conducted under an agreement between the landowner and Independent Archaeological Consulting, LLC (IAC).

Historic research determined that Daniel Morse bought approximately 25 acres at the corner of Gleason and Roxbury Streets in Thomaston in 1845. There was no mention of buildings in the deed. The house is built in the Greek Revival style with the gable-end and a long wing facing Gleason Street. Historic photographs show an attached barn that was no longer standing at the time of survey. Greek Revival houses were most commonly built between 1830 and 1860 (McAlester 1997), the style of the house coupled with the date of purchase indicates the house was built sometime shortly after the purchase of the property. Census records from 1850 to 1880 show that the property operated as a diversified farm, on which Daniel Morse raised cattle, harvested timber, and grew apples.

Descendants of the Morse family had occupied the house until 1985, when it was sold and made into apartments. Neighbors say the barn was removed sometime after 1950. Otherwise the house remained in an almost unaltered condition at the time of survey, although it was beginning to show signs of decay.

Archaeological survey was conducted in order to determine whether there were intact deposits related to the 19th century occupation and operation of the house and farm. The survey primarily focused on the yard immediately surrounding the house, with additional testing in peripheral areas to determine site boundaries. Metal detector surveys were planned to help define site boundaries and locate potential artifact concentrations. Subsurface excavation would follow, allowing archaeologists to gather a representative artifact assemblage and test for intact subsurface features.

An 8-m grid was established at the site in order to facilitate both metal detector surveys and subsurface shovel testing. Four metal detector transects were conducted across the site, with targets along each transect marked with pinflags. Since the purpose of the metal detector survey was solely to define site boundaries and locate artifact concentrations, none of the targets were recovered.

The results of each metal detector survey were recorded by counting the number of flags per 8-meter interval along each transect. The transects crossed the site from north to south and from east to west, allowing archaeologists to observe how artifact density changed across the site. In those areas where the number of pinflags dropped to less than 5 per 8-meter interval, site boundaries were delineated. Areas that showed 20 or more flags per 8-meter interval were designated as an artifact concentration.

The first New England field trial of the metal detector was a success. Site boundaries based on the metal detector surveys (Figure 3) coincided almost perfectly with boundaries found through shovel testing (Figure 4). Moreover, an area showing unusually high density of metal targets despite its distance from the house was found to represent an extensive midden dating to the turn of the 20th century. The midden had remained undiscovered despite its size due to an extremely dense growth of briars that had intertwined with a thorn apple so as to become almost impenetrable. However, the

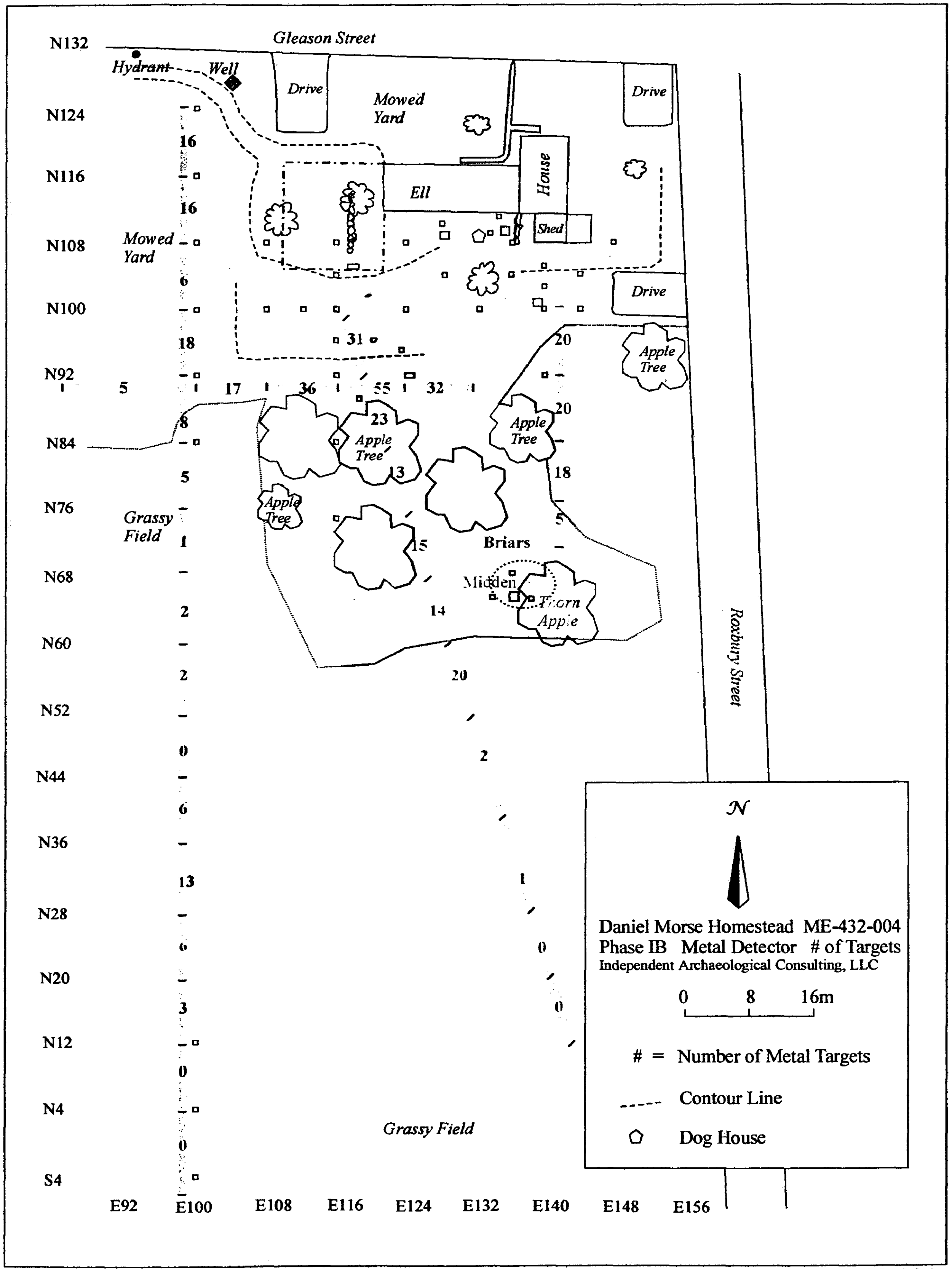

Figure 3. Results of the metal detector survey at the D. Morse Farmstead, ME-432-004.

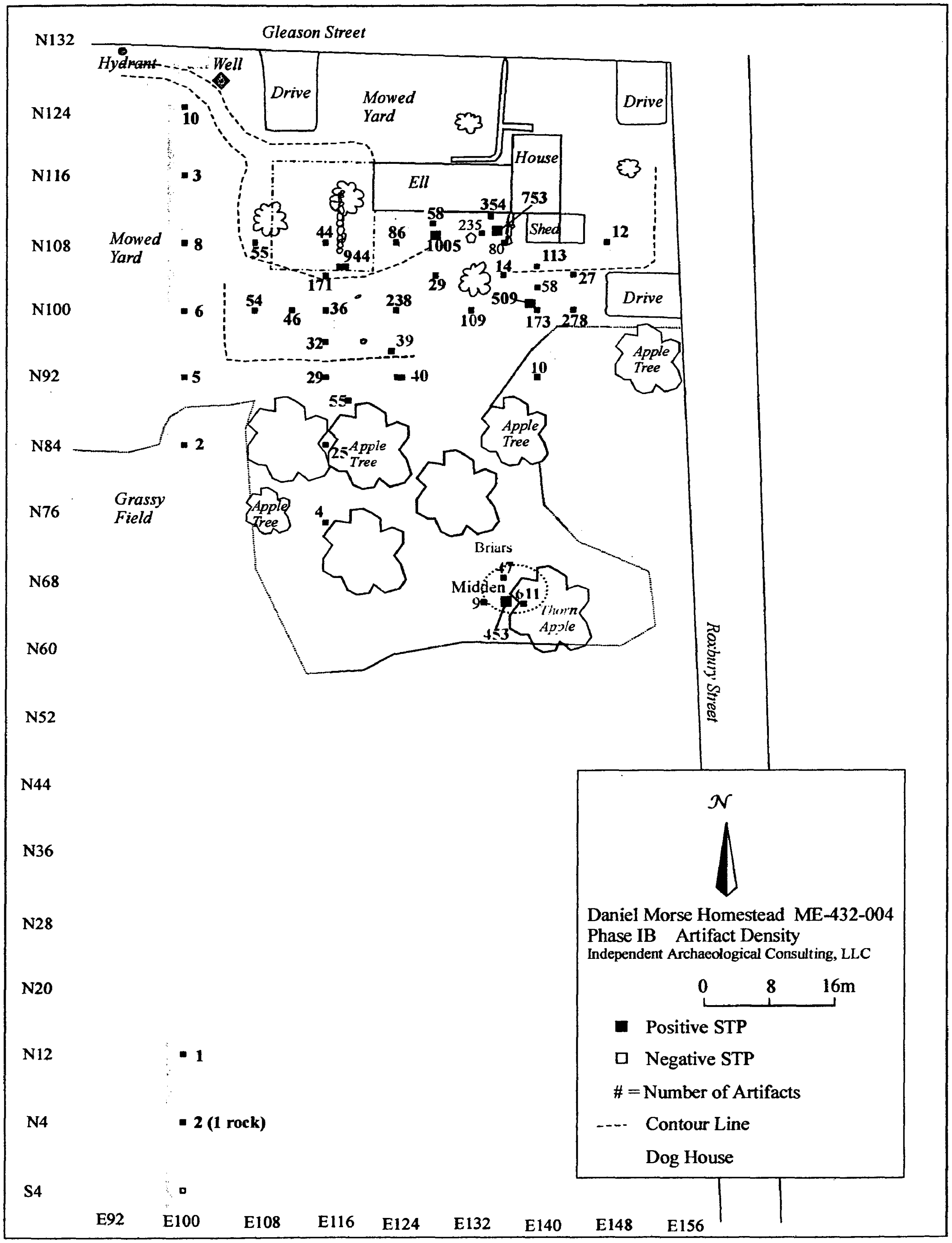

Figure 4. Results of shovel testing at the D. Morse Farmstead, ME-432-004.

unusually high amount of metal targets in the vicinity caused archaeologists to push past the barrier and identify the midden.

Metal detector surveys carried out during the examination of the Daniel Morse Homestead were an essential part of this archaeological investigation. Besides assisting in the determination of site boundaries and the discovery of artifacts at the site, the metal detector could be used in areas where shovel testing could not. The period during which the project was carried out was wet and rainy in Thomaston, Maine. Soils at the site were poorly drained and, due to wet conditions, ranged from difficult to impossible to screen. Despite being wet, areas that were not conducive to excavation could still be subjected to metal detector survey. Moreover, the results of the survey helped double-check the effectiveness of screening that was being carried out under difficult conditions. STPs that yielded low numbers of metal artifacts despite their location within previously identified artifact concentrations were double checked with the metal detector, and missed artifacts were recovered.

The metal detector survey did locate one group of artifacts in an area too wet for the recovery of artifacts along the E100 transect between N20 and N44. Standing water several inches deep precluded the investigation of the spot. However, the concentration of metal targets was never more than 13 per 8-meter interval; less than 2 metal artifacts per meter. Three STPs excavated immediately south of this area yielded only 2 artifacts, a piece of white granite ceramic and a piece of flat glass. The area was located approximately 50 meters from the house; the artifacts may indicate the presence of an outlying shed. Small, affiliated structures associated with the production of farm products are common and would not be unusual for a diversified farm of this type.

Difficulties that arose during this project allowed further refinement of the way in which the metal detector can be best used at historic sites. First, the results of the survey indicated occupation of the building during the last 15 years had resulted in the deposition of many modern artifacts of a metallic quality in the yard surrounding the house. Cigarette wrappers, aluminum cans, pull tabs, and screw tops were strewn about the area. Although an attempt was made to screen these items out, they undoubtedly accounted for some of the readings around the house. Also, a children's play area (N80-88 E116) had accumulated a variety of debris including pots, pans, spoons, and other materials that were sometimes registered by the metal detector. The modern materials could not always be seen at the surface and were sometimes included in the results of the survey. The additional modern materials undoubtedly inflated the results of the metal detector survey somewhat. The conclusion here is that modern metallic trash can mask earlier historic deposits, or create clusters of artifacts that when excavated, yield little useful information. One method of combating this problem would be to recover suspected modern targets; another would be to discriminate against pull-tabs, foil, and screw tops if the metal detector has the ability to do so.

A second difficulty that occurred during survey involved a discrepancy between the amount of metal sensed by the metal detector compared to the number of metal artifacts found during actual excavation. In some cases, when shovel tests were excavated in areas that had displayed a high number of metal targets, no metal was recovered from the screening process. The problem was found to lie in the manner in which the shovel tests were being excavated. In order to preserve the appearance of the house yard, the sod was stripped from the shovel test in a single piece and not subjected to the screen. When the sod was searched with the metal detector, several iron nails were found. Therefore, when attempting to reconcile the number of targets found by a metal detector to the number of metal artifacts recovered from excavation, it is important to screen all removed soils.

Overall, the application of the metal detector at the Daniel Morse Homestead was a success. With a time investment of about 8 hours, the metal detector aided in the identification of site boundaries, helped locate artifact clusters, led archaeologists to discover an extensive surface midden, and double checked the efficiency of screening. These results were well worth the 8-hour investment.

Great Bay National Wildlife Refuge

The Great Bay National Wildlife Refuge is located in southeastern corner of New Hampshire in the town of Newington. The Refuge was created from a portion of the Pease Airforce Base that was closed in the early 1990s. The western and northern edge of the Refuge is bordered by a series of coves along the Piscataqua River and contains a number of historic sites.

The survey of the Refuge was undertaken as part of a larger study of the Newington area conducted by IAC (Marlatt and Roach 2000). Newington was first settled in the 1600s, and as a result the town contains a number of early historic sites. The purpose of the study was to create a predictive model for the area in order to allow the town to effectively direct future development away from sensitive areas. Portions of the Refuge deemed highly sensitive for historic or prehistoric archaeological sites based on their slope, vantage, and access to water were examined for potential archaeological resources. One of these areas was also subjected to metal detector survey.

The single area subjected to metal detector survey lay on the north side of the Ferry Way Trail on Furber Point. The survey was conducted on June 13, 2000. Vegetation in the area was mixed forest with an open understory that was relatively easy to survey. The area lay on a knoll overlooking Welsh Cove to the north and east. The area possessed high potential for early historic settlement, as a ferry had operated from a point of land just west of this test area, and other historic sites had been previously identified nearby. However, numerous tree falls had created an uneven ground surface that was difficult to visually examine for structural features. Prehistoric potential was judged to be moderate because of its elevated position overlooking Welsh Cove.

Six transects at 8-meter intervals were surveyed across the area which measured approximately 50 square meters. The entire survey took about one hour but if shovel tests were excavated at the same interval the survey would have taken about two days. Soil cores were also taken across the site in order to determine how well drained the soils were. Poorly drained soils are much less likely to have supported any kind of occupation, while better drained soils are useful for cultivation and/or occupation. Two shovel tests were excavated in those spots judged to have well-drained soil and therefore the most potential for archaeological deposits.

Despite the generous size of the survey and the promising location, only eight metal targets were identified across the entire area (Figure 5). None of the targets were recovered, however one target visible at the surface was identified as an empty can for an unidentified substance. Soil cores revealed the majority of the area was very rocky and

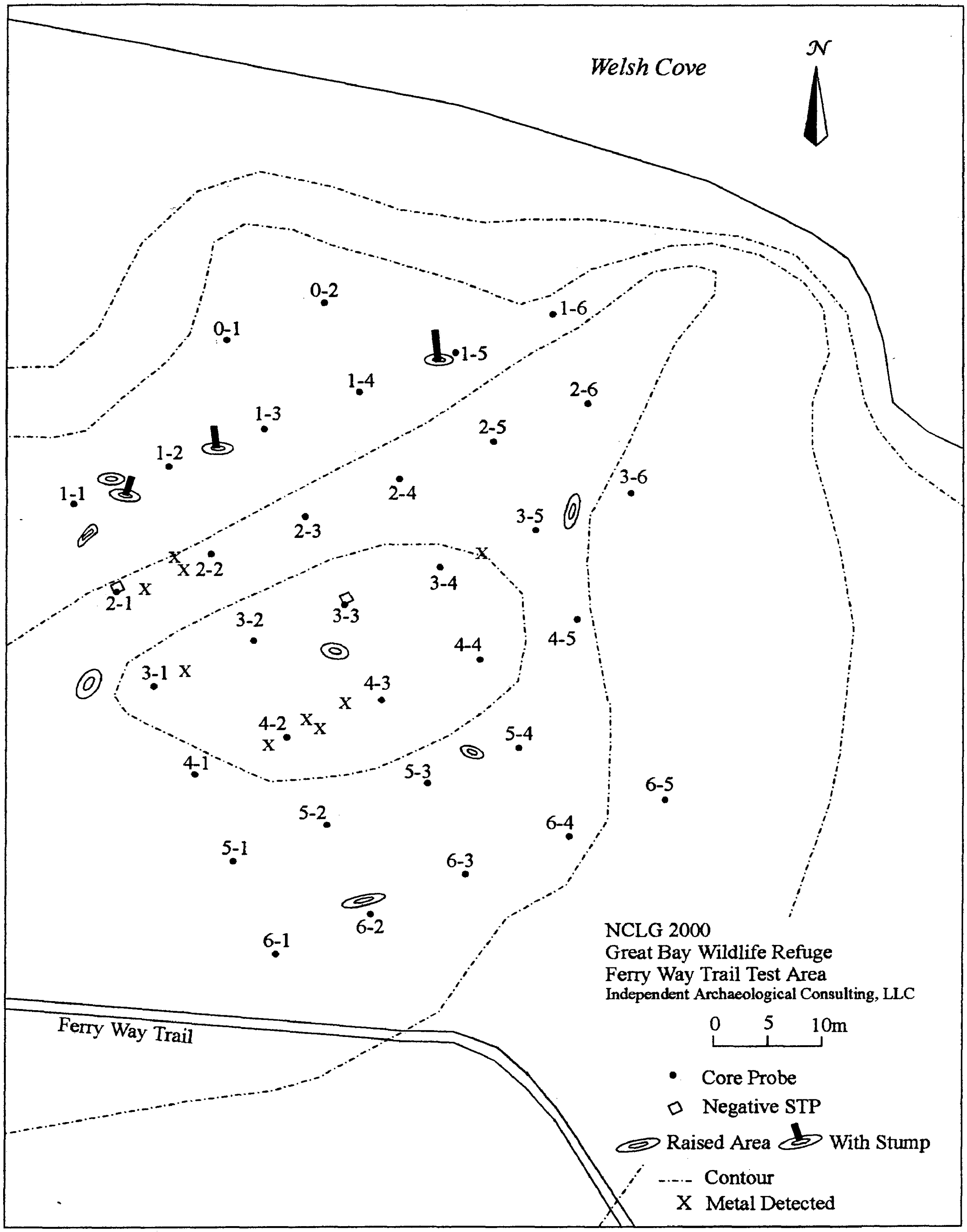

Figure 5. Results of the metal detector survey at the Ferry Way Trail Area, Great Bay Wildlife Refuge.

not especially well drained. The two shovel tests were also quite rocky and yielded no artifacts.

The negative results of this survey only served to highlight the efficiency of using a metal detector to conduct site surveys. Based on the presence of previously identified historic sites nearby, archaeologists felt there was a very good chance of an early historic occupation on this knoll. The uneven ground surface made it very difficult to tell if there was a cellar hole in the area, but there were several wide, shallow depressions in the area that looked promising. However, once the metal detector survey had been completed, it was apparent that there was no historic site present. The almost complete absence of metal artifacts gave an indication that there had never been a historic occupation of the area. The presence of the empty metal can on the surface gives reason to believe that the handful of metal targets identified were probably deposited during the use of the area as a military base. The area may have been used for either recreational or military activity of Airforce personnel.

Again, the highly effective nature of the metal detector survey was demonstrated during the survey of this test area within the Refuge. Any kind of historic occupation would have deposited much more that the eight metal targets that were found. Field trials at other sites have shown that even plowed fields tend to have more metal artifacts than this area. Based on previous surveys, once the survey here had been completed, it was clear we could expect no historic artifacts from testing in the area. The rocky nature of the soils coupled with the north-facing aspect of the knoll may have precluded settlement of the area.

D. D. Blaisdell Site

The second historic domestic site at which the metal detector was implemented was the D. D. Blaisdell Site in Dedham, Maine. Survey was conducted on October 2-3, 2000. The site consisted of two cellars approximately 24 m apart, situated along a dirt road in the mid-coastal region of Maine. The cellars lay on a parcel that was scheduled to be developed as a housing development for low-income families. The work was conducted under an agreement between the private developer and IAC (Wheeler, Marlatt, and Roach 2001).

The main goal of this project was to determine site boundaries so that development could avoid the site. This was a task at which the metal detector had already proven itself useful. In this case, the metal detector survey would serve to double-check the results of shovel testing at the site.

Archaeologists established an 8-m grid that encompassed both cellar holes and the area immediately surrounding them. Five transects across the site were searched with the metal detector. A two-person team consisting of the operator and a flagger worked to complete each transect and record the results. At the completion of each transect, the number of flags were counted, recorded, and removed. Site boundaries were considered to exist around the area where there were at least 2 targets per meter.

Although the 48 shovel test probes took two days to excavate, the metal detector survey was done in half a day. When the shovel tests were completed, the site boundaries as defined by the excavations (Figure 6) were compared to those found with the metal detector (Figure 7). They were identical. What had taken several days with the shovel tests had been done in a few hours with the metal detector. Archaeologists also

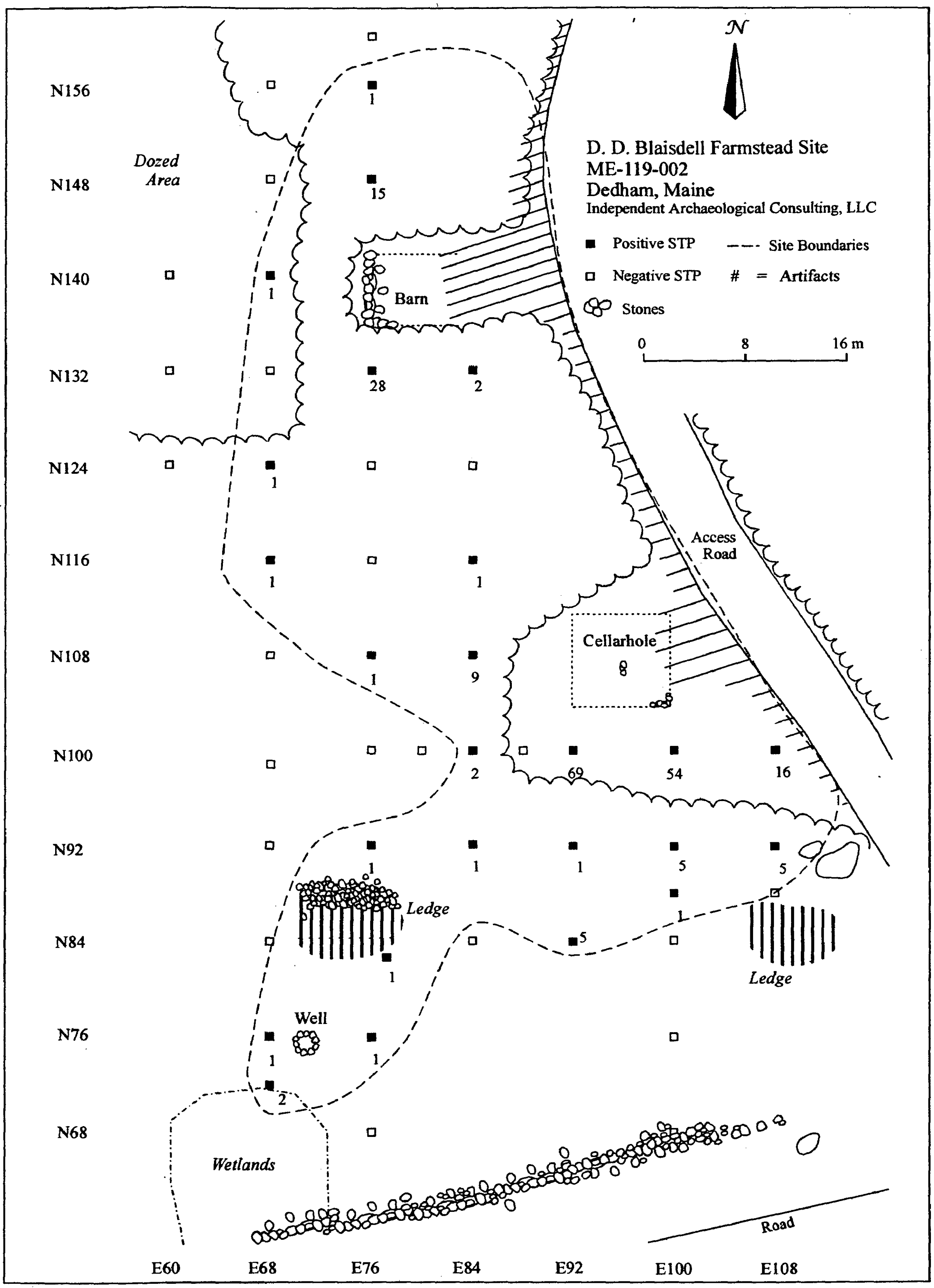

Figure 6. Results of shovel testing at the D. D. Blaisdell Farmstead, ME-119-002.

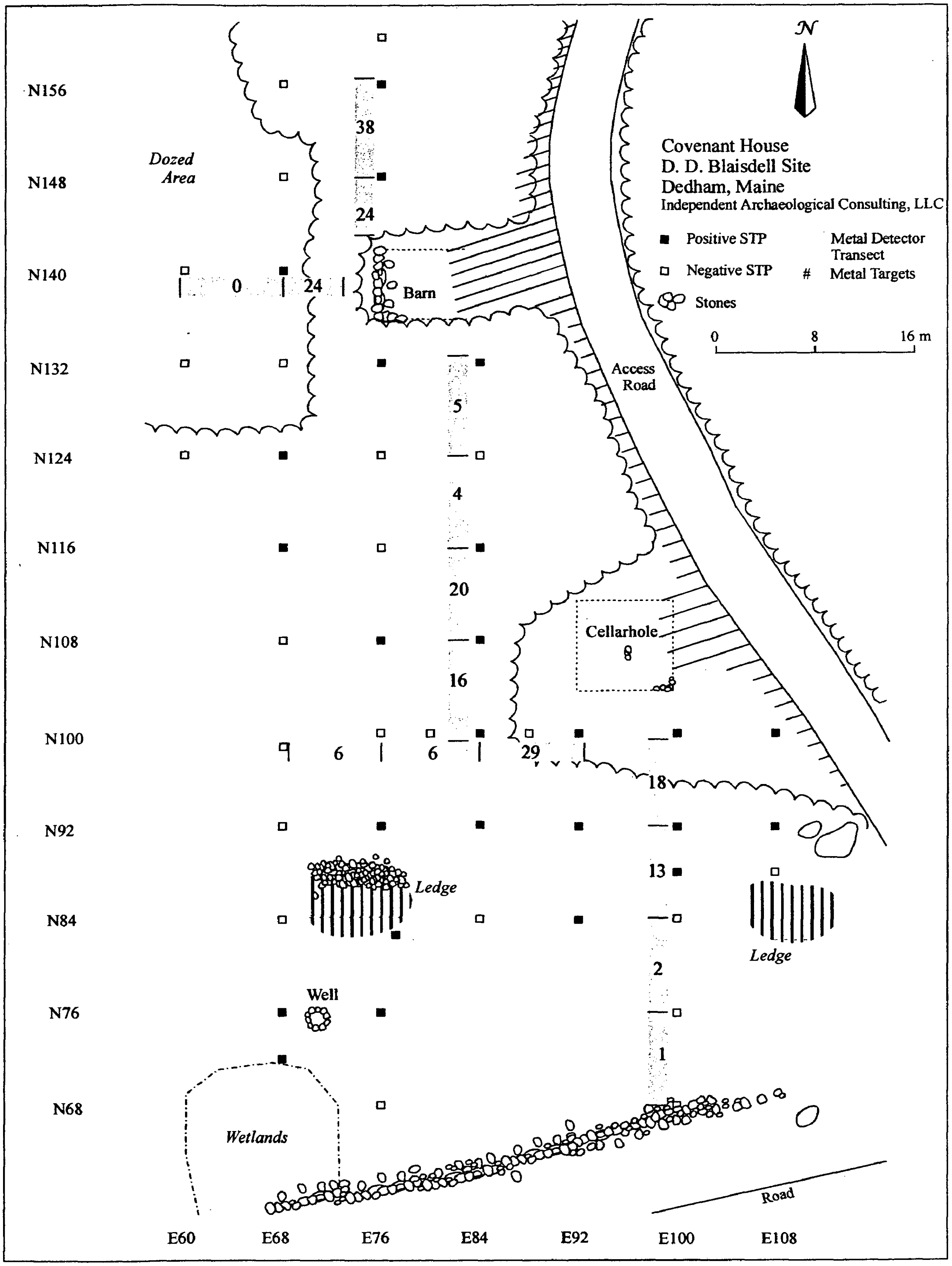

Figure 7. Results of the metal detector survey at the D. D. Blaisdell Farmstead, ME-119-002.

successfully defined a peripheral artifact scatter related to the well southwest of the cellar holes.

Although the main goal of the survey had been to identify site boundaries, the metal detector survey also began to define artifact patterning across the site. While substantial numbers of metal targets were identified around both cellars, density dropped between the two. Artifacts were generally clustered tightly around each cellar. This pattern serves as an indication that the two were not part of a connected structure, but rather existed as separate buildings.

In addition, a cluster of metal targets was located between N100-116 and E76-84. Although the number of recovered artifacts was relatively low, archaeologists were stripping the sod layer from STPs in this area before beginning screening. The metal targets then were most likely in the sod layer. The missing metal targets were found at the Daniel Morse Homestead to be nails in the first 5 cm of sod. It seems likely that the artifact concentration here is also due to nails in the first few centimeters of soil that were not recovered due to the method of excavation. If they are nails, they may offer evidence that the southernmost building had only a partial cellar, and was larger than the dimensions of the cellar itself.

The metal detector surveys at the D. D. Blaisdell Site added substantially to the information gathered during the archaeological investigation. The survey correctly identified site boundaries in less than a day. It helped locate the well associated with the property. And the metal detector survey in a limited way began to identify intra-site artifact patterning that gives further information on the size and conformation of the structures that once stood over the cellars at the site. Again, for the amount of time invested in the metal detector survey, archaeologists gained a great deal of useful information.

Effingham Survey

On July 21 and 28, 2000, another field trial was conducted in Effingham, New Hampshire. The State Archaeologist's Office officially requested that a metal detector survey be carried out on a parcel of land locally known as "Cato's Field," which was scheduled to be impacted by the realignment of Route 25 as it crosses the Ossipee River. The work was conducted under an agreement between the New Hampshire Department of Transportation (NHDOT) and IAC (Marlatt, Wheeler, and Roach 2001).

Cato was the name of a slave who had died and supposedly been buried on the property around 1800. Although a prehistoric site had been previously identified along the banks of the river (Kenyon 1985, 1986), the lingering implications of an early slave burial remained unconfirmed. Moreover, local informants had identified a pile of stones within the proposed road corridor as the slave's grave. It was requested that IAC conduct a metal detector survey of the potential grave and the immediate area as one way of investigating the site's potential.

The metal detector survey for this project began with the supposed grave located at the top of the slope above the river. Once the pile of stones had been thoroughly searched, the survey moved on to the rest of the terrace. Survey was conducted along two transects - one along the edge of slope and one located 8 to 16 meters away from the edge. A series of soil cores were also taken to test for well-drained soils, and two STPs were excavated to examine site stratigraphy and test any metal concentrations. Finally, the area was mapped with all testing recorded.

The metal detector immediately targeted several metal artifacts in and near the pile of stones identified as Cato's grave. The artifacts sensed were a disintegrating metal bucket and a Budweiser beer can, both of which lay under the rocks, the bucket at the west end of the stone pile and the can near the middle. Several fragments of ceramic bearing mocha-style decoration were associated with the metal bucket. Moreover, another pile of stones associated with artifacts including broken bottles, roofing shingles and cut nails was found approximately 12 m south.

Metal detector survey along the second transect further from the top of the slope yielded a single .22 caliber lead bullet, and a cut nail. Further south and closer to the road, a mason jar lid and other modern trash were visible on the surface.

Based on the results of the metal detector survey two shovel test pits were excavated. The first was placed at the west end of the pile of stones where the rusting bucket and ceramic fragments were found. The second was placed 8 meters west, upslope from the stone pile. The shovel test pit located upslope was sterile, but the pit closest to the stone pile contained a high concentration of artifacts, including over 100 fragments of pearlware, pieces of a large iron spoon, and a few glass bottle fragments (Figure 8).

Preliminary interpretation of the metal detector survey and shovel testing was that the margin of the property above the river had been used for domestic refuse disposal for the last 200 years. The modern trash along the edge of the woods coupled with the beer can and asphalt shingles on the stone piles seemed to support this hypothesis.

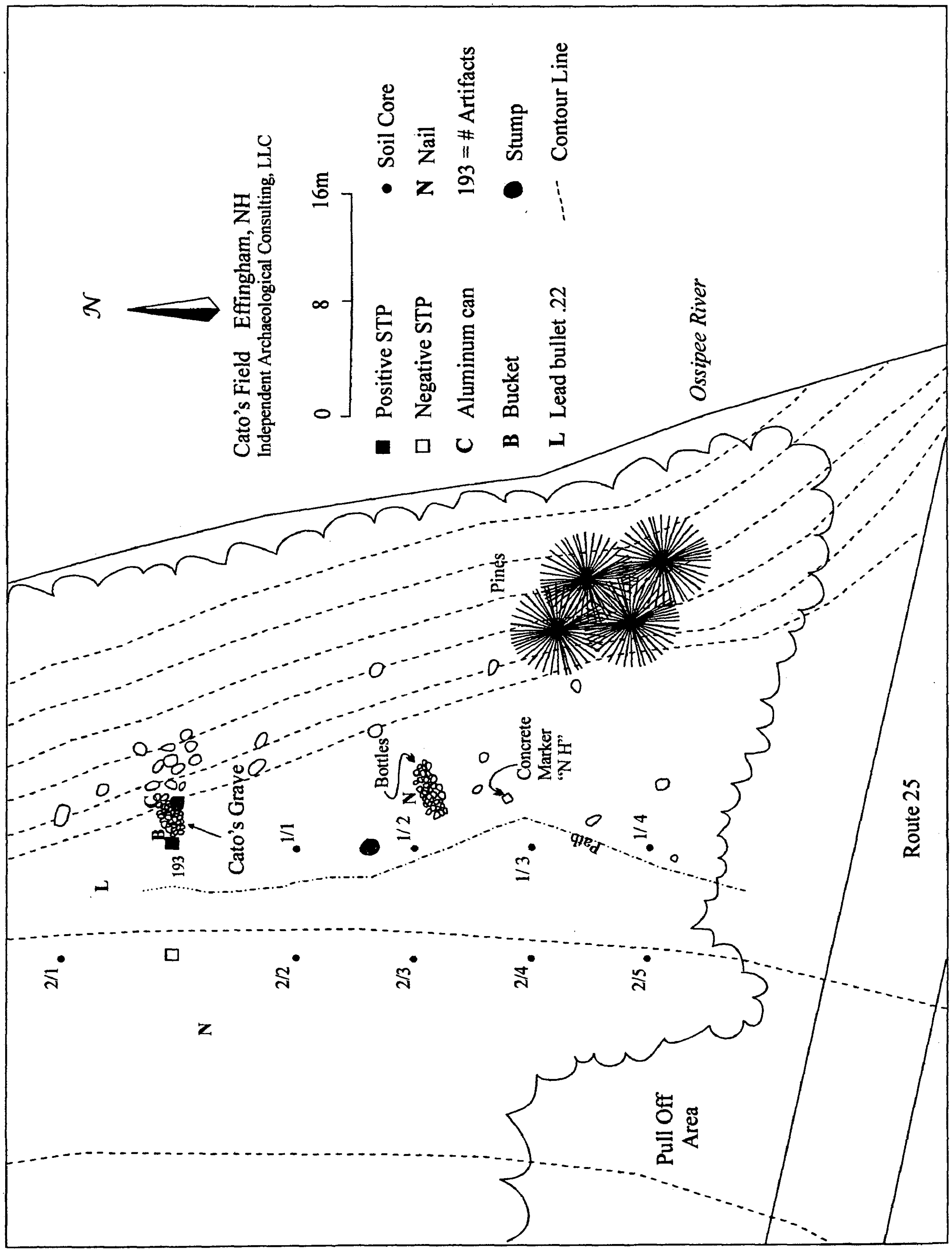

Figure 8. Results of testing at Cato's Field in Effingham, New Hampshire.

However, research conducted into the typical burial practices of rural slave and free black communities indicated stone piles, or cairns, were a common method of marking black graves. In addition, relatives and community members often placed grave goods on the body during burial or on the grave after burial. The goods left with the dead were usually coins, plates, bowls, bottles, and spoons. Moreover, the graves were usually oriented east-west, just as the two stone piles in Effingham were oriented.

With the circumstantial evidence mounting, the artifacts were re-examined. The ceramic sherds were reassembled to form an almost complete pearlware pitcher with a mocha decoration characteristic of the early 1800s. Furthermore, the large iron spoon also appeared to be of the type common during the first part of the 19th century (Hume 1969). It now appeared almost certain that the stone piles above the river were in fact graves. Further archaeological excavation is pending.

Each of these field trials gave further proof of how useful metal detectors could be at historic sites. Despite the fact that the metal detector used for these trials is one of the cheapest on the market, it was infallible when detecting metals and never gave a signal unless metal was present. Using the metal detector, the boundaries of historic sites could be found quickly and accurately, and it could be used in areas where environmental conditions precluded excavation. It alerted archaeologists to artifact concentrations that may have otherwise gone unnoticed and recovered diagnostic artifacts that allowed sites to be dated.

The most difficult part of learning to use the metal detector is learning to trust the machine. Often unfamiliar with metal detectors, archaeologists may be tempted to doubt the accuracy of the machine. However, modern metal detectors are often preset to tune out minerals, and even the cheapest detectors can be trusted to locate only metal artifacts. The archaeologist using the machine must be confident in its abilities as doubts about the accuracy of signals turn meaningful patterns to nonsense and negate the metal detectors usefulness. The metal item may be small and almost impossible to find - items like boot tacks and .22 caliber bullets fall into this category. However, execution of effective methods of recovery (as described previously) will allow survey to move along quickly and efficiently.

Although a relatively inexpensive model of metal detector was used for this project, more expensive machines could be useful, especially if the goals of the survey are to recover only diagnostics from a Civil War battlefield, or if there are a large number of modern trash items that need to be tuned out. However, a basic machine requiring an investment of only about $200 will generally fulfill the archaeologist's needs.

Chapter V

The Future of Metal Detecting

The presence of metal detectors at retail stores such as Walmart and Radioshack creates the impression that these machines are mere toys. However, metal detectors are actually cheap, totally non-destructive, remote sensing devices that, when applied to archaeological sites, are remarkably effective tools for recovering artifacts. Because they are so affordable and because they are so effective, the public has largely co-opted their use for recreational purposes. In the wrong hands, metal detectors have undeniably been used to do enormous amounts of damage to archaeological sites. The widespread destruction of historic sites has become so intimately associated with these machines that most archaeologists want little or nothing to do with them.

Despite the stigma, metal detectors are beginning to see some use by archaeologists. However, they usually call on local hobbyists, also known as relic collectors, to do the metal detector surveys for them. There a couple of reasons they do this. The first is that the surveys often involve large tracts of land, and the ready and willing volunteers in local metal detecting clubs provide a free source of labor and get the job done quickly. The second is that many archaeologists labor under the impression that metal detectors are highly technical machines, difficult to operate, that take a long time to understand. The first reason is a good rationale for using hobbyists; the second reason is a totally false impression and therefore a bad rationale for using hobbyists.

Two glossy popular magazines, *Lost Treasures* and *Western and Eastern Treasures* appear monthly on the magazine shelves of local bookstores. People who use metal detectors tell stories of their fabulous discoveries and successful 'treasure' hunts. The things they discover include items such as gold rings, jars full of coins, caches of valuables, and also include cannonballs, bullets, and canteens from military campsites.

Relic collectors believe they are 'saving' the artifacts from the ground before they completely disintegrate. Once 'rescued,' the artifacts are put on display or sold, thereby making a piece of history available to others. Many relic collectors also believe that archaeology and relic hunting are not all that different. In fact, the professional archaeologist is often seen as a competitor for a prize. The collector may even go so far as to mimic the methods of archaeologists by digging square holes or by keeping all the artifacts they recover, not just the bullets or buckles. They may even drop by an ongoing professional dig with their own artifacts, much like comparing the results of a hunt after a day in the woods. Hobbyist view the American (and European for that matter) past as an unlimited source of recreation.

Even Charles Garrett, an electrical engineer who founded Garrett Metal Detectors, labors under the impression that artifacts underground are just going to disintegrate if someone does not dig them up. He says, "Not only will all the 'historical' sites never be discovered, the passage of time will continue to destroy them along with their artifacts and treasure" (Garret 1998).

The rationale is that archaeologists could never dig up *all* the historical sites; therefore they should not begrudge the hobbyists a few. The trouble is, the source is *not* unlimited, and there are no sites that can be simply offered up for random hobbyist collection. Moreover, hobbyists themselves, when pressed, will admit that areas can be "hunted out." This phrase is used to refer to an archaeological site that once provided many artifacts, but over time has been stripped clean.

Because hobbyists and professional archaeologists gravitate towards many of the same sites, encounters between the two factions are relatively common. Therefore, most archaeologists are aware of the fact that many relic collectors feel they are essentially the same as archaeologists. For this reason, professional archaeologists are reluctant to use metal detectors because they feel it reinforces the idea that professional archaeology is closely akin to relic collecting.

It would appear that public outreach initiatives must occur in order to educate relic collectors about the differences between archaeology and looting. Some work is being done, for example, archaeologists often attempt to educate collectors about archaeology by allowing them to assist with survey. To their credit, relic collectors often work long hours for no pay and survey large areas during these cooperative projects. However, even after learning more about the important information gained through careful archaeological procedures, volunteer relic collectors retain their desire to dig on their own. The reluctance on the part of the relic collector to accede the right to excavate to archaeologists is understandable, for to do so would mean to forever forego the right to possess the 'treasures' they desire.

The responsibility, therefore, rests on the professional archaeologists. Not only must public outreach programs continue, archaeologists must also continue to deny the right to dig to relic collectors. If the relic collectors still destroy sites after learning about archaeology and realizing exactly what they are destroying, the aims of the outreach are not being achieved. The archaeologist is simply allowing them access to sites where relic collectors would normally be arrested for looting.

Instead, archaeologists should become familiar with metal detectors. Although they may have been difficult to operate twenty years ago, modern detectors are built to be easy to use. There is nothing more complicated involved than there would be in learning to use a transit. It simply requires learning what all the buttons are for (such as on/off, all metal/discriminate, etc.) and how to understand the readings (positive/negative). The method of implementation then depends upon the goals of the project.

Despite all the destruction that has occurred, the despicable actions of certain individuals does nothing to diminish the value of the metal detector as a tool for finding metal artifacts. In fact, the success of those who loot sites is a demonstration of exactly how effective a tool these detectors are. Archaeologists who are against the professional use of metal detectors should reconsider. As stewards of the past, archaeologists have the responsibility to use all available means to recover the information that resides within archaeological sites. It is impossible to say what is being missed by not utilizing the metal detector. While shovel testing is still very necessary for understanding site stratigraphy and artifact sampling, the metal detector is equally necessary for understanding overall artifact patterning and also serves as an incredibly efficient method of locating site boundaries. At times, the metal detector may be the archaeologist's best option for locating diagnostic artifacts vital to the proper identification of sites. For all of these reasons, the metal detector is a readily available, easily implemented remote sensing device that archaeologists should be utilizing.

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VITA

Wayna Lee Roach

Born in Mt. Sterling, Kentucky in 1972, the author attended Menifee County High School in Frenchburg, Kentucky and graduated in 1990. She earned a B.A. in Anthropology at the University of Notre Dame in 1994. After graduation, she worked for the next four years as an archaeological field technician in Kentucky, Montana, New Hampshire, Maine, Vermont, and Massachusetts.

In 1998, she was admitted to the M.A. program at the College of William and Mary and completed the coursework in 1999. Since then she has been working as Project Archaeologist for a private archaeological consulting firm in Portsmouth, New Hampshire and teaching at the College for Lifelong Learning also in Portsmouth, New Hampshire.