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Integrating Archaeological Modeling in DoD Cultural Resource Compliance
Project RC-200720

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14. ABSTRACT

The purpose of Environmental Security Technology Certification Program (ESTCP) project RC-200720 was to (1) demonstrate that predictive models of archaeological site location are sufficiently accurate to serve as the foundation for programmatic approaches to compliance with the National Historic Preservation Act (NHPA) and the National Environmental Policy Act (NEPA) and (2) develop protocols for validating/refining predictive models and integrating them into the compliance process. The project involved two demonstration sites: Fort Drum, New York, and Eglin Air Force Base, Florida. Additional work was conducted at Saylor Creek Range, Idaho, and the Utah Test and Training Range, Utah. The technology needed to predict archaeological site location was demonstrated via the development and refinement of surface, subsurface, "red flag," and zonal management models. The result shows that considerable savings in time and money can be achieved by focusing inventory and evaluation efforts on areas likely to contain sites and on significant sites and by integrating models into NHPA Section 106 Programmatic Agreements.

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ACRONYMS

AAC	Air Armament Center
ACC	Air Combat Command
ACHP	Advisory Council on Historic Preservation
ADI	Area of Direct Impact
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and Environment
AFMC	Air Force Materiel Command
AIM	Air Intercept Missile
AMRAM	Advanced Medium Range Anti-Aircraft Missile
AMSL	Above Mean Sea Level
ANN	Artificial Neural Network
APE	Area of Potential Effect
ArcGIS	Name of a GIS software program
BCA	Baked Clay Artifacts
BP	Before Present (i.e., “1950”)
BLM	Bureau of Land Management
C14 (^{14}C)	Carbon-14 (radiocarbon organic assay dating method)
CART	Classification and Regression Tree
CEMML	Center for Environmental Management on Military Lands
CERL	Construction Engineering Research Lab
COE	Army Corps of Engineers
CRM	Cultural Resource Management
CSDGM	Content Standard Digital Geographic Metadata
DEM	Digital Elevation Model
DESCIM	Defense Environmental Security Corporate Information Management
DISP	Defense Installations Strategic Plan
DoD	Department of Defense
DoDI	Department of Defense Instruction
DOT	Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
ELM	Ethnographic Land Model
EOD	Explosive Ordinance Disposal
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
ESTCP	Environmental Security Technology Certification Program
EUA	Exclusive Use Area
FGDC	Federal Geographic Data Committee
FONSI	Finding of No Significant Impact
FPO	Federal Preservation Office/Officer
GAP	Gap Analysis Program
GIS	Geographic Information System
GMI	Geo-Marine, Inc.
GOR	Gain over Random (statistic)

GSLD	Great Salt Lake Desert
HPP	Historic Preservation Plan
HQ	Headquarters
ICRMP	Integrated Cultural Resources Management Plan
IDFG	Idaho Department of Fish and Game
IDRISI	Name of a GIS software program
IMCOM	U.S. Army Installation Management Command
JCHS	Jefferson County Historical Society
LBA	Louis Berger & Associates, Incorporated
LI	Light Infantry
LIDAR	Light Detection and Ranging
MLP	Multi-layer Perception
MnModel	Minnesota Model
MOA	Memorandum of Agreement
NATHPO	National Association of Tribal Historic Preservation Officers
NBII	National Biological Information Infrastructure
NCSHPO	National Conference of State Historic Preservation Officers
NED	National Elevation Dataset
NEPA	National Environmental Policy Act
NHD	National Hydrographic Dataset
NHL	National Historic Landmark
NHPA	National Historic Preservation Act
NRHP	National Register of Historic Places
NRCS	National Resource Conservation Service
NTTR	Nevada Test and Training Range
NWR	New World Research, Incorporated
OOB	Out of Bag error estimate
OSL	Optically Stimulated Luminescence
PA	Programmatic Agreement
PD	Provenience Designation
POC	Point of Contact
PPO	Poverty Point Objects
PTA	Prentice Thomas & Associates, Incorporated
PUMP	Preferred Upstream Management Practices
RAZON	Range Azimuth Only
RMSE	Root Mean Square Error
ROC	Receiver Operating Characteristic
ROD	Record of Decision
S	Sensitive Score (statistic)
SAA	Society for American Archaeology
SAM	Surface to Air Missile
SCR	Saylor Creek Range
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and Environment
SERDP	Strategic Environmental Research and Development Program
SHPO	State Historic Preservation Office/Officer
SRI	Statistical Research, Incorporated

SRIF	SRI Foundation
SSURGO	Soil Survey Geographic Data (NRCS)
ST	Shovel Test
STP	Shovel Test Pit
SWReGAP	Southwest Region GAP Analysis Program
TCP	Traditional Cultural Property
THPO	Tribal Historic Preservation Office/Officer
URS	URS Corporation, Incorporated
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTTR	Utah Test and Training Range
UXO	Unexploded Ordnance
WST	Western Stemmed Tradition

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Individuals who helped us conceive this work and facilitated our efforts include Martyn Tagg, currently the cultural resource manager for Fort Huachuca. Prior to his current position, Tagg was the cultural resource manager at Headquarters, Air Force Materiel Command (HQ AFMC) when he and Altschul developed the predictive modeling initiative in 2000; Tagg served as principal investigator on three Legacy projects involving predictive modeling. Likewise, senior level DoD staff have supported and encouraged our efforts for more than a decade. These include present and former DoD Federal and Deputy Federal Preservation Officers (FPOs) Maureen Sullivan, Serena Bellew, and Brian Lione, respectively. Support for the premise that archaeological predictive modeling holds enormous potential to streamline environmental compliance also came from Julia King of the Advisory Council on Historic Preservation (ACHP) and other members of the ACHP who invited us to make a presentation in 2010 on the predictive modeling project reported herein in Washington, D.C.

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Last, but not least, we wish to acknowledge the assistance of members of our own staffs who performed a variety of tasks critical for the completion of this research project. SRI Foundation (SRIF) served as prime on this subcontract; Terry Klein oversaw the financial aspects of the five-year project whereas Carla Van West served as project manager, author, editor, and report compiler. SRIF took the lead in developing programmatic agreements that integrated model

results in compliance decisions and producing website guidance content for the project. Statistical Research, Inc. (SRI) took the lead in model development and refinement. SRI's Jeffrey Homburg—a soil scientist and archaeologist—provided essential information for the development of subsurface archaeological models at the installations. SRI archaeologists and Geographic Information System (GIS) specialists Michael Lerch, William Hayden, and Joshua Trampier were responsible for the development of the red flag model prepared for the Saylor Creek Range. We also wish to note that early contributions to this project were made by SRI data analyst Christopher Nagel and SRI GIS specialist Stephen McElroy.

To each and every person who contributed to our success, we say thank you for your help and support. We could not have done it without you.

PREFACE

Four DoD installations agreed to participate in the Demonstration Plan for ESTCP Project 200720, "Integrating Archaeological Modeling in DoD Cultural Resource Compliance." The installations were Eglin AFB, Florida; Fort Drum, New York; Saylor Creek Range (SCR) Idaho; and Utah Test and Training Range, (UTTR), Utah. The period of performance for the project was 2007–2011.

The project was largely successful at Eglin AFB and Fort Drum. Predictive models at both installations were improved to a point that the State Historic Preservation Offices (SHPO) in Florida and New York and the installations are now in negotiations on programmatic agreements that incorporate modeling into their Section 106 compliance programs. Unfortunately, the project has ended before the new programs have been implemented. Based on past performance, however, we have modeled expected outcomes of the new compliance approaches and are encouraged that they will be more efficient, less costly, and provide a better preservation outcome than the installation's traditional reactive approach to compliance.

In 2010, the cultural resources staffs at UTTR and SCR decided that their management interests would be better served if SRI and SRIF developed other kinds of archaeological models designed to help them solve specific problems. For SCR, their decision to forego predictive modeling was based on an agreement with the SHPO that the installation would survey 100 percent of the range and that these surveys would be repeated periodically in the future. Hence, they had no need for a predictive locational model. At UTTR, the installation had contracted with another firm to prepare a predictive model.

SCR and UTTR, therefore, withdrew from the demonstration plan but not the project. SRI and SRIF discussed the management needs of both installations and, in consultation with Dr. Paul Green (Cultural Resource Manager, Headquarters, Air Combat Command [HQ/ACC]), and at the direction of their respective cultural resources staffs, developed new models for their use. At SCR, the staff requested development of a model of archaeological data quality to help them assess the effectiveness and reliability of previous archaeological survey at the installation. To meet this goal, an archaeological visibility model was developed for SCR, indicating areas where previous survey was most likely to be least reliable due to poor visibility. For UTTR, the staff wanted to be able to predict the location of traditional cultural properties potentially associated with descendant Indian tribes in the region. In response, an ethnographic location model predicting the location of historical-period Native American village settlements was developed.

The modeling efforts conducted for UTTR and SCR fall outside of the Demonstration Plan. As such, the results of the modeling research conducted for UTTR and SCR are presented in appendices to this report. These research products are presented to illustrate the maxim "one size does not fit all," and demonstrate that DoD installations have many different CRM needs that can and should be met through a variety of modeling tools and approaches. It is our contention that with this broader understanding of the utility of archaeological modeling, DoD can help its installations better meet their mission goals through more effective management of cultural resources.

EXECUTIVE SUMMARY

OBJECTIVES OF THE DEMONSTRATION

The Department of Defense (DoD) is legally required to inventory and evaluate archaeological sites, Native American resources, and other cultural assets on lands it administers. To date, the agency has inventoried less than 40 percent of its holdings and has another 13.4 million ac to inventory. More than 110,000 sites are recorded, of which more than 20,000 are either listed in or eligible for listing in the National Register of Historic Places (NRHP) Many others lack determinations of eligibility and must be treated as if they are eligible until their status is finalized.

DoD must take account the effects of military actions on thousands of potential historic properties on lands that have not been inventoried and resources that have not been evaluated. One particularly effective technology that can be adapted to reduce cost and effort associated with cultural resource management (CRM) requirements is archaeological predictive modeling. To be effective, predictive models must be operationalized in a database using Geographic Information System (GIS technology, refined as new data become available, statistically validated to demonstrate their accuracy, and incorporated into programmatic agreements (PAs) that will streamline compliance with the National Historic Preservation Act (NHPA, Sections 106) and National Environmental Policy Act (NEPA).

Over the last 30 years, a number of DoD installations, especially those with large land holdings, have developed and used predictive models as planning tools. Few installations, however, have operationalized, refined, and validated their predictive models, and none have incorporated their models into PAs.

The overarching objective of this demonstration project was to demonstrate that predictive models of prehistoric archaeological site location can be sufficiently accurate to serve as the foundation for programmatic approaches to compliance that, when implemented, can achieve greater efficiency and lower costs for administering CRM programs. The specific performance objectives—improving surface, subsurface, and “red flag” predictive models; developing Section 106 PAs; and demonstrating that models integrated into compliance protocols can significantly reduce the level of effort, cost, and number of evaluated sites—were met. Existing models at Fort Drum and Eglin AFB were used successfully to demonstrate the technology and their potential. Additional modeling work was conducted at Saylor Creek Range and Utah Test and Training Range; however, these were not formal demonstration sites.

TECHNOLOGY DESCRIPTION

The project team designed a multiphase process to demonstrate that highly effective archaeological predictive models can be developed to inform management decisions and streamline compliance through the creation of installation-specific PAs. The process begins with (1) collection and evaluation of relevant archeological and environment data, followed by the (2) development of a formal model that can be operationalized with GIS technology. Once this formal model is created, it is subject to (3) validation procedures that test the model’s accuracy and determine whether it meets predefined performance criteria. At this stage, modelers may refine the model with new or better data to improve its performance, and then repeat the validation process. With the development of one or more accurate, validated models, the process continues with the (4) creation of a zonal management model that synthesizes the results of each underlying model. It is this zonal model that DoD managers and stakeholders use to make decisions about inventory and site evaluation protocols in different probability or “sensitivity” zones for finding sites.

Through consultation, the final phase is the (5) preparation of a PA that stipulates how Section 106 requirements will be met.

DEMONSTRATION RESULTS

Using the above process, the project team demonstrated that three types of predictive location models could be developed or refined and subsequently integrated into a zonal management model that has been incorporated into draft PAs. The ESTCP project ended before the draft PAs could be finalized and executed, but the project team developed alternate methods to demonstrate the efficacy of using predictive models to manage cultural resources. These alternative methods, which use historic data from each installation on the level of effort and cost of past archaeological inventories, demonstrate considerable time and cost savings when effective models are used.

For Eglin AFB, the project team formalized and tested an existing surface sites model, refined and tested this model, created a model for information-rich habitation sites that would be expensive to mitigate ("red flags"), and created a model for deeply buried or subsurface archaeological sites. The first two of these models met and exceeded the specified performance criteria for a successful model. The subsurface model could not be tested due to a lack of appropriate data. Team members used the refined surface model, the red flag model, and the subsurface model to create a zonal management model that has been included in a draft PA for managing archaeological resources on Eglin AFB.

For Fort Drum, the project team formalized and tested an existing lowland surface sites model and an existing upland surface sites model, refined and tested these models, and created a model for deeply buried or subsurface archaeological sites. Whereas the refined lowland surface model met and exceeded their performance criteria, the upland surface model did not. Insufficient data were available to test the subsurface sites model, but a preliminary test using available data suggests that the model is close to meeting the criterion. Team members used the refined surface model and the subsurface model to create a zonal management model that has been included in a draft PA for managing archaeological resources on Fort Drum.

IMPLEMENTATION ISSUES

Future efforts to create or improve predictive models of archaeological site location now have a tested process for their development, refinement, validation, and integration into the compliance process. Website guidance on how validated and accurate predictive models can be created will serve as the medium of technology transfer for this demonstration project.

Future efforts should consider four implementation issues. First, the weakest link in developing and refining formal, inductive predictive models is the quality of the archaeological and environmental data. To build models efficiently, relevant archaeological data should be maintained in computerized databases usable by GIS. Similarly, environmental data should be of sufficient accuracy and resolution to facilitate the measurement and correlation of site locations with natural features. Second, to efficiently create and test predictive models, modelers and installation staff need to work together early and often to ensure that key variables are included in both the underlying model and the resulting management model. Third, for predictive models to be incorporated into PAs, installation CRM staff must involve their consulting parties (State Historic Preservation Office staff, Native American groups, other interest parties) from the beginning of the modeling process and maintain regular contact. Consulting parties will need assurance to maintain their confidence in the value of modeling for finding and protecting sites as well as enhancing knowledge of past cultural systems. Finally, it is critical to view modeling as a process and not an event; models get better with more data, allowing CRM to meet stewardship and mission goals more efficiently and with better results.

1.0 INTRODUCTION

1.1 BACKGROUND

The Department of Defense (DoD) administers lands containing more than 110,000 documented archaeological sites and many times that number of unrecorded sites (DoD 2011:Figure 3-2). Each year, the agency spends an average of about $46 million on cultural resources, primarily to comply with the law (DoD 2011:Figure 1-4). In the past, much of the historic preservation compliance effort has been directed toward identifying archaeological sites and simply avoiding impacts to them, rather than assessing their eligibility and identifying measures to minimize or mitigate effects. This practice has left military installations with large numbers of unevaluated archaeological sites over vast expanses of their land base. With the shift in military training toward intensive joint operations, there will be a shift from inventory to evaluation and ultimately to excavation or other forms of mitigation in order to make large areas available for military missions. It is likely that annual expenditures will have to increase substantially unless DoD changes its approach to compliance.

DoD recognizes the challenge. Among the policy goals in two recent Defense Installations Strategic Plans (DISPs) are:

- Accurately inventory 100 percent of archaeological sites, Native American resources, and other cultural assets, and establish quality ratings in the real properties inventory by the end of 2007 (DoD 2004, updated to 2009 by DoD 2007).
- Develop standards to ensure that the possible presence of archaeological sites, Native American resources, and other cultural assets are modeled, inventoried, and managed in close integration with project and operational planning by the end of fiscal year 2006 (DoD 2004).
- Manage cultural resource assets efficiently, in full integration with other facilities and project planning activities, and in full compliance with all legal requirements (DoD 2007).

Although the 2007 deadlines have passed, DoD continues to adhere to these policy goals as it had for most of the previous decade (DoD 2004). Inventory remains a high priority and a substantial level of effort is dedicated to identifying historic properties. DoD administers about 41,000,000 ac. Of the total, 21,900,000 ac are available for archaeological survey (DoD 2011:21). To date, about 8,500,000 ac have been inventoried for cultural resources (DoD 2011:21), leaving DoD with another 13,400,000 ac left to survey—a task requiring the expenditure of between $1.5 and $2 billion. To make matters worse, the inventory quality of the already surveyed 8,500,000 ac is suspect (Heilen et al. 2008), with very little having been inspected for traditional cultural properties (TCPs) or adequately assessed for buried archaeological sites. Further, many U.S. states have a “life expectancy” for archaeological survey, after which an area must be resurveyed.

As DoD struggles to meet its inventory goal, DoD must continue to meet its legal obligation to manage cultural resources under agency control. Currently, both National Environmental Policy

Act (NEPA) and National Historic Preservation Act (NHPA) compliance tend to be carried out on a project-by-project and historic property-by-historic property basis, which is time-consuming and inefficient both for cultural resources stewardship and for mission planning and implementation. There is nothing in the laws or their regulations to prevent a larger-scale programmatic approach to compliance, however. In fact, the implementing regulations for NHPA Section 106 encourage programmatic approaches. The Section 106 regulations also urge agencies to develop ways to coordinate Section 106- and NEPA-compliance efforts as much as possible, in order to save time and resources.

To take advantage of the flexibility inherent in the Section 106 process and to make sound decisions in the NEPA process, installations need to demonstrate in an objective and replicable manner that they are basing decisions about cultural resource management (CRM) on sound information about the likely nature, distribution, and significance of the archaeological sites within their land base. Archaeological modeling is ideally suited to meeting this need and can form the basis of a rational understanding of this key asset that affects the extent and intensity of operational training. Archaeological models also can reduce the time and money needed to complete the Section 106 process and lower the risk of mission delays.

DoD acknowledges the potential of modeling in the second DISP goal cited above. DoD has a long history of sponsoring modeling, particularly locational correlative approaches termed "predictive models." These models have been used primarily as heuristic devices that provide managers with a sense of where they may encounter cultural resources. By and large, they have not been integrated into NEPA and NHPA compliance, nor have they been used to manage resources. This Environmental Security Technology Certification Program (ESTCP) demonstration project, building on seven years of Legacy-funded work, was designed to validate models and demonstrate their potential for streamlining and economizing compliance and improving asset management. In the process of completing this project, this project demonstrates two fundamental facts about modeling archaeological site location: (1) modeling is a process that must be maintained to be effective, and (2) if maintained, model predictions will improve as more data are incorporated into the model.

1.2 OBJECTIVE OF THE DEMONSTRATION

The purpose of the archaeological predictive modeling project was twofold: (1) demonstrate that predictive models of archaeological site location are sufficiently accurate to serve as the foundation for programmatic approaches to NHPA and NEPA compliance, and (2) develop protocols for validating and refining predictive models and integrating these models into the compliance process. To achieve these ends, the demonstration project had three specific objectives:

1. Develop protocols for validating predictive models of archaeological site location
2. Develop protocols for refining the predictive models to meet standards set by regulatory stakeholders
3. Develop protocols for integrating refined models into DoD Section 106-compliance and NEPA processes, as well as in early planning processes

Most of the concerns raised about archaeological predictive modeling are epistemological: how do we know that the model works short of surveying the area? Even then, how do we know that the absence of cultural material means a site is not present as opposed to it being there, but deeply buried? To demonstrate that models work, we must satisfy regulators that our use of sampling theory is sound, that our field methods produce data of sufficient quality to use in modeling, and that the statistical techniques employed produce accurate predictions. Additionally, we must show that the use of geographic information system (GIS) technology allows us to characterize the environment in sufficient detail to produce proxy variables of the resources and resource decisions made by prehistoric peoples.

Four installations were initially chosen as demonstration sites: Eglin Air Force Base (AFB), Florida; Fort Drum, New York; Saylor Creek Range (SCR), Idaho; and Utah Test and Training Range (UTTR). As a group, they were selected to represent a set of installations with contrasting missions, in different regions of the U.S., with distinctive environmental and historical attributes that produced dissimilar cultural histories and archaeological legacies. Each installation, however, incorporated a large area, contained many cultural resources, possessed a well-established CRM program, and had developed (Eglin AFB and Fort Drum) or was interested in developing (UTTR and SCR) some type of predictive model. As explained in our Preface, midway through our project, UTTR and SCR decided that their environmental management interests would be better served if the project team developed other kinds of predictive archaeological models to help them address their cultural resource management needs. Consequently, they withdrew from the demonstration project, as it was originally conceived and approved.[1] Only Eglin AFB and Fort Drum participated in our ESTCP demonstration project on archaeological predictive modeling and the balance of this report pertains to work undertaken at these two installations.

To perform the demonstration, we defined several different types of predictive models: (1) baseline surface models, (2) refined surface models, (3) preliminary subsurface models, (4) "red flag" models, and (5) zonal management models.

Predictive models generally come in two forms: formal predictive models and informal predictive models. *Formal predictive models* consist of explicit statements regarding the definition of variables and their relationship to site location in such a manner that the model can be logically defined within a GIS. *Informal predictive models* lack formal definitions and in their present state require such definitions in order to be operationalized in a GIS, tested, and implemented in a systematic fashion. Installation archaeologists generally have a strong sense where sites will be found, but rarely have these insights been captured in formal models. To be

[1] At SCR, the staff requested development of a model of archaeological data quality to help them assess the effectiveness and reliability of previous archaeological survey at the installation. Project Team staff developed a predictive model of archaeological site detection for SCR, which indicates where previous survey is most likely to be unreliable due to poor surface visibility (Appendix D). For UTTR, the staff wanted to be able to predict the location of traditional cultural properties potentially associated with descendant Indian tribes in the region. Project team staff developed an ethnographic land use model predicting the location of historical-period Native American village settlements (Appendix E).

used in the NEPA and NHPA compliance, archaeological insights must be transformed into models that can be replicated and tested for accuracy within agreed upon parameters.

Baseline surface models were defined as models that had already been developed by the installation, but needed to be formalized and operationalized in a GIS in order to be tested. For each of the demonstration sites, existing baseline models were formalized as necessary and operationalized in a GIS. To do this, ideas about where archaeological sites tend to be located were transformed into explicit statements about site location that could be codified within a GIS. Formalization and operationalization of baseline models thus allowed those models to be tested with available inventory data.

Refined surface models were defined as models that were created as part of the project in order to improve upon the predictive capacity and statistical strength of the existing baseline surface models. In order to develop refined surface models of archaeological site location, a number of tasks needed to be performed. These included the development of additional environmental variables in a GIS and evaluation of their potential association with site location; the identification of installation areas and site types with distinctive environmental associations or locational characteristics; the use of current inventory data to develop site and nonsite sample locations for modeling; and the application of advanced statistical modeling techniques. Once developed, refined surface models were validated using existing inventory data and the application of performance metrics defined as part of this project.

Preliminary subsurface models were geoarchaeological models developed as part of the project in order to predict where buried archaeological deposits are possible on an installation. To develop these models, the project geoarchaeologist visited each installation and worked with regional geoscientists and geoarchaeologists and compiled existing geoarchaeological literature to arrive at an understanding of the kinds of geomorphological contexts where archaeological deposits could potentially have been buried as a result of environmental processes that occurred on an installation during the Late Pleistocene and Holocene geological epochs. These understandings were then formalized in a GIS using existing environmental data on soil types and geomorphology. Many of the GIS data used to develop these models were derived from National Resource Conservation Service (NRCS) Soil Survey Geographic (SSURGO) data that identify soil horizons to a depth or 151 cm.

Red Flag models were defined as models of site types that would be especially costly and time-consuming to mitigate should such a site be accidentally discovered during ground disturbing activities (Altschul 1990). For the purposes of the demonstration, we defined red flag sites as intensively used residential sites. Due to the need for relatively comprehensive site type information, a red flag model was only created for Eglin AFB as site type information was not available for Fort Drum. The red flag model for Eglin AB was developed in the same manner as the refined surface models, but focusing only on site types associated with intensive residential activity (villages or hamlets, burial sites, and mound sites).

Zonal management models were defined as models that combined the predictions of the refined surface model, preliminary subsurface model, and red flag model to indicate the kinds of predictions made about the potential for cultural resources in a given area of an installation. To

develop a zonal management model, the three models listed above were intersected in a GIS to combine the predictions of the three models. Management categories were then developed for any specific combination of model predictions (e.g., medium or high subsurface sensitivity; medium or high red flag sensitivity; low, medium, or high surface sensitivity).

1.3 REGULATORY DRIVERS

Although other federal statutes apply, the main regulatory drivers of DoD cultural resource compliance are NHPA and NEPA. DoD installations are required to meet the federal requirements under Sections 106 and 110 of NHPA, as well as NEPA and its regulations listed at 40 CFR 1500–1508.

Section 106 of NHPA requires federal agencies (in this case DoD) to take into account the effects of proposed undertakings on historic properties listed in or eligible for listing in the National Register of Historic Places (NRHP or National Register), and provide the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on the undertaking. The regulation implementing Section 106 (36 CFR Part 800) establishes the process through which federal agencies can meet their responsibilities under this statute. This process consists of *four steps*, all done in consultation with the Section 106 "consulting parties," as stipulated in the regulation.

In the *first step*, the agency initiates the Section 106 process by first determining if its action is an undertaking that falls under the requirements of Section 106, and whether or not the action has the potential to affect historic properties. If the action is an undertaking that has the potential to affect historic properties, then the agency initiates consultation with the appropriate State Historic Preservation Officer (SHPO), Tribal Historic Preservation Officer (THPO) (if appropriate) and other consulting parties.

The *second step* involves the identification of historic properties within a project's area of potential effects (APE). An APE is the area within which a project may directly or indirectly cause changes in the character or use of historic properties, if such properties exist. Since, as noted above, many properties have not been identified and evaluated for National Register listing, agencies must make a reasonable and good faith effort to identify such properties within the APE and then evaluate their eligibility for listing in the National Register.

During the *third step*, the agency assesses the effects of the undertaking. If no historic properties are found in the APE, or if properties are found but the project will not affect the properties, the agency makes a finding of "no historic properties affected." A finding of "no historic properties affected" completes the Section 106 process. If there are historic properties within the APE and the agency determines that its project may affect one or more of these properties, the federal agency evaluates the nature of these effects. If the project will not diminish those qualities that qualify a property for listing in the National Register, the agency makes a finding of "no adverse effect." A finding of "no adverse effect" completes the Section 106 process. If the project will diminish these qualities, the agency makes a finding of "adverse effect."

In the *fourth step*, the agency works with the Section 106 consulting parties to resolve any adverse effects on historic properties.

Section 110 of NHPA requires federal agencies to assume responsibility for historic properties under their jurisdiction. It also requires agencies to establish a program to identify, evaluate, nominate, and protect these properties. In addition, agencies are to consider the effects of their actions on properties not under their jurisdiction or control. Agencies are also to consult with other agencies, tribes, and the public concerning historic preservation planning activities.

NEPA requires federal agencies to balance federal actions and environmental protection. To comply with NEPA, agency decision-makers must be fully informed about the environmental consequences of their decisions to approve, finance, permit, or license a project. They must also solicit input from and inform the public about the proposed project, the environmental consequences of the proposed action, and the ultimate agency decision about how the project will proceed. The results of the NEPA decision-making process are disclosed through an environmental document.

The key components of the NEPA process (for those actions that are not categorically excluded or exempt from NEPA compliance) include definition of purpose and need, identification of project alternatives, alternative analysis, and mitigation of adverse impacts. The purpose and need is the statement of the problem to be solved and guides the development of alternatives. The latter are the possible solutions to the problem. Each of the alternatives retained for detailed study is then analyzed in terms its environmental characteristics and setting (referred to as the affected environment). Next, the potential impacts to these characteristics and setting are assessed. This analysis includes evaluating impacts on properties listed in or eligible for listing in the NHRP. Once these potential impacts are identified, the agency examines ways to mitigate these impacts. The results of this NEPA environmental review are documented in an Environmental Impact Statement (EIS)/Record of Decision (ROD) or an Environmental Assessment (EA)/Finding of No Significant Impact (FONSI). After the completion of these documents, the agency implements their selected alternative.

2.0 TECHNOLOGY/METHODOLOGY DESCRIPTION

The technology demonstrated by this project was designed to streamline and expedite military cultural resource compliance. This was accomplished through the creation, validation, and refinement of existing predictive models of archaeological site locations at Eglin AFB and Fort Drum. These improved and validated models will ultimately be integrated into the NHPA- and NEPA-compliance programs at each installation through implementation of NHPA Section 106 Programmatic Agreements as further discussed below. Figure 2-1 illustrates the process that was followed during and demonstrated by this project.

2.1 TECHNOLOGY/METHODOLOGY OVERVIEW

Archaeological models are formal frameworks that characterize in an objective and replicable manner aspects of past human behavior that often are reflected in the archaeological record. Some archaeological models focus on the location of archaeological sites. These models can be described as location models, which can be derived from theoretical relationships (deductive models) or from empirical data (inductive models). Among the latter are what have become to be known as "predictive models," which use empirical observations from a sample of known sites to predict particular characteristics of suspected sites that have not been found. Most archaeological models developed for military installations over the past 30 years are *predictive models of archaeological site location*. Though predictive models have been used in CRM since the late 1970s, the first substantial guidance for developing and using these models was a comprehensive text prepared by the Bureau of Land Management in 1988 (Judge and Sebastian 1988). One of the first major compliance breakthroughs for locational predictive models occurred in 1997 when the Minnesota Department of Transportation (DOT) successfully implemented a statewide model (MnModel) as a planning tool (BRW 1996; Hudak et al. 2002).

Even with all the technological advancement, it was not until 2003 that the scientific adequacy of locational modeling, as it has been used by the military, was demonstrated. Based on recommendations from a CRM workshop sponsored by the Strategic Environmental Research Development Program (SERDP) and the Legacy Resource Management Program (Legacy) at Patuxent River Naval Air Station in Lexington Park, Maryland (Legacy #00-101; Briuer et al. 2000), the first of three Legacy projects (#01-167, 03-167, and 06-167) on predictive modeling that led to this ESTCP proposal were completed.

In a report entitled, *Predictive Modeling in the Military: Similar Goals, Divergent Paths*, Altschul and his colleagues (2004; Legacy project #01-167) analyzed models from select DoD installations and provided recommendations for their improvement. This project showed that predictive models—even those using technologies from the late 1970s—have worked surprisingly well. A subsequent Legacy project in 2003 (#03-167) brought together a working team of DoD managers, SHPO representatives, tribal representatives, and modeling experts. The report of this conference was published as *A Workshop on Predictive Modeling & Cultural Resource Management on Military Installations* (Altschul et al. 2005). The team addressed the recommendations from the first project and determined how the DoD could best utilize modeling in their compliance process. They developed a blueprint by which locational predictive modeling

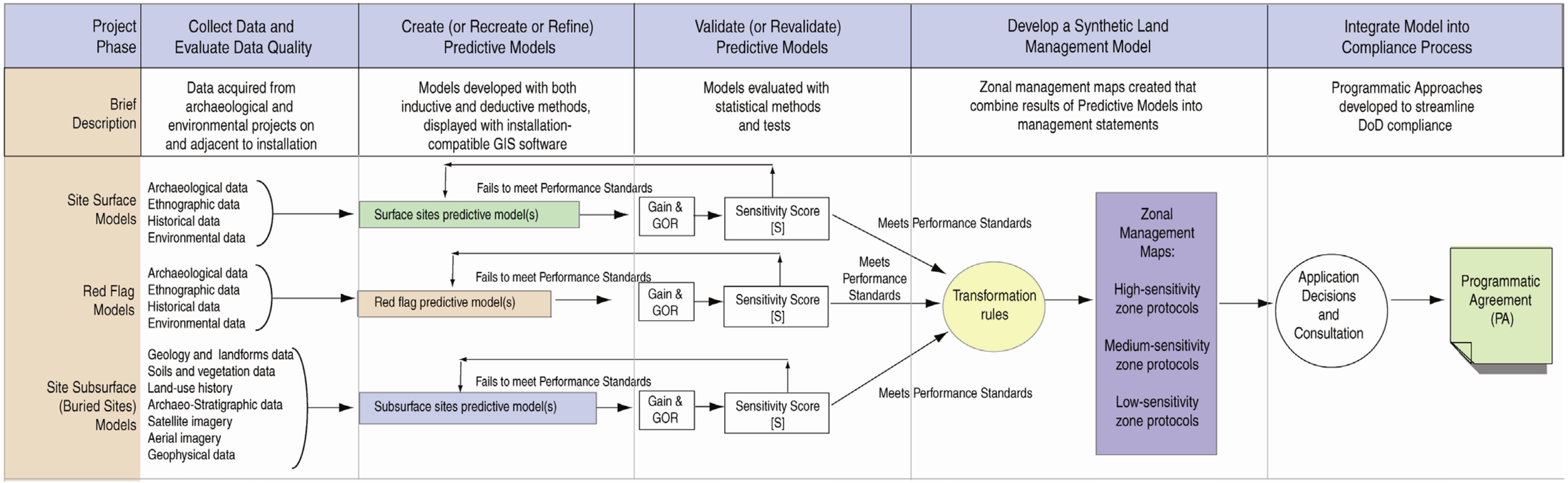

Figure 2-1. Flow diagram illustrating the demonstration technology process.

could be incorporated more effectively into DoD cultural resource compliance and recommended that new kinds of archaeological models be developed that could address the site evaluation process programmatically. Headquarters, Air Combat Command (HQ/ACC) initiated a 2006 Legacy project (#06-167) to implement the innovative blueprint created by the team. The report of this effort is entitled, *Integrating Archaeological Models: Management and Compliance on Military Installations* (Cushman and Sebastian 2008). Legacy project #06-167, which is the foundation of this ESTCP demonstration project, involved (1) working with two installations (Fort Drum and Eglin AFB) to develop case examples of more effective integration of locational predictive models with compliance and planning, and (2) working with one installation (UTTR) to develop a significance model, which ranks the importance of classes of sites relative to their scientific importance and other heritage values. The Legacy project team, in consultation with installation CRM staff, the New York and Florida SHPOs, and some tribes, has developed a conceptual outline for a programmatic agreement (PA) stipulating how Eglin AFB and Fort Drum would integrate predictive modeling into each installation's Section 106-compliance program. The Legacy team also developed a significance model for the UTTR aimed largely at streamlining NRHP evaluations.

In the last 20 years, the technology of predictive modeling has come of age. Since 1990, five Strategic Environmental Research and Development Program (SERDP) projects have been funded for predictive modeling—one focused on GIS modeling (#CS-1130) and the other four centered on increasing the detection of archaeological sites on military lands from terrestrial, air, and space remote sensing techniques (#CS-1142, 1260, 1261, and 1263). None, however, examined the role of predictive modeling in historic preservation or environmental compliance. In contrast, the Department of Energy sponsored a Preferred Upstream Management Practices (PUMP) grant that focused on the use of predictive models in cultural resources compliance for the oil and gas industry. SRI Foundation and other team members performed the modeling and compliance study for the New Mexico portion of the PUMP grant (Sebastian et al. 2005). Perhaps the biggest technological gains have been in the field of information management, particularly GIS. Numerous studies have been conducted (e.g., Aldenderfer and Maschner 1996; Allen et al. 1990; Mehrer and Westcott 2006; Wescott and Brandon 2000), including SERDP (#CS-1130) and Legacy projects (Altschul et al. 2004).

The most direct testing of predictive modeling technology as used within DoD was performed by HQ Air Force Materiel Command (AFMC) (Altschul et al. 2004). As mentioned above, HQ AFMC obtained Legacy funding (Project #01-167) to determine if predictive models created by DoD installations were accurate in light of subsequent archaeological inventory. Using a Sensitivity Score (S) that measured model performance, researchers demonstrated that DoD predictive models worked, but that they could work much better if a number of issues were addressed (Altschul et al. 2004). These issues, which form many of the demonstration/validation issues of this ESTCP project, are: (1) military predictive models are rudimentary in nature and would be much better predictors if they incorporated multivariate statistical techniques, (2) military models tend to be limited to predicting surface manifestations and would improve if they incorporated geomorphic variables by which they could predict buried sites, (3) the models would improve if they incorporated validation and refinement components, (4) the models are not being used effectively and creatively in the compliance process, and (5) there is no centralized instruction on predictive modeling available to military installations.

2.2 TECHNOLOGY/METHODOLOGY DEVELOPMENT

Prior to the field demonstration, ESTCP allowed some project activities to move forward after a draft demonstration plan had been completed and was undergoing review and revision. These activities involved the acquisition and organization of CRM and environmental data relevant to locational modeling and efforts to begin formalizing and operationalizing baseline models in a GIS. Visits to installations to gather information contributing to the development of subsurface models was also permitted.

To perform these tasks, each of the installations was visited by a project archaeologist who worked with installation staff to acquire digital CRM data and hardcopies of relevant CRM reports. Interviews with installation archaeologists and review of materials describing baseline models were also conducted. In addition, the project geoarchaeologist met with installation staff and regional geoarchaeologists at each installation, where he visited important environmental and site contexts and gathered information relevant to model building.

Organization of CRM data and evaluation of data quality required considerable effort. For many installations, CRM data are organized in multiple, separate databases and GIS datasets. Often, individual records in these datasets have been completed or validated to varying degrees and conflicting or erroneous information between datasets is common. In addition, information related to survey history or site attributes can be spread inconsistently over multiple datasets as well as captured informally in comments fields that need to be systematically mined for relevant information. Moreover, since the turnover rate is relatively high for installation staff and comprehensive records on CRM data development are often absent or lacking, interpreting CRM data can be difficult.

For installation CRM data represented in a GIS, it is often the case that there are problems with the topology of polygons that need to be fixed; layers with differing projections, extents, and mapping unit dimensions must be standardized; and erroneous or incomplete data must be quarantined and examined in detail. For instance, in the case of Fort Drum, a data layer representing the different physiographic zones was not matched up precisely with another layer representing the installation boundary. As a consequence, differences between the two layers needed to be resolved in order to divide the installation into physiographic zones for modeling purposes. At Eglin AFB, survey polygons corresponding to an individual survey area were sometimes duplicated within the database as many as eight times, requiring that these redundant polygons be removed in order to work with the data. Fortunately, extensive evaluation of data quality was made possible by a Legacy program grant (#07-353) to assess archaeological data quality (Heilen et al. 2008). This project allowed us to organize the data and evaluate CRM data quality in a manner that ultimately contributed to working effectively with the data for modeling purposes.

Digital environmental data used for modeling purposes were initially acquired from installation staff, but it ultimately proved necessary in many cases to acquire the most recently available environmental datasets directly from national mapping agencies, rather than from the installations themselves. We acquired these data to ensure that we were working with the most

up-to-date and comprehensive environmental datasets as well as to relieve installations of the burden of unnecessarily transmitting large datasets via the internet or on external hard drives.

Environmental datasets acquired from national mapping agencies included:

- *Seamless digital elevation models (DEMs)*—used to derive slope and aspect, identify topographic landforms considered important (such as ravines), develop cost surfaces, and to calculate elevation above potable water
- *U.S. Environmental Protection Agency (EPA) National Hydrographic Dataset Plus Data*—used to calculate distance to potable water sources, distance to hydrological network junctions, distance to navigable waterways, stream order, and identify water bodies and ravines
- *National Resource Conservation Service (NRCS) Soil Survey Geographic Data (SSURGO)*—used to identify soil types and soils with particular properties, such as thick A horizons
- *U.S. Fish and Wildlife Service (USFWS) Geospatial Wetlands Digital Data*—used to identify wetland areas
- *U.S. Geological Survey (USGS) National Biological Information Infrastructure (NBII) GAP Analysis Program (GAP) National Land Cover Data*—used to identify vegetation types and to calculate metrics such as vegetation richness within a specified radius

These data were brought into a common projection and extent for each installation and, when necessary, resampled such that all predictor variables were defined using an identical raster grid of uniform cell locations and dimensions.

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY/METHODOLOGY

The advantages of predictive modeling of archaeological site locations potentially are numerous. Predictive modeling provides a framework by which previous knowledge on cultural resources gathered on DoD installations over the last 40 years at a cost in the tens of millions can be used by managers to more effectively meet their NHPA- and NEPA-compliance obligations. A draft white paper prepared as part of Legacy project #06-167 outlines 20 uses of GIS-based predictive modeling in the context of both NHPA (Sections 106 and 110) and NEPA compliance. These are:

NHPA, Section 106 compliance:

- Managing the effects of agency actions on known archaeological sites in areas that have been previously surveyed
- Anticipating the kinds of properties likely to be encountered in an Area of Potential Effect (APE) or an Area of Direct Impact (ADI) so that appropriate identification strategies can be developed as required under Section 106 of NHPA
- Anticipating the costs of inventory needed to satisfy the identification requirement under NHPA
- Planning site inventory in situations where phased identification is used to fulfill the requirements of Section 106

- Stratifying the impacts/effects of agency actions on a landscape level within the installation, in whole or in part
- Evaluating the integrity of archaeological sites and their NRHP eligibility under the criteria contained in 36 CFR 60.4
- Developing research designs and field methods needed to guide treatment conducted in compliance with Section 106 of NHPA
- Redesigning undertakings to avoid/minimize adverse effects—thus preserving sites and reducing costs
- Anticipating potential mitigation costs as part of early project planning
- Assisting with Tribal consultation by providing information on potentially sensitive areas or resources that may be of special concern
- Facilitating the development of PAs to streamline compliance with 36 CFR 800
- Identifying potential high value resources for management pursuant to Section 110 of NHPA
- Developing appropriate historic contexts to tailor National Register eligibility evaluations for each installation
- Developing future CRM research and management objectives for the DoD installations
- Enhancing internal communication between staff and management concerning the preservation and management of archaeological sites

NEPA:

- Coordinating environmental planning by integrating potential archaeological site locations with information on the spatial distribution of natural resources, known and modeled
- Facilitating the scoping of potential impacts/issues for a proposed action and informing the public and other stakeholders about the action's potential impacts
- Selecting project alternatives to be retained for detailed study
- Developing archaeological inventory strategies needed to characterize the affected environment within project alternatives; inventory strategies might include archaeological sample surveys of each alternative retained for detail study
- Characterizing, when appropriate, the affected environment and potential impacts of project alternatives without conducting archaeological fieldwork within each alternative; such an approach would be used for the alternatives presented in draft EAs and draft EISs

The limitation to predictive modeling of archaeological site locations is that it runs counter to DoD's *ad hoc*, project-by-project approach to NEPA and NHPA compliance. This site-by-site, project-by-project approach has worked for DoD in the past, although it is the most costly and least efficient approach to cultural resource compliance. With some notable exceptions at the installation level, predictive modeling is as yet unproven as a compliance vehicle in DoD; however, it has worked effectively for other agencies, such as state Departments of Transportation (DOTs).

Part of the challenge of this study, and its primary justification, is to convince DoD installation managers that despite the time and expense of building and maintaining archaeological predictive models, there is a payoff over time resulting in savings in time and money as well as better preservation outcomes than normally achieved through the standard case-by-case approach to CRM.

Advantages and Strengths:

- Refined models can better assist installations in meeting their management and compliance objectives.
- Advanced statistical techniques for developing refined models (e.g., random forest modeling, neural network models) can be highly useful.
- The strengths and weaknesses of refined models can be readily identified and recommendations for future improvements can be provided.
- CRM staff involvement can ensure the construction of models tailored to the needs of the individual installation.

Disadvantages and Limitations:

- Archeological and environmental data needed to build models and evaluate performance are often lacking or inadequate, thereby requiring a large initial outlay of time and effort to acquire essential information.
- The time and effort coordinating with personnel at military installations during model development, testing, and validation, as well as during the development of draft Programmatic Agreement documents, can be labor intensive.
- Heavy workloads and severe scheduling conflicts can prevent CRM staffs from making the initial investments needed for predictive modeling to succeed.

The advantage and disadvantages have provided valuable lessons learned. Both Eglin AFB and Fort Drum have used, and will continue to use, their predictive models to assist in meeting their respective planning and compliance needs. In this sense, the utility of the technology is already being demonstrated on a daily basis. The demonstration project has contributed to the effectiveness of their CRM programs. As the PAs go into effect, greater returns in time and cost savings are expected.

3.0 PERFORMANCE OBJECTIVES

As noted previously, both NEPA and NHPA compliance tends to be carried out on a project-by-project and historic property-by-historic property basis, which is time-consuming and inefficient both for cultural resources stewardship and for mission planning and implementation. The creation, refinement, validation, and implementation of archaeological predictive modeling, however, provides a foundation for programmatic approaches to both NEPA and NHPA compliance, allowing installations to reduce or eliminate costly and inefficient case-by-case practices.

The performance objectives for this project, therefore, were to improve predictive models at selected installations by refining and validating their baseline models and then to demonstrate how these improved and validated models can be used to streamline installation NEPA and NHPA compliance responsibilities. Table 3-1 lists the specific performance objectives that were developed for this demonstration.

The following are descriptions of each of the performance objectives listed in Table 3-1 and a summary statement on whether or not the success criteria were met.

3.1 PERFORMANCE OBJECTIVE: IMPROVE ARCHAEOLOGICAL SURFACE, SUBSURFACE, AND RED FLAG PREDICTIVE MODELS

Three types of predictive models were developed for the demonstration project. The first is a model of the *surface* (or near-surface[2]) archaeological record. The second is a model of *buried cultural* deposits. The third is a subset of the surface models and focuses on archaeological "*red flags*" that have the potential of impacting the cost and scheduling of mission activities. Discussions on the metrics, data requirements, and success criteria associated with improving the performance of these three types of model are presented below.

3.1.1 Metric (Quantitative)

The primary quantitative metric used to evaluate model performance in this demonstration project is the Sensitivity Score (S). It is based on the performance standard for a successful model adopted by Minnesota stakeholders for the MnModel (BRW 1996; Hudak et al. 2002). Through a process of consensus, these stakeholders agreed that a successful model should "predict at least 85 percent of the known sites, with 33 percent or less of landscape classified as high and medium site potential" (Hudak 2002: Chapter 8.3, http://www.mnmodel.dot.state.nm.us).

[2] Archaeological sites may be buried by a thin (as thin as 20 to 30 cm) veneer of aeolian, alluvial, or colluvial sediment, but such shallowly buried sites have the potential to be identified by surveys using shovel pits or larger test pits. These sites are considered surface sites for the purpose of this demonstration project.

Table 3-1. Performance Objectives

Performance Objective	Metric	Data Requirement	Success Criteria	Results
Improve archaeological surface predictive models	Large proportion of surface or near-surface archaeological sites in a small proportion of the model area (i.e., Sensitivity Score [S])	Spatially arrayed data on mappable environmental features and archaeological resources from inventory	S ≤ 0.39, when 85 percent or more of surface and near-surface archaeological sites are located in no more than 33 percent of the model area	Eglin: Criterion met, S (med/high) = 0.17; Gain = 0.70; GOR = 69.3 Fort Drum: Criterion met, S (med/high)= 0.30; Gain = 0.75; GOR = 66.5
Improve archaeological subsurface predictive models	Large proportion of buried archaeological sites in a small proportion of the model area (i.e., Sensitivity Score [S])	Spatially arrayed data on geomorphic surfaces and deeply buried archaeological resources	S ≤ 0.39, when 85 percent or more of all buried archaeological sites located in no more than 33 percent of the model area	Eglin: insufficient data Fort Drum: Criterion nearly met, S (med/high) = 0.42
Improve archaeological "red flag" predictive models	Large proportion of "red flag" archaeological sites in a small proportion of the model area	Spatially arrayed data on mappable environmental features and archaeological resources from inventory	S ≤ 0.25, when 95 percent or more of all "red flag" sites located in no more than 24 percent of the model area.	Eglin: Criterion met S (med/high) = 0.03 Fort Drum: no red flag model
Develop Section 106 Programmatic Agreement (PA) based on modeling	Complete draft(s) and final version of PA	Consultation with installation stakeholders and Section 106 consulting parties to develop the PA	*PA executed and filed with the Advisory Council on Historic Preservation	Draft PAs prepared and under review
Streamline NHPA Section 106 and NEPA Compliance	Reduce inventory level of effort	Acreage and time (person-days) per survey project	≥ 15 percent reduction in level of effort for inventory	Eglin: Criterion met. Time reduced 68% Fort Drum: Criterion met. Time reduced 58%
Streamline NHPA Section 106 and NEPA Compliance	Reduce inventory cost	Acreage figures and costs per survey project	≥ 15 percent reduction in cost for inventory	Eglin: Criterion met. Cost reduced 67%. Fort Drum: Criterion met. Cost reduced 66%
Streamline NHPA Section 106 and NEPA Compliance	Reduce number of evaluated sites	Number of sites per site class that require evaluation	≥ 15 percent reduction in number of sites that must be evaluated and treated	Eglin: Criterion met. Sampling reduced number of sites evaluated by 64%
Streamline NHPA Section 106 and NEPA Compliance	Increase in effective value of compliance process (1 [less effective] to 5 [more effective] ordinal scores)	Survey users before and after models and PA implemented (i.e., compare installation compliance process before and after models in place)	Values of 4 or 5 (the highest satisfaction and value scores)	Eglin, Fort Drum: Survey not conducted.

Altschul (Altschul et al. 2004: 21) adopted the MnModel performance standard and formalized it as follows:

$$S_i = (a_i)/(b_i)$$

Where:
S_i is the Sensitivity Score ranging between zero (0) and infinity
a_i is the proportion of sensitivity zone (i) area to the total modeled area
b_i is the proportion of the number of sites (or total site area) within the sensitivity zone to the total number of sites (or total site area) within the modeled area

Expressed verbally, the S Score is the ratio of the proportion of area encompassed by a sensitivity zone to the proportion of archaeological sites located in that sensitivity zone. Assuming that each sensitivity zone has at least 1 site, S varies from 0 to infinity. At a basic level, the smaller S becomes, the higher the sensitivity of the zone (i.e., high model performance). Conversely, the larger S becomes, the lower the sensitivity of the zone (lower model performance). However, the S Score must be considered in light of the proportions used to calculate the metric, as is discussed below.

Altschul expressed the verbal MnModel performance standard for combined high- and medium-sensitivity zones as:

$$S = 0.33/0.85 = 0.39$$

The objective of this performance standard is for 85 percent *or more* of surface sites to fall within medium- and high-sensitivity zones. Together, these zones should comprise 33 percent *or less* of modeled area. By extension, the low sensitivity zone in such a scenario should cover *more than* 67 percent of modeled area and contain *less than* 15 percent of sites.

Since a_i and b_i are proportions, both variables range from zero to one; neither variable can be negative or exceed one. Similarly, a_i cannot exceed S, since $a_i = S$ when b_i equals one. For instance, when S is 0.39, a_i cannot exceed 0.39 ($a_i = S * b_i = 0.39 * 1 = 0.39$); a_i is less than S when b_i is less than 1. In other words, when S = 0.39 for both medium- and high-sensitivity zones combined (following the MnModel standard), these zones cannot cover more than 39 percent of a modeled area since a_i cannot exceed S. For the same reason, the low-sensitivity zone for such a model can comprise a no less than 61 percent of the modeled area.

A particular S Score (e.g., S = 0.39) can be achieved by a wide variety of combinations of a_i and b_i, however. When S is held constant, a_i can vary from near zero to S and b_i can vary from near zero to one. For instance, if $a_i = 0.10$, then b_i would only need to be 0.26 in order to achieve an S Score of 0.39. Although the target S Score in this scenario could be interpreted as having been met with the underlying proportions of $a_i = 0.10$ and $b_i = 0.26$, the intent of the metric would not have been met. For the MnModel standard to be met, for instance, S must be *less than or equal* to 0.39, when a_i is *less than or equal* to 0.33 and b_i is *greater than or equal* to 0.85. If these latter conditions are not met, then the performance standard also has not been met.

The MnModel standard is a very high standard of performance for a predictive model. A different and lower standard could be established, given the prevailing environmental and

cultural conditions or stakeholder interests. The MnModel standard reflects its stakeholders' low tolerance for risk. Because a lower level of effort would be placed in the low-sensitivity zone of the MnModel, stakeholders (including MnDOT, SHPO, and THPOs) wanted to make sure that few surprises awaited them (e.g. finding sites during MnDOT construction).

The level of risk stakeholders are willing to accept must be established for each installation and for different types of predictive models. It may not be reasonable to assume, for instance, that 85 percent or more of sites will fall within a zone that comprises a third or less of installation area. Conversely, stakeholders may feel that some kinds of models should be held to a stricter standard than the MnModel standard.

After consulting with the demonstration installations, we established a series of performance standards for the ESTCP project. Similar to stakeholders in Minnesota, demonstration installations had a low tolerance for risk. Thus, the MnModel standard was adopted for all-sites surface models and subsurface models. An even higher standard was adopted for red flag models:

All-Sites Surface Models and Subsurface Models:

- High- and medium-sensitivity zones combined should encompass 33 percent or less of the modeled area, but contain 85 percent or more of the sites in the all surface-sites and buried sites models ($S \leq .39$, when $a_i \leq 0.33$ and $b_i \geq 0.85$)

Red Flag Models:

- Combined high- and medium-sensitivity zones should encompass 24 percent or less of the modeled area, but contain 95 percent or more of all residential sites ($S \leq 0.25$, when $a_i \leq 0.24$ and $b_i \geq 0.95$).

Other statistical measures are available to test the predictive power of a model. Two of the most frequently used statistics to measure an archaeological model's success are the Gain statistic and the Gain-over-Random statistic. We used both of these metrics as secondary tests of model performance at Eglin AFB and Fort Drum.

The Gain statistic was created by archaeologist and modeler Kenneth Kvamme. The term "gain" signifies that there needs to be an increase or "gain" in the accuracy of correctly identifying the presence of sites in a target area by using the predictive model, in comparison to using a random model. Kvamme (1989:329) defined the Gain statistic as follows:

Gain = 1 – (percentage of total area covered by model/percentage of total sites within model area)

As the Gain statistic approaches +1.0, the model's predictive accuracy increases. Conversely, a Gain Score near 0.0 means the model has little or no predictive utility. A negative Gain Score means the model is actually a worse predictor than random guesses.

The Gain statistic is calculated using a random sample of surveyed land parcels. For the purposes of this project, we calculated model area as the area falling in medium- and high-sensitivity zones or in high-sensitivity zone in the case that no medium-sensitivity zone was defined.

For example, if the model predicts sites in 60 percent of land parcels, and these land parcels contain 85 percent of observed sites, then the Gain Score equals 1 – 60/85, or 0.29. The relatively low Gain Score results from a model that predicts sites in land parcels that encompass a large proportion (60 percent) of the study area. Alternatively, if the percentage of land parcels with model-predicted sites encompasses 85 percent of the observed sites, but only covers 15 percent of the study area, the Gain Score increases to 1 – 15/85, or 0.82, a much improved result.

Kvamme defined a second statistic that he termed Gain-over-Random (GOR) to calculate the proportional gain of a model's prediction over randomly assigning grid cells as containing or not containing sites. Kvamme (1992) defined GOR as follows:

GOR = (percentage of sites within model area – percentage of area covered by model area)

GOR ranges from -100 to +100. Negative index values reflect a model that works worse than random chance; low positive values reflect a model that works little better than random chance. High positive values reflect a model that accurately predicts site parcels within a relatively small model area. For example, using the first figures above, the GOR for the former case is only +25 (i.e., 85 - 60). The model predicts sites accurately but within a large model area. According to the GOR statistic, the gain over random chance is minimal. In the latter case, however, a GOR of +70 (i.e., 85 - 15) indicates a substantial improvement over random guesswork as most sites were discovered within a relatively small model area.

3.1.2 Data Requirements

Cultural data required for *surface models* (all sites surface models and red flag models) were obtained from cultural resources inventories in the form of either pedestrian surveys in areas of good ground visibility or subsurface probes or shovel tests units in areas where the ground surface is obscured. Environmental data were obtained from primary GIS layers, such as digital elevation models, or secondary layers using algorithms to calculate environmental variables from primary data (e.g., slope, aspect, and distance to water).

Cultural data required for *subsurface models* were obtained from subsurface cores, probes, and trenches combined with observations about landform evolution inferred from surface morphology. These explorations yield information on soils, stratigraphy, and geology that permit researchers to produced geomorphic maps. These data are combined with archaeological information on settlement patterns, paleoenvironment, and formation processes to produce archaeological sensitivity maps. Buried sites are defined as ones that are at least 1 m deep and may lack cultural deposits above them that extend to the surface.

3.1.3 Success Criteria

Because DoD has not set performance standards for archaeological predictive models and most stakeholders have a low tolerance of risk, we adopted a similar standard for a successful model accepted by the Minnesota DOT, the Minnesota SHPO, the ACHP, and other stakeholders in Minnesota. As discussed above, these parties have set a minimum standard of 85 percent of archaeological sites in high- and medium-sensitivity zones in 33 percent of the model universe, or an S Score of 0.39, for the acceptance of MnModel, the state-wide predictive model

Although we have set the overall model performance standard to 0.39, we also have established more refined guidelines for each sensitivity zone. We treat these zonal scores as guidelines that will allow stakeholders to measure and interpret model performance.

All-sites Surface Models and Subsurface Models:

- High-sensitivity zones should encompass about 15 percent or less of the modeled area, but contain about 75 percent or more of the sites in the all surface-sites and buried site models ($S \approx 0.20$).
- Medium-sensitivity zones should encompass another 15 percent of the modeled area, but contain about 20 percent of the sites in the all-sites and buried site models ($S \approx 0.75$).
- Low sensitivity-zones should encompass the remaining 70 percent of the modeled area, but contain only 5 percent of the sites in the all-sites and buried site models ($S \approx 14.0$).

Red Flag Models:

- High-sensitivity zones should encompass just 10 percent of the modeled area, but 80 percent of all residential sites ($S \approx 0.13$).
- Medium-sensitivity zone should encompass about 13 percent of the modeled area, but only 15 percent of all residential sites ($S \approx 0.87$).
- Low-sensitivity zone should encompass about 77 percent of the modeled area, but only 5 percent of all residential sites ($S \approx 15.4$).

Models will be judged successful if the calculated S Score for combined (and individual) high- and medium- sensitivity zones is equal or less than the specified performance S Score. Models will be judged successful if the calculated S Score for low-sensitivity zones is equal to or greater than the specified performance S Score.

3.1.4 Results

The demonstration project was successful in improving the performance of *surface models* at both installations, and the refined surface models met and exceeded the established threshold for a successful models (S=0.39). Whereas *baseline surface models* reconstructed for Fort Drum and Eglin AFB both failed to meet the threshold S Score, the Eglin baseline model was, in fact, close to meeting the performance criteria in a number of respects. After refinement, the surface model for Eglin AFB resulted in an S Score of 0.17 and the surface model for Fort Drum resulted in an S Score of 0.30.

The demonstration project was unable to adequately test *subsurface models* developed for Eglin and Fort Drum due to a lack of information on the location of buried sites as these two installations. Due to their depth and frequent lack of surface indications, buried archaeological sites are notoriously difficult to locate. Often they are encountered after a significant natural erosion event or during land-modifying activities. Insufficient data were available to test the Eglin subsurface model; therefore our results are inconclusive. Minimal data available for Fort Drum, however, permit us to test the subsurface model. Fort Drum's subsurface model came close to meeting the threshold for successful models (S = 0.42 versus S = 0.39), and there is good reason to believe the model's performance could be improved in the future.

The demonstration project was highly successful in developing a *red flag model* for Eglin AFB, which represents surface and near-surface residential sites. The S Score of 0.03 for the tested red flag model exceeds the established performance criteria of 0.25. This result suggests that this is a highly effective model for anticipating information-rich residential sites, which can be expensive and time-consuming to excavate. Insufficient data were available to test the red flag model developed for Fort Drum.

3.2 PERFORMANCE OBJECTIVE: DEVELOP NATIONAL HISTORIC PRESERVATION ACT (SECTION 106) PROGRAMMATIC AGREEMENT BASED ON MODELING

The intent of this study is to demonstrate that archaeological predictive models are viable resource management tools for streamlining NHPA (Section 106)- and NEPA-compliance activities within DoD installations. This is accomplished through the development of a Section 106 PA. Developing this agreement is the fourth performance objective and has qualitative parameters (see Table 3-1). Each PAs prepared for this project is a negotiated legal instrument designed to specify a programmatic Section 106 process that uses the validated models as its foundation. Each PA is to answer the following questions:

- Which installation undertakings fall under the Section 106-compliance process established by the PA?
- How will models be used in decision-making efforts that are associated with the identification of archaeological sites within an installation (e.g., the application of different levels of effort and/or field methods within contrasting archaeological sensitivity zones)?
- How will models be used in making decisions on the National Register eligibility of identified sites?
- How and when will models be refined and validated using data from future archaeological investigations within and adjacent to the installation (e.g., every three years, or after the completion of a set number of archaeological investigations)?

3.2.1 Metric (Qualitative)

The qualitative metric is a dichotomous yes/no variable, which scores whether a PA was drafted and/or finalized.

3.2.2 Data Requirement

The data required to prepare Section 106 PAs for managing archaeological resources at Eglin AFB and Fort Drum are numerous. They include installation-specific information related to archaeological and historical resources (e.g., inventories, National Register properties and districts, TCPS), consulting tribal organizations, existence and use of predictive models, and agreed-upon procedures for certain situations that may arise. Among the anticipated situations are consultation, unanticipated discoveries, treatment of human remains, dispute resolution, periodic meetings with SHPO, the need for management summaries for the SHPO, exemptions, and sunset provisions. Beyond the required data need to prepare a PA, cooperation among required signatories and consulting parties, as well as sufficient time to negotiate the details of the agreement, are paramount.

3.2.3 Success Criteria

Upon completion, the final PA will be signed by the installation, the appropriate SHPO, other consulting parties, and the ACHP—if participating in the preparation of the PA. Once the PA is executed and filed with the ACHP, the installation has fulfilled its Section 106-compliance responsibilities for all future undertakings that fall under the PA stipulations.

3.2.4 Results

The demonstration project team worked with the Eglin AFB and Fort Drum CRM staffs to draft the PAs. By the time the modeling was sufficiently complete and the results could be shared with installation staff, however, there was insufficient time remaining to engage the consulting parties in preparing an executable PA. Instead, the installations agreed the demonstration project team would write a complete first draft that subsequently could be used as the basis for consultation with their respective consulting parties. These drafts are contained in Appendix B and C of this report.

The PAs were drafted in close consultation with the CRM staffs at Eglin AFB and Fort Drum during 2010 and 2011. Conceptual agreements prepared for a 2007 DoD Legacy-funded project (Cushman and Sebastian 2008) were used as a starting point in the drafting process. In both draft agreements, decisions about survey location and intensity of Section 106 undertakings and Section 110 studies will be made using the refined models prepared for this study. Provisions have been added to ensure that the archaeological predictive models at Eglin AFB and Fort Drum will be periodically reviewed, refined, and validated, in consultation with the Florida and New York SHPOs.

Neither Eglin AFB nor Fort Drum decided to pursue significance modeling for National Register eligibility at this time, and this was not included in the draft PAs. Modeling for National Register eligibility has the potential to be an important management tool (Cushman and Sebastian 2008). Insufficient data on the relationship between surface and subsurface archaeological deposits at Eglin AFB and Fort Drum means that the former cannot be used to predict the latter at this time.

More time will be required to complete consultation with the appropriate parties and to prepare signature drafts of the PAs for execution. In short, the success criterion for this performance objective was only partial met.

3.3 PERFORMANCE OBJECTIVE: STREAMLINE NATIONAL HISTORIC PRESERVATION ACT (SECTION 106) AND NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

NHPA Section 106- and NEPA-compliance activities are combined within this objective given their linkage within the overall federal environmental review process. When the steps in the Section 106 process are streamlined and conducted in a programmatic manner, the steps in the NEPA process are also automatically streamlined. For example, reducing the cost, time, and areal coverage of archaeological investigations under the Section 106 process, streamlines the consideration of impacts to National Register-eligible archaeological sites that may be located within the project alternatives retained for detailed NEPA study. The intent of this performance objective was to demonstrate the savings in time and money that can be achieved through the use of archeological predictive models. At Eglin AFB and Fort Drum the data needed for the before and after comparison were not available because both have had inductive, intersection-type models for as long as their records have been maintained. Very few records predate the development of predictive models at Eglin AFB and Fort Drum; consequently, we were unable to conduct the necessary comparative analysis. We did, however, collect data that would address cost and time savings “with” and “without” the information provided by using archaeological predictive models.

3.3.1 Inventory Level of Effort

3.3.1.1 Metric (Quantitative)

There are several methods of evaluating the performance of model incorporation into the Section 106 process. The simplest method is to measure how much survey was done prior to the PA and how much is being done after its execution. If this information is unavailable, an alternative method is to infer the amount and type of inventory that will be required in the future and compare these figures with historical data from the demonstration installations under study. Historical data can be used to *retrodict* (i.e., simulate past performance with statistical methods) when the model was sufficiently strong to be incorporated into the Section 106 process; and then, calculate how much effort would have been allocated to inventory as opposed to how much effort was actually expended. If these data are unavailable, another method of demonstrating the performance objective is to reconstruct the level of effort expended on past survey based on existing data for two scenarios that can be compared. The first scenario reconstructs level of effort at a given installation in the absence of using a model (“without model”) and simulates a situation where 100 percent of the installation would have been intensively inventoried for its archaeological remains to meet the identification requirements of Section 106. The second scenario reconstructs level of effort at the same installation had a predictive model been used to direct and constrain where survey took place and at what intensity (“with model”). Survey intensity refers to parameters such as crew spacing along survey transects, pedestrian speed per terrain and vegetation type, number of shovel test units per transect meter, shovel test pit size and

depth, and number of sites recorded and in what detail. After these two scenarios are reconstructed, they may be compared to evaluate if and how much time and money could have been saved when information gained from developing predictive models was used to manage inventory efforts.

As there are no guidelines that specify a performance goal for measuring level of effort, we have specified a minimal value 15 percent as a reasonable "savings" for reduction of level of effort using a predictive model.

3.3.1.2 Data Requirement

Annual data on inventory coverage and level of effort are required to demonstrate this objective. Ideally, these data take the form of number of new survey acres per year, number of resurveyed acres per year, inventory methods (e.g., using shovel tests or visual inspection of the modern ground survey without test units), crew spacing, crew size, and duration of survey. From these data it is possible to generate person-days/hours (level of effort) for different portions of the installation per year. Unfortunately, not all these data are regularly recorded. For example, existing records do not regularly specify how much acreage was resurveyed or how much acreage was inventoried using different inventory and recording methods. Consequently, the demonstration project team was only able to collect sufficient data on survey crew size and duration of survey to derive person-days/hours from Eglin AFB and Fort Drum. These data allowed us to conduct a "with model/without model" analysis of level of effort for each installation.

3.3.1.3 Success Criteria

We expect that the greatest savings in inventory effort will occur in low-sensitivity zones where the survey requirement is relaxed or eliminated altogether. We also anticipate that there may be no savings in medium-sensitivity zones, and that the effort to survey high-sensitivity zones may, in some cases, increase. We considered assigning performance criteria for each sensitivity zone; however, we believe that such an approach would be of very little utility. Survey intensity is largely a management decision, based only loosely, if at all, on scientific results. Overall, our expectation is that the level of effort for inventory will decrease with the use of the models.

3.3.1.4 Results

Because we were unable to collect level of effort data for years before and after models were in place at Eglin AFB and Fort Drum, we evaluated level of effort through a simulation of "with model" and "without model" comparisons for Eglin AFB. Using this analytical approach, we determined that using information derived from the revised baseline model will result in a 68 percent reduction in the level of effort required for inventory. Therefore, the success criterion at Eglin AFB has been met.

A different approach to the "with model" and "without model" comparison was devised for Fort Drum to meet the limitations of its CRM data. This comparison also met the success criterion of achieving at least a 15 percent reduction in level of effort for inventory; Fort Drum has saved 58

percent on level of effort by using its baseline model. We are confident, however, that this savings can be achieved in the future.

3.3.2 Inventory Cost per Acre

3.3.2.1 Metric (Quantitative)

This quantitative metric involves comparing the average cost per acre-surveyed-per year with the average cost per acre-surveyed-per year under various scenarios. We had hoped that this metric would yield a monetary value associated with cost of inventory undertaken before and after the implementation of the PA. Because the demonstration project's PAs have not yet been implemented, it was not possible to conduct this particular analysis. Retrodiction analysis also was not used because data at Eglin AFB and Fort Drum did not allow for this kind of analysis. Instead, we used cost data to compare what each installation has actually paid for archaeological survey using their respective models with what they would have paid without the benefit of their models.

3.3.2.2 Data Requirement

Annual data on the number of acres surveyed per year and their associated costs are required to demonstrate this objective. It is important to note, however, that these annual dollar sums do not take into account variables such as costs for using installation personnel versus costs for using outside contractors. The project team used data on survey costs per year and survey costs per acre collected from Eglin AFB and Fort Drum.

Cost information on annual inventory at Eglin AFB and Fort Drum differed substantially given differences in how funding is managed for their respective CRM programs. At Fort Drum, survey is conducted every summer with the intention of eventually inspecting the whole installation for prehistoric archaeological sites. As of 2008, Fort Drum CRM staff report that 90 percent of the Fort has been inventoried or cleared for its cultural resources. Annual funding is provided for archaeological survey, and surveys are conducted in-house by a staff of professional archaeologists. Financial information on Fort Drum's annual CRM costs was collected during preparation of the Demonstration Plan in 2007 and supplemented by cost data for 2008. Survey data on level of effort were provided to the demonstration project team by Fort Drum in 2010.

Eglin AFB conducts archaeological survey for individual undertakings under Section 106 as well as Section 110. Funding comes from different sources for different needs. The archaeological work is almost always performed by outside contractors. The CRM program at Eglin AFB does not keep financial records per task, so it was not possible to isolate cost data for archaeological survey and testing. Collection of summary data is possible, however, through the installation contracting office and other sources; but Eglin AFB decided, due to concerns about releasing proprietary information associated with contracted services, not to make project level cost information available for this ESTCP study. As an alternative, Eglin's CRM staff provided the demonstration project team with current cost information for archaeological survey by sensitivity

zone, as well as cost/labor expectations for a hypothetical 100-acre survey. These data were used to estimate inventory costs per acre.

3.3.2.3 Success Criteria

Because archaeological inventory expenditures are driven by personnel costs, we expect reductions in inventory level of effort to mirror those in cost. We have established a performance measure of 15 percent reduction in cost to represent success.

3.3.2.4 Results

Using the "with model/without model" protocol, the demonstration project team was able to compare cost data for Eglin AFB and Fort Drum. These analyses clearly demonstrate that substantial cost savings have been achieved at both installations using their respective models to direct where archeological survey has been conducted. Eglin AFB's costs would be reduced by 67 percent by using the revised surface model, whereas Fort Drum's cost would be reduced by 66 percent. The cost difference between archaeological survey conducted with the model and the projected costs without the model indicate that the success criterion has been met.

3.3.3 Number of Evaluated Sites

3.3.3.1 Metric (Quantitative)

One of the objectives of this ESTCP-funded project is to demonstrate how predictive modeling of archaeological site locations can assist installation staff make better management decisions. One of the problems faced by the CRM staff is testing archaeological sites for their eligibility for listing in the National Register. Testing often requires labor-intensive excavation or use of mechanical equipment supplemented by hand excavation. Predictive modeling can be used to justify sampling sites for National Register testing that are part of larger classes of archaeological phenomenon. To conduct this analysis, archaeological sites were grouped by environmental setting. Sites that exhibit similar archaeological records and are located in similar settings are considered members of the same class. On the basis of these data, a reasonable argument can be made by CRM staffs and accepted by their consulting parties that evaluation of a sample of sites will satisfy Section 106 compliance requirements. Evaluating a class sample rather than evaluating the entire class will unquestionably result in time and cost savings to the installation. Classes that may be amenable to sample evaluation include artifact scatters, low density midden deposits, and other classes of sites with limited information potential.

3.3.3.2 Data Requirement

Data requirements included information on three variables: sites classified by their inferred function, sensitivity zone in which a site is located (for this analysis, each site was assigned to a sensitivity zone based on which zone the most site acres were located), and the presence or absence of temporal data. This resulted in three classes of archaeological sites being created by sensitivity zone: campsites, resource collection stations, or sites of undetermined function. Arbitrary assumptions about the percentage of sites per class being tested versus percentage of

sites not tested and held in reserve for future testing were made to complete the demonstration of this modeling utility.

3.3.3.3 Success Criteria

Given our assumption that CRM staffs and their consulting parties would be conservative in terms of sampling sites for eligibility testing, we selected a modest value of 15 percent to be a reasonable estimate of the reduction in site evaluations when using predictive models to guide sampling. This number represents a high percentage of sample evaluations occurring among site classes of limited information potential, poor integrity, and modest scientific significance offsetting evaluations of all other sites that are members of site classes with greater information potential and integrity.

3.3.3.4 Results

Fort Drum was not an appropriate candidate for this analysis because the garrison has never clearly defined archaeological site classes (i.e., site types). Eglin AFB, however, has clearly defined site types, and we were able to examine this objective using its archaeological site data.

The analyses of Eglin AFB data clearly demonstrate the savings in time and cost associated with archaeological testing for National Register eligibility that can be achieved by using predictive models for this purposes. Given our data and assumptions, Eglin AFB could easily achieve a 64 percent time and cost savings. For this performance objective, the success criterion was met for Eglin AFB.

3.3.4 Effectiveness of National Historic Preservation Act and National Environmental Policy Act Compliance Process

As discussed above, NHPA Section 106- and NEPA-compliance activities are combined given their linkage within the overall federal environmental review process. When the steps in the Section 106 process are streamlined and conducted in a programmatic manner, the steps in the NEPA process are also automatically streamlined.

3.3.4.1 Metric (Qualitative)

The measure proposed to evaluate the effectiveness of implementing a new programmatic approach to Section 106-compliance process is a survey that will be administered to the CRM staff at each installation. The survey will be designed to query the views of the staff regarding the effectiveness of the Section 106 process before and after the PA is implemented. A list of questions will be developed that can be addressed with ordinal-ranked values.

The ordinal scores for this metric are as follows:

- *Score 1: Clearly less effective* compared with prior compliance procedures
- Score 2: *Somewhat less effective* compared with prior compliance procedures
- Score 3: *Neither contributes or detracts* from effectiveness of new compliance procedures compared to prior compliance procedures

- Score 4: *Somewhat more effective* than prior compliance procedures
- Score 5: *Clearly more effective* compared with prior compliance procedures

3.3.4.2 Data Requirement

There are no data requirements for this conducting this survey other than securing the agreement of CRM managers and other installation staff responsible for Section 106 compliance that they would be willing to participate. An on-line survey tool, such as Survey Monkey®, will be used to host the survey and collect responses.

3.3.4.3 Success Criteria

As the PAs have not yet been finalized and executed, a before and after comparison is not possible at this time. Questionnaires completed by Eglin AFB and Fort Drum CRM staff in 2007 (Cushman and Sebastian 2008), however, provide a preliminary evaluation of the performance criteria. The 2007 completed questionnaire from Eglin AFB indicated that staff members are satisfied with the use of their archaeological predictive model for making Section 106-compliance decisions. What the CRM staff wants is statistical confirmation of the model's validity, which will help them convince management that the model is a robust management tool. The PA becomes the vehicle for continued use of this tool.

At Fort Drum, the CRM staff members are looking for greater autonomy to make more compliance decisions without prior consultation with the New York SHPO. The changes they seek through the PA are not related to the use of their predictive model per se, but rather relate to how they meet their consultation requirements. Nonetheless, it is clear from discussions with the New York SHPO staff that improving the accuracy and reliability of the model through the activities conducted as part of this demonstration project has resulted in their agreement to change the relationship with Fort Drum in a positive way that provides for this greater autonomy. Once the drafted PA is finalized and in place, we expect the compliance process will be greatly improved.

3.3.4.4 Results

Until PAs for Fort Drum and Eglin AFB are final and executed, it is impossible to evaluate this performance objective.

4.0 SITE DESCRIPTION

4.1 SITE LOCATION AND HISTORY: EGLIN AFB

Eglin AFB is within the AFMC and home to the 96th Air Base Wing. Eglin's Air Armament Center plans, directs and conducts test and evaluation of armament, navigation, guidance systems, and command and control systems over a very large test range. The land occupied by Eglin AFB was officially transferred to the War Department in 1940. During World War II, Eglin played a primary role in the testing of new weapons and tactics. Eglin again assumed an active role in weapons research, development, and testing during the Korean Conflict, Cold War Era, and global events of the late twentieth century.

4.1.1 Location and Site Characteristics

Located in the Florida panhandle, Eglin is bordered by the Yellow River, Shoal River, and Titi Creek to the north, Highway 331 and private lands to the east and northeast, Choctawhatchee Bay and the Gulf of Mexico to the south, and Escambia Bay to the west (Figure 4-1). Eglin is approximately 84 km (52 mi) east to west and 29 km (18 mi) north to south and is nearly contiguous with the Blackwater River State Forest to the north (National Audubon Society 2011). The main reservation encompasses portions of Okaloosa, Santa Rosa, and Walton counties along Florida's northwest coast; however, two contiguous training and radar sites are located in Gulf and Bay counties. Eglin covers approximately 188,300 ha (465,284 ac) and includes 322,798 sq km or 124,642 sq mi of water edges (Figure 4-2). Eglin is unique for its offering of expansive land and water ranges for military training.

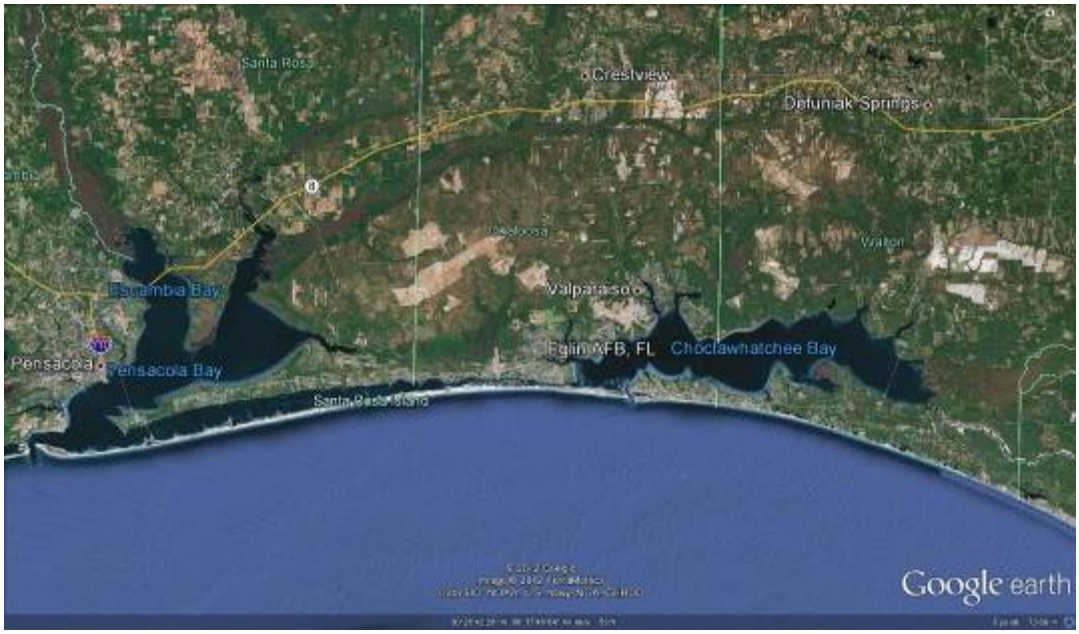

Figure 4-1. General location of Eglin AFB in the panhandle of Florida.

Figure 4-2. Marine (top), riparian (middle), and estuarine (bottom) environments characteristic of Eglin AFB.

4.1.2 Culture History[3]

The culture sequence presented below is taken from Thomas and Campbell (1993) and supplemented by data gained through subsequent investigations. The interpretations were based on a 10-year study at Eglin, as well as synthesis and incorporation of data previously gathered from the reservation and surrounding area. Data recovered subsequently are a result of fieldwork undertaken since 1990 by various contract firms and Eglin staff. Over 1,000 cultural occurrences have been identified on Eglin and hundreds more are located in the surrounding areas of the culture region defined in the Historic Preservation Plan (HPP, now referred to as an Integrated Cultural Resource Management Plan or ICRMP). The synthesis of these combined data has led to a significant advancement in the knowledge of the regional culture history. For reference in this discussion see Table 4-1, a chronological chart based on the synthesis of area data (Thomas and Campbell 1993).

4.1.2.1 Paleoindian/Early Archaic

Although occasionally found, evidence on Eglin of classic Paleoindian fluted points, such as Clovis, is rare. Most of the fluted points found in the region have been recovered from waters near sites on the south shore of Choctawhatchee Bay, which was well inland during the Paleoindian period because of lower sea level. The points provide evidence that there was some movement into the area by Paleoindian groups. If the manufacturers of the classic fluted Paleoindian points were intensively exploiting the coastal zones of this region, evidence would now lie offshore. These early populations roamed a landmass considerably larger than present day Florida. The rise in sea level around 6500 B.C. would have submerged any sites that were on the former coastline of the Gulf.

The best evidence of early occupation at Eglin is represented by point types that are variously viewed as Terminal Paleoindian or Early Archaic. Most common are Bolen points, although specimens of the types Santa Fe, Nuckolls, Dalton, Kirk Serrated, Suwannee, and Wacissa have also been found (Morehead et al. 2004; Thomas and Campbell 1993). These types are all similar in age and represent a change in technology away from the severe fluted points of earlier times, although some minor fluting was evident and basal thinning continued to be a technological characteristic. Morehead et al. (2004) investigated a series of Late Paleoindian and Early Archaic components through test and evaluation. Based on the findings, they hypothesized on the elements within tool kits when certain points are dominant. For example, they found that tool kits with Bolen points tended to have more evidence of bifacial reduction and a preference for chert as a raw material. There also seems to be some crossover between point types that may span the time frame from Late Paleoindian to Middle Archaic (see below), and a locational association with a particular soil has been indicated; this topic is discussed more below.

[3] This section on Eglin AFB's Culture History is taken directly from Aubuchon et al. (2011), *Cultural Resources Survey of X-1139, Cultural Resource Management Support, Eglin Air Force Base, Okaloosa County, Florida,* with only minor editorial changes.

Table 4-1. Eglin AFB Culture Sequence (modified from Thomas and Campbell 1993)

STAGE	A.D./B.C.	PERIOD	CULTURE	PHASE/COMPLEX
Historic	A.D. 1800— A.D. 1700— A.D. 1600—	Historic		
Mississippian	A.D. 1500— A.D. 1400— A.D. 1300— A.D. 1200— A.D. 1100—	Late Mississippian	Fort Walton/ Pensacola	Four Mile Point Indian Bayou
		Middle Mississippian		
		Early Mississippian		
Woodland	A.D. 1000— A.D. 900— A.D. 800— A.D. 700— A.D. 600— A.D. 500— A.D. 400— A.D. 300— A.D. 200— A.D. 100— —	Late Woodland	Weeden Island	
		Middle Woodland	Santa Rosa/ Swift Creek	Horseshoe Bayou Lassiter
		Early Woodland	Deptford	Okaloosa Alligator Lake
Gulf Formational	100 B.C. — 200 B.C. — 300 B.C. — 400 B.C. — 500 B.C. — 600 B.C. — 700 B.C. — 800 B.C. — 900 B.C. — 1000 B.C. —	Gulf Formational	Elliotts Point/ Norwood	Elliotts Point
Archaic	2000 B.C. — 3000 B.C. — 4000 B.C. — 5000 B.C. —	Early to Middle Archaic		
Lithic	6000 B.C. — 7000 B.C. — 8000 B.C. — 9000 B.C. — 10,000 B.C. — 11,000 B.C. —	Paleoindian/Early Archaic		

4.1.2.2 Early to Middle Archaic

The Early Holocene was characterized by tool kits with point types such as Wacissa, Palmer, and Kirk. Wacissa is a stemmed point with considerable similarity to Kirk Stemmed and Kirk Serrated, although it does not seem to have been directly dated and has been suggested to be anything from Late Paleoindian to Late Middle Archaic (Farr 2006). The similarity of the type to the later variants of Kirk suggests an interval near the Early to Middle Archaic transition.

At the onset of the Holocene at 10,000 B.P., sea level was 20 to 30 m lower than now, but rising rapidly. The Gulf coastline reached its current level at about 6000 to 5500 B.P. (Bradley 1999; Cronin 1999; Fairbridge 1992; cf. Saucier 1994).[4] Many of what would have been prime site locations in the Early to Middle Holocene are: (1) now drowned; (2) have been buried by fill in aggraded stream valleys because of rising sea level; and/or (3) are currently offshore, as the coastline was further south. This means that many of the present bayous were not there, and associated creeks (e.g., Rocky Creek) discharged into the Choctawhatchee River, which is believed to have joined other streams such as the Yellow River before reaching the Gulf south of Pensacola (Morehead et al. 2004).

Starting in the Early Archaic, there is evidence of a definite shift away from complex flake tools and tool kits towards bifacial technology and simple retouched flake tools. By the Middle Archaic, most industries seem heavily biface oriented. However, this is simply a hypothesis, which should not be taken as proven. Most sites are small, upland hunting stations, and the assemblages of hunting stations are remarkably consistent: one or two projectile points, utilized flakes, and retouch/maintenance flakes. The proof of this conjecture awaits further research at more complex sites, such as base camps, where a fuller range of tools and technology may be expected.

Of additional interest for other Early Holocene components is the odd quasi-spodic characteristics found with some consistency. Examples include Wacissa sites, 8OK433 on Rocky Creek, and 8WL1151 on Alaqua Creek, as well as the Palmer component at 8WL1151 and the component with Hardee and Kirk-like points at 8WL1150, and a Dalton component at 8WL1147, all of the latter on Alaqua Creek. All of these components were in the lower deposits at the respective sites, occurring on a soil unlike any described in the Okaloosa, Santa Rosa, and Walton County soil manuals (Campbell et al. 2008a:274–275). It has some similarity to the Kureb series, and might be a Kureb taxadjunct, suggesting that Kureb mappings and mappings of soils known to host unmapped inclusions of these soils warrant special attention.

4.1.2.3 Gulf Formational

The Late Archaic is not defined separately in this region from the Gulf Formational, which is recognized in the Eglin area as the Elliotts Point Complex, a local manifestation of the Poverty Point Complex situated in northeastern Louisiana within the lower Mississippi River Valley (Lazarus 1958; Webb 1982). According to Campbell et al. (2004), the Gulf Formational is

[4] Cronin (1999) cites research that suggest sea level may have been as much as one meter higher than present as early as 6000 B.P. (4000 B.C.). The Early Holocene is also the time of the Hypsithermal warming event of circa 9000 B.P. to 5000 B.P.

bracketed by radiocarbon dates between about 2500 B.C. and 600 B.C. The earliest dates for Elliotts Point are based on a series of radiocarbon assays from 8OK898, the Eglin Prison site, the oldest of which was 2535 to 2140 B.C. (Beta-129298 [calibrated (cal.) to a 2-sigma probability range]) and the most recent at 2205 to 1860 B.C. (Beta-129297 [cal. 2-sigma probability range]). 8SR17 also helps bracket the earliest range with a date of 2470 to 2210 B.C. on charcoal (Beta-191432 [cal. 2-sigma probability range]), but the most recent date at that site nearly mirrors that from 8OK898, 2230 to 1870 B.C. (Beta-203566 [cal. 2-sigma probability range]).

Sometime after its initial appearance, the Elliotts Point complex fluoresced into its classic form, marked by a distinctive artifact inventory that includes well-formed baked clay objects, known as Elliotts Point objects (EPOs) for their similarity to Poverty Point Objects (PPOs), microliths and exotic items indicative of participation in the Poverty Point trade network. Points are Florida Archaic Stemmed types, including the locally recognized Destin point.

Researchers continue to study the composition of Elliotts Point assemblages throughout the phase to determine variation in traits. While all of the attributes of classic Elliotts Point do not appear in the earliest assemblages, stone vessels are present, as they are in early Stallings Island contexts on the Georgia-South Carolina coastal areas. A notable example on Eglin is 8WL1005, the Stone Vessel site, which contained 14 pieces of lithic debitage, two sand-tempered sherds, five fiber-tempered sherds, and two nested stone bowls, the latter of which appear to have been deliberately cached (Hemphill et al. 1995:30).

Although no prepared pit could be discerned, it seemed clear that the vessels were either placed in a newly dug-out hole or a then-existing subsurface exposure for later reuse. They represent site furniture: heavy objects that were frequently left behind by the occupants to avoid the effort of transporting them to another site or region. Artifacts at the site suggest that it was a camp where limited tool maintenance and, perhaps, given the presence of a core, some limited manufacture took place. The presence of the stone vessels and fiber-tempered pottery would suggest food preparation and storage were also activities. The fact that the vessels were left behind suggests intent to return and use of the vessels for some type of activity involving subsistence exploitation or food preparation.

Steatite, once believed to occur in low quantity, appears now to be quite common throughout the temporal spectrum of Elliotts Point assemblages. It is represented by bowls, pipes, boat stones, and ornaments. However, 8WL1005 is unique to the Eglin area, representing the first regional recovery of two stone vessels from what appears to be a deliberately cached location. Caching of stone vessels was reported by Webb (1982) at the Poverty Point site in northeastern Louisiana and a deliberate caching of stone vessels was documented at the Claiborne site. The latter is a horseshoe-shaped shell midden on the Mississippi Gulf Coast where Gagliano and Webb (1970:59) describe a cache of 10 steatite vessels found in sterile sand underlying the midden near the center of the horseshoe apex. The corrected radiocarbon date range on the bowls from 8WL1005 is 2290 to 1975 B.C. (Beta-81709 [cal. 2-sigma probability range]).

Accretional mounds are also characteristic of Elliotts Point, and the Meigs Pasture site (8OK102) on Rocky Bayou may represent one begun early in the Gulf Formational with continued use (Thomas and Campbell 1993). Radiocarbon dates, all on shell, range from 2425 to 1955 B.C.

(Beta-21253 [cal. 2-sigma probability range]) to 990 to 755 B.C. (Dicarb—no number assigned [cal. 2-sigma probability range]). Meigs Pasture produced nine clay balls, likely crude Elliotts Point objects, which are believed to have been used for cooking. No stone vessels were present, but two small sandstone fragments were found in the backdirt from trench excavation. Likewise, 8OK898 has yielded no steatite vessels. However, that site has rich midden deposits and has produced lithic debitage, tools, including points, hammerstones, and Jaketown perforators, and Elliotts Point Objects (Campbell et al. 2009b).

Elliotts Point sites south of Choctawhatchee Bay are exceptional in some ways, an impressive cluster of which are believed to represent the fluorescence of Elliotts Point (Thomas and Campbell 1993; Webb 1982). These are located on Fourmile Peninsula, which appears to have been a hub of Elliotts Point activity, hosting the Buck Bayou Mound (8WL90), an accretional shell mound surpassed in size only by 8OK6, a Mississippian platform mound in downtown Fort Walton Beach (Thomas 1989). Although exotic items are found at many Elliotts Point sites in the study area, the most compelling evidence for affiliation with the Poverty Point trade network is derived from Fourmile Peninsula sites, including the Buck Bayou Mound and others (Campbell et al. 2004; Thomas and Campbell 1993).

Data from 8WL87, which were examined by Webb and Reichelt (Florida Master Site Files n.d), reveal it to have been a lithic workshop, characterized by finished points, sidescrapers, denticulates, utilized flakes, flaking debris, lamellar pieces including a core, drills and blades, hammerstones, one loaf-shaped mano, galena, baked clay objects or artifacts (BCAs), a jasper gorget, and one possible jasper saw, among other items. Also found were over 50 steatite vessel fragments that Gagliano and Webb (1970) believe to represent at least five vessels. The separation of the lithic workshop from the mound is reminiscent of the community patterning at Poverty Point (Thomas and Campbell 1991, 1993). Another specialized activity area is the Fourmile Drill site (8WL92) on the east side of Fourmile Peninsula, north of both 8WL87 and the Buck Bayou Mound. The collection from this site consists almost exclusively of Jaketown perforators, a hallmark of Poverty Point, and other microliths (Thomas and Campbell 1991; Webb 1982; Don Sharon, personal communication, 1985).

Situated on the Gulf of Mexico a short distance from Fourmile Peninsula, the Alligator Lake site (8WL29) is one of the richest Elliotts Point sites in the area (Lazarus 1965). Clear evidence of trade is documented by the recovery of three copper beads fashioned from small ingots of copper, steatite, two gorgets, ground stone tool fragments, Jaketown perforators, a pumice hone, and a hematite plummet. Twelve projectile points were also recovered, and seven of these are very much like Delhi points, a popular type at the Poverty Point site. Seven of the points were produced on exotic chert, four on quartzite, and one was on translucent quartz. Lazarus (1965) was only able to sample the site, but it is obvious from the collection he gathered that Alligator Lake exhibits among the most dramatic evidence of Elliotts Point Complex trade found to date.

Thomas and Campbell (1993) hypothesized that Fourmile Peninsula was a center of trade for the Elliotts Point population, which gathered periodically to exchange local goods and obtain exotic items. In this scenario, Poverty Point-associated traders along the Gulf may have stopped at Alligator Lake; from there, they could move overland and continue northward up to the Choctawhatchee River and on into the interior or continue in either direction along the Gulf.

There does not appear to be any similar collection of sites earlier in the Gulf Formational. However, although Meigs Pasture lacks the associated artifact inventory, data are not sufficient at present to call it a center of trade. Nevertheless, the idea it could be a predecessor of Buck Mound cannot be ruled out.

As far as settlement is concerned, the majority of Elliotts Point sites exhibit a preference for settings along the coast and shores of bays and bayous where associated middens are dominated by shellfish, including *Mercenaria* sp. (quahog), *Aequipecten irradians* (bay scallop), and *Crassostrea virginica* (oyster). The contents are noteworthy because bay scallops and quahog never occur in major quantities in any prehistoric middens in the study area after Elliotts Point, a fact that appears to be attributable to the formation of Moreno Point, the barrier spit at the current location of Destin, Florida that changed salinity levels in the bay.

The issue of fiber-tempered pottery is noteworthy as it has been the subject of discussion among researchers as to when it arrived in assemblages, how important it was, and why the quantities are overall quite low as noted by Campbell et al. (2004). It is clear from radiocarbon dates that steatite vessels were in the study area well before fiber-tempered pottery. 8WL1005, in the Alaqua drainage, attests to that observation. While the bowls themselves were made on non-locally available resources, the deliberate caching of artifacts underscore use by a local population that utilized 8WL1005 as a collection camp or other resource exploitation site, with a more substantial residential locus nearby. One candidate would be 8WL994 (Morehead et al. 2000), which is near the former on the east side of Alaqua Creek.

Fiber-tempered pottery has been dated on the basis of charcoal with which it was found at Alligator Lake. The date 3135 ± 125 B.P. (AC-32, 1675 to 1025 B.C., 2-sigma cal.) is within a time frame contemporaneous with the emergence of fiber-tempered pottery to the east in the Apalachicola region, where dates obtained by Phelps (1966) and White (1981, 2003) indicate an age as early as about 3970 to slightly later than 2962 B.P. (2900 to 806 B.C., 2-sigma cal.). These dates, along with the recovery of fiber-tempered wares stratigraphically underlying later Deptford sherds (cf. Thomas and Campbell 1993) support the proposition that fiber-tempered pottery was an addition to an already well-established material culture in the pre-pottery Late Archaic. Lazarus' (1965) date on Deptford materials from Alligator Lake establishes the presence of that culture by about 2575 ± 80 B.P. (GX-155, 840 to 415 B.C., 2-sigma cal.), based on a date on charcoal. A Deptford date from 8OK126, the Fish Fry site, located on Eglin AFB, was 2580 ± 70 B.P. on shell (Beta-39712, 375 to 190 B.C., 2-sigma Cal). Therefore, it seems safe to assume that the Deptford culture was firmly in place no later than around 2600 B.P. (cal.).

However, despite a widespread presence of fiber-tempered sherds at sites across the region, the quantities are remarkably low. For example, of 84 sites with fiber-tempered pottery studied by Campbell et al. (2004), the cumulative total of sherds was only slightly more than 200 vessel fragments. There also seem to be areas devoid of any evidence of fiber-tempered pottery, suggesting a potential for differential patterning to the location of sites with fiber-tempered pottery in the study area. Perhaps even more noteworthy is the observation that the settlement patterning of sites with fiber-tempered pottery is divergent from that of sites with the main trappings of Elliotts Point, the latter confidently identified in Campbell et al.'s (2004) study at 57 Gulf Formational sites. Of those on Fourmile Peninsula, considered the nexus of activity, only

two sites (8WL28 and 8WL36) have produced fiber-tempered pottery, the combined collections amounted to 10 ceramics.

The late arrival of pottery to the Eglin area in the Gulf Formational seems to support Sassaman's (1993) posture on the slow and erratic movement of pottery after its introduction on the Atlantic Coast. He believes that part of the reason for the delayed appearance of pottery west along the Gulf Coast lies in the control of trade networks. Essentially, the people who controlled the Late Archaic trade networks probably enjoyed prestige and power, and were likely also influential in shaping the direction and pace of technological change in a given region. Extremely important in that network was the trade of steatite for use as containers. Pottery vessels presented a direct threat to the value of steatite. Thus, the powerful Poverty Point trade network, viewed by some as the perfect conduit for the diffusion of pottery, may have instead worked to stall its spread and acceptance across the Southeast.

These concepts could be applicable to the northwest Florida study area. Steatite vessels were an integral part of the Elliotts Point assemblage, and they appear to have been in use well before fiber-tempered pottery came on the scene. The influence of peddlers who controlled the network locally may have been highly resistant to the pottery innovation. The value of steatite and perhaps other exotics would have certainly plummeted if they could be replaced by items that could be made in the region with locally available raw materials. This argument could be strengthened if other factors were operating to affect the Elliotts Point lifestyle, changes in subsistence, for example.

As noted, shellfish collection already formed a major component of the prehistoric diet during Elliotts Point times; however, there was a shift in the availability of shellfish species that took place at the end of Elliotts Point times and may have had an effect on the distribution of labor. By around 3000 B.P., the restriction of flow between Choctawhatchee Bay and the Gulf of Mexico caused a reduction in the availability of shellfish, like scallop and quahog, which were exploited heavily by Elliotts Point populations, leaving oyster as the major species available (Goldsmith 1966; Johnson et al. 1986; Thomas and Campbell 1993). Associated with these shifts in the natural environment was an increase in inland, riverine settlement.

Throughout the entire era of Elliotts Point, however, scholars have been challenged by the interpretation of aspects of the occupation critical to cultural reconstructions. Whether as a result of the unique aspects of the time, environmental influence, and/or undetermined factors, clear patterns for the colloquial Elliotts Point occupation and land use has been elusive. Specialized workshops and centers of trade are rather easily recognizable from the configuration and/or classic assemblage compositions, but residential loci do not fit established concepts of villages or base camps and the nature of deposition is such that significant remains can be easily missed by inexperienced personnel. A noteworthy example is 8OK898, a large Elliotts Point site on the former federal prison camp on Eglin. Although rich deposits have been encountered, there is no observable pattern to the distribution. It is possible to excavate in one area and uncover dense shell midden and features, and then place excavation units less than 10 m away and find no evidence of Elliotts Point remains whatsoever (Campbell and Mathews 1997). Similar situations have been encountered at a series of Elliotts Point sites along Rocky Bayou and Rocky Creek

where multiple investigations failed to reconstruct intra-site residential versus activity patterning (Campbell et al. 2008a).

Thus, while the investigations of Elliotts Point sites have advanced the status of knowledge considerably since first identified by Lazarus in the 1950s, many cultural gaps remain. What we see in the study area is a bustling population at the end of the Archaic with strong ties to the Poverty Point network and unambiguous evidence of participation in long-distance trade. Sometime near the end of the Elliotts Point heyday, fiber-tempered pottery makes its appearance, but does not seem to have been widely accepted until the culture may already have been in decline.

The decline of the Elliotts Point Complex has been viewed as related somehow to the demise of Poverty Point, the latter being a much-debated topic. One explanation is T. R. Kidder's Climate Hypothesis in which global cooling increased rainfall, triggering massive flooding in the Mississippi Valley (Kidder 2006). In this scenario, the flooding disrupted the Late Archaic and, by extension, Poverty Point culture. Ken Sassaman offers another possibility, suggesting the disruption of raw material trade could have contributed to the end of Poverty Point (Sassaman 1993). While not answering the question of what transpired to have such a profound effect on the Poverty Point culture, Gibson (personal communication, June 22, 2009) is dubious of attributing it to natural events, but does observe that whatever occurred, it seems as if the people of Mason Ridge disappeared, taking with them their traditions, beliefs, and most of the cultural aspects of their lifeways that had developed over centuries.

Similarly, with the decline of Elliotts Point around 650 B.C., the Gulf Formational tradition was truncated in the project area by emergent Woodland (Deptford) culture. Fiber-tempered pottery continues to be found in some Early Deptford assemblages, but much of the way of life so closely associated with the Poverty Point Complex and its sphere of influence seems to have also disappeared.

4.1.2.4 Deptford Culture

The restriction of the pass from Choctawhatchee Bay to the Gulf of Mexico sometime after 1000 B.C. resulted in environmental changes in the bay ecosystem and subsequent adaptive changes that are evident in the Deptford middens found in the project area. Whereas the previous Elliotts Point sites contained quantities of scallops and a wide variety of shellfish, the restricted pass limited these species, and consequently, Deptford middens are characterized by oyster with little other variation. These adaptive shifts stemming from environmental change were accompanied by other cultural changes that would ultimately lead to the decline of the Elliotts Point complex. The combination of more refined techniques of ceramic manufacture, settlement shifts in response to lower sea level, and the decline of the dynamic Poverty Point trade network created a situation in which Deptford culture became firmly established.

While there does appear to have been a radical shift in material culture, there is also some evidence of continuity between the Elliotts Point complex and Deptford occupations. The continuity is attested to by a continued selection for coastal settings and the continued occupation of some, though not many, of the same sites. The most dramatic aspect of Deptford settlement is

a concentration of Deptford sites on the north shore of Santa Rosa Sound along the Narrows. This dense concentration of village sites begins at the Narrows where the sound joins the bay and continues west along the sound shore. The Narrows represent a superb ecotone where the bay and sound converge near the Gulf of Mexico and seem to have been a highly attractive setting.

Three phases have been suggested for Deptford in the region. The dates from Alligator Lake (8WL29) and 8OK126 confirm an early phase of Deptford—the Alligator Lake Phase—beginning around 630 B.C. Stratum II at 8OK126, which produced the date of 630 B.C., yielded 21 unidentified plainwares and seven eroded check stamped sherds, as well as one Deptford Bold Check stamped and two Deptford Linear Stamped ceramics (Thomas and Campbell 1993). The level from which Lazarus (1965) obtained the date of 625 B.C. at Alligator Lake produced seven Deptford Bold Checked Stamped, five Deptford Simple Stamped, and two Deptford Linear Checked Stamped sherds. It would appear from these data that the full suite of Deptford stamped ceramics was being manufactured by the earliest populations of this culture.

The earliest deposits at 8OK126 were stratified under a later occupation that produced dates of 330 and 320 B.C. (Thomas and Campbell 1993:257). The associated pottery included only 26 unidentified plainwares, an obliterated stamped sherd, and seven eroded Deptford Check stamped sherds. This assemblage provides an inadequate basis for distinguishing any differences between the ceramics of the two occupations, but the radiocarbon dates and the stratigraphic positioning make it clear that the site was occupied by two temporally distinct Deptford groups. Additional excavations at sites like 8OK126 may ultimately enable us to discriminate between the early and middle phase assemblages. However, Deptford culture apparently endured over a long period of time. Like their western counterpart, Tchefuncte, in the Lower Mississippi River valley, it may be the Deptford people were a conservative lot and slow to change.

Change did come around 50 B.C. when influence from Marksville to the west and Swift Creek to the east becomes evident. These changes are manifested as the Okaloosa phase, defined by Thomas and Campbell (1985a) on the basis of their work at the Pirates' Bay site on Santa Rosa Sound in Okaloosa County, Florida, and confirmed by University of West Florida excavations at the Hawkshaw site (8ES1287) in Pensacola, Florida (Bense 1985, 1994). Similar sites have been found within the area from Escambia through Walton counties (Bense 1994; Thomas and Campbell 1993).

The Late Deptford Okaloosa phase was dated by radiocarbon assays of samples from the Pirates' Bay site (8OK183) to between about 50 B.C. and A.D. 150 (Thomas and Campbell 1985a). The artifact inventory is characterized by a continuation of Deptford pottery, the presence of classic Santa Rosa series sherds, some Marksville remains and crude, incipient Swift Creek styles. It was a time of renewed or increased influence from the west and, with the introduction of the Swift Creek styles from the east, the Okaloosa phase potters were actively engaged in ceramic experimentation. The lithic assemblage is distinguished by the presence of small, backed white quartz pebbles that appear to have been specialized tools. These items appear in Santa Rosa/Swift Creek assemblages as well.

At Okaloosa phase sites, such as Pirates' Bay (8OK183), Santa Rosa series pottery appears in classic form. It is possible that Santa Rosa series pottery began to take on a sacred position in the

assemblage at some point in time. This is suggested by excavations at 8WL58, a ring midden on the north shore of Choctawhatchee Bay (Figure 4-3). There Thomas et al. (1996) remarked that the plaza was almost devoid of Swift Creek Complicated Stamped, a type common in the middens on either side, but yielded a high incidence of Basin Bayou Incised. The authors hypothesized that pottery like Basin Bayou Incised and some of the other Santa Rosa series pottery may have served ceremonial functions, whereas the complicated stamped wares were more utilitarian.

Figure 4-3. Eroding shell midden site 8WL58, Eglin AFB.

A few sites on Basin Bayou with Late Deptford components are noteworthy for differences in the ceramic assemblages. These sites, which include 8WL150, 8WL151, and 8WL152, were substantial occupations, indicating evident stability. Their assemblages are characterized by Deptford pottery and the experimentation on complicated stamped designs seen in the Okaloosa phase, but lack any Santa Rosa series pottery (Meyer et al. 1996). Although unsubstantiated by a sufficient sample of data, it is possible these sites are part of a Terminal Deptford, transitional to Santa Rosa/Swift Creek and characterized by increased ceremonial activities. In this hypothesis, the Santa Rosa series pottery may have assumed a largely sacred status and been reserved for ritual, including burial offerings such as was apparently the case at the Basin Bayou mound, 8WL14. Having taken on a ceremonial status, Basin Bayou Incised and other Santa Rosa series pottery may have been removed from earlier Deptford contexts for ceremonial use by Santa Rosa/Swift Creek people.

In general, evidence gathered on Eglin and in the surrounding study area shows that settlement shifted from camps, small hamlets, and specialized activity areas around a regional mound center during Elliotts Point to a settlement pattern reflecting the growth of central base villages in Deptford. With the beginning of Deptford, the area hosted large villages that were probably

occupied year round. Moreover, except for the changes in ceramics in the Okaloosa phase, there is little evidence of a difference in villages between early, middle, and late Deptford sites.

In addition to the central base villages, numerous small Deptford artifact scatters and shell middens are found throughout Eglin and the surrounding area. Many of these probably represent camps that were visited by village occupants for the purpose of resource exploitation. Few radiocarbon dates have been obtained for these occupations; these dates would be useful in fitting these small scatters in the settlement scheme by phase.

Ample evidence of subsistence is provided by sites both on and off Eglin. Numerous middens indicate the Deptford people were engaged in the exploitation of shellfish. Oyster predominates, but *Rangia*, *Mercenaria*, *Strombus*, and *Busycon* represent minor occurrences along with incidental amounts of *Pecten*, moon snail, and *Fasciolaria*. It is unlikely, however, that shellfish exploitation accounted for a major part of the diet. Floral remains suggest gathering was also a subsistence pursuit, while faunal remains from Deptford sites reveal that the occupants were actively hunting and fishing as well.

The best evidence for hunting and fishing is derived from the faunal remains at 8OK126 on Eglin and DeFrance's (1985) detailed analysis of remains from Pirates' Bay (8OK183). Among the fish species are blue runner, Jack Crevalle, sheepshead, striped mullet, southern flounder, marine catfish, black drum, red drum, speckled trout, white trout, bluefish, and some evidence of barracuda, sea bass, and shark. Other faunal remains represented in the Deptford middens include white-tail deer, gray squirrel, rabbit, opossum, rodents, striped skunk, muskrat, and black bear. Migratory fowl and reptiles were also recovered.

The Deptford culture in the study area overall appears quite different from that found to the east. The absence of mounds in the study area is one difference and the apparent non-participation by Eglin-area people in the Yent ceremonial complex is another. Instead, it appears that the Deptford people here disposed of their dead in graves within or adjacent to their villages. The HPP cites several examples of village-associated burials, including one uncovered at 8OK126 on Eglin (Thomas and Campbell 1993).

4.1.2.5 Santa Rosa/Swift Creek Culture

After a long period of relative conservatism and what appears to have been a reasonably stable economy based on fishing, hunting, and shellfish collection, the Late Deptford Okaloosa phase occupants of the project area became the recipients of renewed outside influence. The continued appearance of Santa Rosa series pottery represents the continuing spread of Marksville influence from the west, while classic Swift Creek traits from cultures to the northeast were fully adopted by local inhabitants. Environmental shifts occurred again in the bay, altering the availability of certain shellfish species. These effects were marked by changes in material culture, subsistence pursuits, and community patterning. These are identified in the archaeological record by the appearance of sites of the Santa Rosa/Swift Creek culture variant.

Looking at the Eglin data in conjunction with that from the surrounding area, there are some significant differences in the patterns of Santa Rosa/Swift Creek site distributions versus those of

Deptford. The major distinction appears to be a shift away from the central base villages on the Narrows to settings around Choctawhatchee Bay. The large Deptford village at Pirates' Bay (8OK183) was abandoned after the Okaloosa phase and not reoccupied until Late Weeden Island (Thomas and Campbell 1985a; Thomas et al. 1991). Although several Santa Rosa/Swift Creek sites are located along the Narrows, most of these represent camp-like occupations. Two sites on the Santa Rosa Sound outside Eglin may represent villages.

Two sites on Choctawhatchee Bay, 8WL58 and 8WL36, have been instrumental in advancing knowledge regarding Santa Rosa/Swift Creek culture. Both were investigated in the 1980s by archaeologists affiliated with New World Research (NWR); archaeologists with Prentice Thomas and Associates (PTA) conducted excavations at the former in early 1995. Site 8WL58 is the Old Homestead site (originally named for its historic component), located on Eglin property on the north shore of Choctawhatchee Bay near the Fort Rucker Recreation Area (Thomas et al. 1996). The latter site, 8WL36, the Horseshoe Bayou site, is found on the south shore on present-day Sandestin property (Thomas et al. 2001).

8WL58 is a classic Santa Rosa/Swift Creek circular village with a plaza surrounded by a ring midden. The ring is a *Rangia* shell midden, averaging about 20 to 40 cm in depth. Although it currently appears horseshoe-shaped as a result of shoreline erosion, the midden was clearly a ring when first investigated by NWR in the early 1980s. The ring midden measures over 100 m east-west. The remaining north-south dimension is 50 m, but using previous research and indications from the curvature of the ring, its original north-south dimensions are estimated at 100 m. The plaza covers an area about 25 m east-west by 30 m north-south.

Rangia comprises more than 99 percent of the shell, excluding some oyster associated with a later, but minor Fort Walton/Pensacola component. Other types of shellfish in the midden include moonsnail, crown conch, scallop, and occasional coquina and oyster. The ring midden is rich in material cultural and subsistence remains and is also the locus of numerous large cooking and refuse pits. Although replete with features, the ring midden is noteworthy for the near absence of postmolds. Only two were identified in the midden and both are from the eastern side. The data would suggest, therefore, that the ring midden was used for food preparation and refuse disposal.

The plaza contains no shell midden, but there is a dark brown earth midden, indicating that the plaza was the site of substantial activity. It is also within this area of the site that numerous postmolds were identified, two lines of which provide the first recorded evidence of a structure at a Santa Rosa/Swift Creek site in this part of northwest Florida (Thomas et al. 1996). Researchers believe that the two lines are parts of structures that may have been domiciles. The entire outline was not exposed so it is unclear whether a portion has eroded into the bay or, instead, extends north of PTA's excavations. The myriad of postmolds, in addition to the two lines of postmolds, attests to the rebuilding that occurred over the years.

The Horseshoe Bayou site, 8WL36, as the name suggests, is a horseshoe-shaped shell midden composed of *Rangia*. The primary occupation at 8WL36 occurred during the Santa Rosa/Swift Creek and early Weeden Island periods. Less intensive or intermittent use of this location was also evidenced during the earlier Deptford period, and the late Weeden Island and Fort Walton

periods (Thomas et al. 1998, 2001). The site is located adjacent to Horseshoe Bayou, on the western side of the Fourmile Peninsula. The shell midden is restricted to a linear ridge that is basically U-shaped. Several isolated shell mounds were also found, and these, in conjunction with the ridge, form a rough enclosure that surrounds a central plaza area. The plaza area corresponds to that portion of the site that is characterized by low-lying terrain, and artifact bearing, but shell-free, soil deposits. Evidence for structural remains and various other prehistoric facilities is restricted to those higher areas of the site that contain shell midden. No prehistoric features like the postmolds at 8WL58 were found within the plaza area, but, as with that site, artifact densities are lower than in the adjacent high ground.

Two phases have been proposed for Santa Rosa/Swift Creek based on these major excavations and comparable data from tested sites. The earliest is the Lassiter phase, identified by investigations at 8WL58, and the latter is the Horseshoe Bayou phase, designated for 8WL36, the site of the same name. The Lassiter phase is characterized by ring shell middens with a central plaza. The ceramic assemblage included high percentages of plainwares; the best represented decorated types are Swift Creek Complicated Stamped, Basin Bayou Incised, Franklin Brushed, and Santa Rosa Punctated. Other complicated stamped types are only minor occurrences and check stamping is rare to absent. Franklin Plain rims display a wide range of treatment from undulating rims to classic pie crust styles and lip treatment includes incising, punctuating, and notching. Subsistence during this phase is based on a well-rounded diet supplied by hunting, fishing, collecting, and *Rangia* shell recovery. Bradford points are typical. A unifacial industry on Two Egg chert is evident, whereas most points are made of Tallahatta quartzite. The opaque citrus section industry evident in Deptford continues, but appears less important. Bone implements, including fishing toggles, are also present. Structural remains include postmolds, refuse pits, storage pits, and cooking pits. There is also some suggestion that ceremonial activities may have taken place in the village—possibly the plaza area.

The Horseshoe Bayou phase is characterized by semi-circular or horseshoe-shaped *Rangia* middens. The ceramic assemblage is markedly consistent at sites of this phase. Swift Creek Complicated Stamped exhibits a variety of designs. Other types in the Horseshoe Bayou phase assemblage include St. Andrews Complicated Stamped, West Florida Cord Marked, Crooked River Complicated Stamped (in minor quantities), Alligator Bayou Stamped, Santa Rosa Stamped, Basin Bayou Incised, occasional Gulf Check stamped, and Franklin Plain. Noticeably infrequent is the type New River Complicated Stamped, a presumably early marker of Santa Rosa/Swift Creek and one that was found in association with the Okaloosa phase of Deptford identified by NWR at the Pirates' Bay site (Thomas and Campbell 1985a). This type is also absent in the Lassiter phase.

A distinctive type of complicated stamping in the Horseshoe Bayou phase, but missing from the earlier Lassiter phase, exhibits a bold check stamp and raised dot in the center of the check stamp. It is similar to Sun City Complicated Stamped, but designated Horseshoe Bayou Complicated Stamped to distinguish it as part of the northwest Florida late Santa Rosa/Swift Creek assemblage. Penton (1970) describes finding 10 sherds with similar raised dots at the Bird Hammock site in Wakulla County and observed that similar sherds were found at the Refuge Tower site in the St. Marks National Wildlife Refuge. Additionally, Sears (1963) reported a single sherd of this type from the Tucker site in Franklin County. The Horseshoe Bayou

Complicated Stamped sherds are part of the overall complicated stamping tradition of the Horseshoe Bayou phase. The ware characteristics are identical to those defined for Swift Creek Complicated Stamped, early variety (Willey 1949:378ff). The type is not a major constituent of the ceramic assemblage but is clearly in a late Santa Rosa/Swift Creek context.

The importation of opaque quartz pebbles, a trade established during late Deptford, continued in the Horseshoe Bayou phase as well but, again, was not as extensive as in Deptford times. It is evident that the Horseshoe Bayou phase lithic assemblage exhibits considerable diversity in terms of raw material. Projectile points, typically expanding stem types, are primarily produced on Tallahatta quartzite with a smaller number made on non-local, gray or rose chert. Morphologically, some of the points are similar to the Columbia type, although Phelps (1966, 1969) refers to them as Swift Creek points.

Bone tool production seems to have been important as many of the Horseshoe Bayou phase sites produced appreciable quantities of vertebrate faunal remains that had been worked; the incidence is greater than evidenced in the preceding Lassiter phase. Worked bone from the Horseshoe Bayou site (8WL36) includes drilled teeth, presumably used as pendants, and polished, pointed pieces of bone that were used as pins, awls, or punches. Similar items have been recovered from other sites in the area, including 8OK107, an Eglin site that yielded a bone awl and a bone projectile point. Of interest is the recovery of bipointed, polished bone tools from 8WL36. These artifacts may have been used as fishing toggles attached to lines. Two examples of these have single transverse grooves, perhaps for attaching lines.

Differences between the two phases are essentially nonexistent when it comes to settlement. Both prefer coastal locations, particularly settings around Choctawhatchee Bay, and the subsistence regime consisted of hunting, gathering, and fishing. Most middens in both phases are dominated by *Rangia* shellfish remains, a shift from earlier and later oyster middens most likely due to availability rather than taste. The cultural differences lie mainly in site configuration, presence or absence of postmolds, and ceramic assemblage characteristics. However, there are also differences in the apparent chronology of the two phases.

The chronology of the Lassiter phase is demonstrated by five dates from the 1995 investigations at 8WL58. These are listed below in Table 4-2. The “Date #” column is for comparative purposes when these assays are examined in relation to those from two other sites below. The earliest and latest dates are from features and/or posts in the plaza. Use of the plaza for both site activities and construction seems to have taken place throughout the duration of occupation at the site. The date on the eastern shell midden is virtually identical to one of the two dates from the western midden. A second date from the western midden overlaps but is slightly later.

Site 8WL36 also produced five dates. Three were from a lower *Rangia* midden and two from an upper *Rangia* midden at the site. Table 4-3 lists the dates[5] for 8WL36 and a third site, 8WL191, for comparative purposes. 8WL191 is an early Weeden Island site that also contains *Rangia* shell midden, but lacks any evidence of Santa Rosa/Swift Creek influence, completely lacking any complicated stamped sherds or Santa Rosa series sherds.

[5]These dates have been calibrated by Beta Analytic, Inc. since they were originally assayed in the 1980s.

Figure 4-4 charts these dates using the "Date #" from Tables 4-2 and 4-3. The horizontal line on each dateline marks the intercept date. The dates from 8WL58 are very early, although there is some overlap with the dates from 8WL36. The dates from 8WL191, the early Weeden Island site, are consistently later than those from the Horseshoe Bayou site. From these data, there is a clear chronological evolution from occupation at 8WL58 to that at 8WL36 and finally the appearance of Weeden Island.

Table 4-2. Radiocarbon Dates from 8WL58

Date #	Beta Sample #	Location	^{14}C Date Range (calibrated, 2-sigma probability)
1	87797	Plaza	115 B.C. – A.D. 160
2	87794	East Shell Ring - Area 4	60 B.C. – A.D. 235
3	87798	West Shell Ring - Area 2	45 B.C. – A.D. 265
4	87795	West Shell Ring - Area 2	A.D. 10 – A.D. 310
5	87796	Plaza - Area 3	A.D. 100 – A.D. 430

Before leaving the Middle Woodland, some additional comments regarding ceremonialism are warranted, particularly with regard to the Lassiter phase. First, as noted in the Deptford discussion, the Basin Bayou Incised ceramics, part of the Santa Rosa series and associated with Hopewellian influence, are found in high quantities at 8WL58, in general, and in the plaza, in particular. PTA believes that the occurrence of this type reflects activities that may have been viewed as sacred.

Table 4-3. Radiocarbon Dates from 8WL36 and 8WL191

Site	Date #	Beta Sample #	Location	^{14}C Date Range (calibrated, 2-sigma probability
8WL36	6	39726	Lower *Rangia* Midden	A.D. 270 – A.D. 590
8WL36	7	39725	Lower *Rangia* Midden	A.D. 245 – A.D. 600
8WL36	8	39723	Lower *Rangia* Midden	A.D. 365 – A.D. 670
8WL36	9	39722	Upper *Rangia* Midden	A.D. 470 – A.D. 715
8WL36	10	39724	Upper *Rangia* Midden	A.D. 545 – A.D. 775
8WL191	11	39716	*Rangia* Midden	A.D. 590 – A.D. 870
8WL191	12	42862	*Rangia* Shell from fire pit	A.D. 600 – A.D. 880
8WL191	13	42863	*Rangia* Shell from shovel test	A.D. 635 – A.D. 830

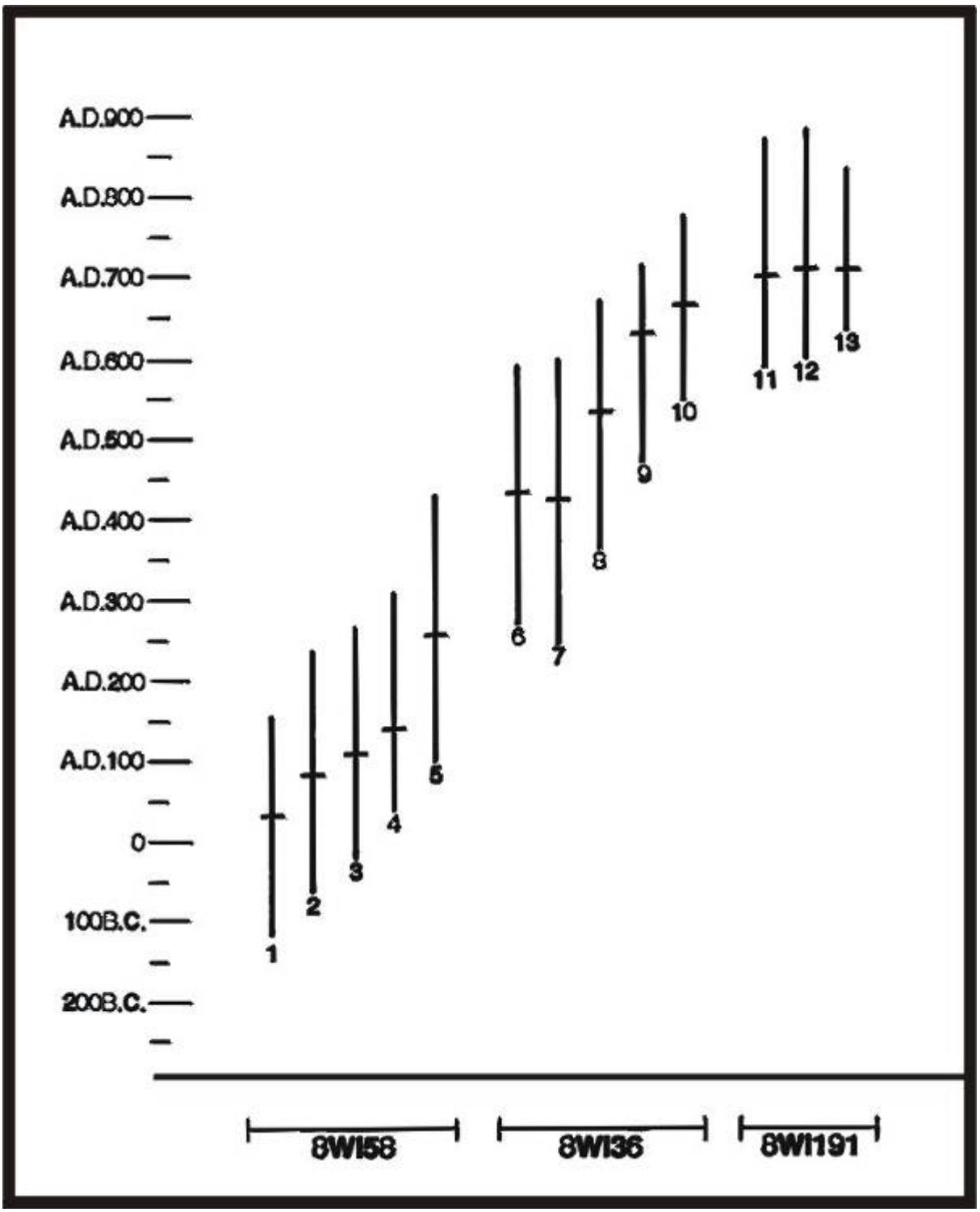

Figure 4-4. Comparison of dates from 8WL58, 8WL36, and 8WL191.

It is somewhat interesting that Santa Rosa series pottery appears in its pure, classic form in the Choctawhatchee Bay area during late Deptford. In contrast, Swift Creek designs that appear at that time are crude. It may be argued that some Santa Rosa series ceramics had ritual symbolism. As such, the bird motifs and similar patterns may have been accepted as sacrosanct by late Deptford people, and hence, not subject to experimentation, but rather produced in classic form; this revered status may have been continued by Santa Rosa/Swift Creek populations.

Willey (1949:223–224) reported that Moore's excavations in 8WL14, the Santa Rosa/Swift Creek mound at the mouth of Basin Bayou, produced Alligator Bayou Stamped and Basin Bayou Incised. This suggests this pottery had ceremonial meaning. Willey (1949) also notes the possibility that actual west to east tribal migrations may have taken place, perhaps associated with the burial mound tradition and both Marksville and Hopewellian influence. In fact, three sherds from 8WL58 fit the description of Marksville Incised based upon the presence of clay tempering, which Willey (1949:372, 375, 384) discusses as a trait occurring sometimes in both Alligator Bayou Stamped and Basin Bayou Incised ceramics. However, in the case of the three Marksville Incised sherds from 8WL58 the clay-tempered examples exhibited extra-local paste and decorative traits indicating they were not produced in this region.

The paste of most clay-tempered ceramics found in northwest Florida more closely resembles Lower Mississippi Valley ceramics than local wares (Bense 1992:59; Thomas and Campbell 1985a). The texture of the paste is very fine and may have inclusions of black organics like those found in Lower Mississippi Valley ceramics. Rarely are examples of mixed sand and clay tempers found, and moreover, clay tempering is characteristic of sherds similar in decorative design to the Santa Rosa series types, not those of the Deptford and Swift Creek series in this region. The sherds from 8WL58 as well as other Marksville ceramics in the region tend to exhibit above-average quality of execution and clay-tempered decorated types almost always outnumber clay-tempered plainware. Given the overall characteristics, it appears that Marksville ceramics in this region were either brought in from the Lower Mississippi Valley or reflect trade either with that region or other traders exchanging goods with Lower Mississippi Valley populations.

The relationship of some Santa Rosa series pottery to ritualistic activity, to Marksville and Hopewell cultures, and to the burial mound tradition is an important avenue for continued research, but the data seem to support not only influence, but also interaction between northwest Florida and these cultures to the west. Assuming this to have been the case, it is logical that Santa Rosa series pottery, which appears in its fully developed form, may have been viewed as ceremonial, ritual, or elite wares in the same manner as would bonafide Marksville and/or Hopewellian pottery and other elements of their material culture. This interpretation would help explain why artisans, beginning in the Late Deptford, freely experimented with other types of pottery, such as complicated stamped wares, but not the Santa Rosa ceramics like Basin Bayou Incised and Alligator Bayou Stamped.

Santa Rosa/Swift Creek ceremonialism is manifested in the Eglin region by the mound at 8WL14 and Marksville/Hopewell cultural interaction or influence. Additionally, there is the recovery of certain artifacts often associated with ritual practices, pipes being one example, three of which

were found at 8WL58. The ring midden configuration of Middle Woodland sites like 8WL58 may also imply ritualistic activity (cf. Bense 1992; Russo et al. 2009).

Case in point, burials in the plaza of the Bernath site (8SR986) in Santa Rosa County led Bense (1992) to suggest that ring middens may have been sociopolitical centers. The plazas of these middens were hypothesized to have served the social and burial needs of resident leaders. Although PTA did not identify any evidence of burials at 8WL58, much of the plaza was untouched by excavation so as-yet-undiscovered graves may be present. 8BY31 and 8BY1359 are sites respectively representing a mound and ring midden on Tyndall Air Force Base in Bay County. The mound was dated by Willey (1949) as Swift Creek and recently investigated by Russo et al. (2009), in conjunction with a nearby Weeden Island mound and ring midden at 8BY30 and 8BY1347, respectively. Burials were recovered by Moore from both mounds (Russo et al. 2009:31).

In contrast, 8WL36 was investigated more thoroughly by excavations and backhoe trenches during mitigation; no evidence of burials was found, and the data argue rather strongly against the potential for interments in the plaza area, which also lacked any evidence of midden. It may be that ceremonialism declined in late Santa Rosa/Swift Creek times so that ritual activity was less evident at sites of the Horseshoe Bayou phase. Alternatively, the waning of influence from Marksville and Hopewell in the later phase may have altered belief systems, burial traditions, and manifestations of ceremonial behavior or aspects of their cultural religiosity.

4.1.2.6 Weeden Island Culture

Remains of Weeden Island occupations are literally broadcast over the reservation and in the immediate areas outside of Eglin. Although coastal settlement continued, the interior patterns of distribution reflect a sharp change in land use from that evidenced by the occurrence of Deptford or Santa Rosa/Swift Creek sites.

The remains of Weeden Island culture can be expected in survey of nearly every area on Eglin. It is the best represented culture in terms of site frequency, has been studied in some depth and was once believed to be far better understood than the case now appears to be. Since the HPP was produced, considerable effort has been expended at Santa Rosa/Swift Creek sites and new data have been generated regarding Deptford chronology and settlement. The interpretations spawned by these data suggest archaeologists do not know as much about Weeden Island as they once thought.

The issue of chronology is a case in point. In the late 1930s, Willey and Woodbury defined two phases of Weeden Island, distinguished from one another on the basis of relative frequencies of complicated stamped versus check stamped ceramics. Willey (1949) later expanded his definition, characterizing Weeden Island I as a culture that continued to produce Swift Creek Complicated Stamped wares in addition to Weeden Island ceramics. Weeden Island II was characterized by a preponderance of Wakulla Check stamped pottery and plainwares and the disappearance of complicated stamped types (Willey 1949:396–397).

His definition basically held sway over archaeological interpretations for the next 25 years. In the 1970s, Percy and Brose (1974) defined five phases of Weeden Island for midden sites in the Apalachicola region. As outlined by Percy and Brose (1974:6), Weeden Island 1 is characterized by a few Weeden Island series incised and punctated types, such as Carrabelle Incised, Carrabelle Punctated, Keith Incised, and Weeden Island Incised, and a predominance of late variety Swift Creek Complicated Stamped. In Weeden Island 2 there is greater variety of Weeden Island types. Weeden Island 3 sees the introduction of Wakulla Check stamped and a slight decline in the importance of complicated stamped wares. In Weeden Island 4, complicated stamping disappears altogether, and Weeden Island 5 is characterized by a dominance of check stamping, a limited quantity of incised and punctated types, and a minor occurrence of corncob-impressed pottery.

In the HPP, Thomas and Campbell (1993) suggest that while Willey's (1949) scheme may have been too broad, Percy and Brose's (1974) phase sequence for midden sites may have been too narrow. White (1981:645) had earlier pointed out the difficulty in many cases in distinguishing between occupations dating to Weeden Island 1, 2, 3, 4, or 5 using the markers designated by Percy and Brose (1974). Using radiocarbon dates in combination with ceramic assemblage traits, archaeologists with New World Research, Inc. (NWR, Thomas and Campbell 1993) proposed alterations to the sequence. They examined the applicability of the sequences of Willey (1949), Percy and Brose (1974), and NWR's three-part sequence developed for the St. Andrew Bay region (Mikell et al. 1989; Thomas and Campbell 1985b). Again, however, it was based on the relative frequencies of certain ceramic types. Their analyses produced findings contradictory to traditional thoughts on the appearance of certain pottery traits. A main concern was whether ceramic type frequencies might have had less to do with temporal variation in emergent Weeden Island populations and more with form and function. If the form and function may have been more important than previously believed, it would cast doubt on the a priori assumption that sites dominated by Wakulla Check Stamped sherds were per force late.

On the issue of form and function over chronology, Fewkes (1924) was the first to notice that certain decorated pottery types were present in burial mounds, while village contexts were dominated by plain wares. Sears (1963) called the differential occurrence of pottery the sacred-secular dichotomy. The dichotomy was based on the belief that elite pottery, presumed to be more difficult and time-consuming to manufacture than plain wares or paddle-stamped ceramics, was produced by craftsmen. Examples of elite wares include finely incised, punctated, and painted decorations, along with applied effigies and other elaborate treatments.

The differential distribution of the elite versus utilitarian pottery at Weeden Island sites was taken to reflect variation in occupation by individuals of a higher social status versus the common folk. Russo et al.'s (2009) investigations at Weeden Island sites on Tyndall AFB in Bay County, Florida have examined the distribution of incised and punctated types to Wakulla Check Stamped, reviving the tripartite distribution of pottery recognized at the inland Weeden Island McKeithen site (Cordell 1984; Kohler 1978; Milanich et al. 1984). Russo et al. (2009) examined the distribution of Weeden Island ceramics at the Hare Hammock group, which included a Weeden Island mound (8BY30) and village ring midden (8BY1347). They discovered that plain wares and utilitarian decorated types occurred were rather well distributed in the ring midden, concluding that either the reliability of using elite versus utilitarian wares is not strong in ring

middens or the occupation at that mound and village was relatively egalitarian, although not ruling out the fact that ceramic types may still be better indicators of function than time.

Attribute analysis of ceramics, taking into consideration a sacred-secular dichotomy and what ceramic types in the study region constitute possible "elite" wares versus "utilitarian" wares is to be embraced if a clear understanding of not only Weeden Island chronology, but settlement patterns and dynamics are to be understood. For example, there are Weeden Island sites around steepheads along the margins of divides well in the interior of Eglin that have assemblages characterized by high quality incised and punctated types, but there appears to be no apparent ritual or function associated with these sites that could explain the presence of such high quality wares more consistent with mounds and villages near mound locations (Campbell et al. 2010).

The issue of ceramic function versus temporal implications will be ultimately sorted out by studies of assemblages from such sites as discussed above as well as comparison of the traits with absolute dates. A number of dates have been obtained, but their implication in terms of cultural variation over time hinges on the analysis of suitable-sized collections. That said, based on the dates alone, Weeden Island populations were in the Eglin area for a very long time. The village at 8WL13 produced dates that range from A.D. 15 to 395 (Thomas et al. 1995). 8OK174 yielded a calibrated radiocarbon date range of A.D. 1085 to 1315 (Thomas et al. 1995).

Turning away from chronology and to the differences evident in Weeden Island people's expanded use of Eglin, there is ample evidence of extensive cultural interaction among Coastal Plain populations, but the factors responsible for the marked changes in settlement and population increase during this time frame are not completely clear. Percy and Brose (1974) regard the trends as a reflection of the increased importance in horticulture. This is very likely a factor, although no direct evidence of horticulture has been documented on Eglin.

The types of sites represented by Weeden Island remains in the Eglin area include mounds, villages, hamlets, and camps. From the evidence accumulated to date, no marked change in community patterning appears through the period of Weeden Island occupation except for an increase in the number of sites.

Villages in the Eglin area are both large and small shell middens much like those described by Milanich and Fairbanks (1980). Several configurations characterize Weeden Island village middens, which have been confidently identified only in coastal settings in the study area. In many cases, the sites contain linear deposits that actually represent a number of small, overlapping, circular heaps of shell. Other villages are marked by horseshoe-shaped shell midden, which is a characteristic of Weeden Island as well as Santa Rosa/Swift Creek community patterning (Milanich and Fairbanks 1980). It is unclear if ring middens such as those found at Tyndall Air Force Base in the St. Andrew Bay area of Bay County are represented in the Weeden Island settlement pattern at Eglin. Certainly it is possible some of the seeming semi-circular middens on the shorelines may be the remains of eroded ring middens, an example of which is the predominantly Santa Rosa/Swift Creek site 8WL58 on Eglin's north shore of Choctawhatchee Bay.

Weeden Island villages on the interior appear to have been smaller, certainly not like the deep middens found in the Apalachicola-Chattahoochee-Flint river area described by Milanich and Fairbanks (1980). However, Weeden Island village sites on Eglin's interior are often strung out in semicircular fashion around springheads, a trend suggested by Milanich and Fairbanks (1980) as distinctive of the culture.

Weeden Island subsistence was broad-based, reflecting fishing, shellfish collection, and gathering (Thomas and Campbell 1993). Fish remains indicate these Late Woodland populations were taking full advantage of the bay, sound, and Gulf. Represented in the collections are boney fish, herring, saltwater catfish, sea catfish, jack, porgies, sheepshead, mullet, flounder, bowfin, drum, and gar. Shell middens indicate a preference for oysters, although conch, *Rangia* and other species may be minor constituents. One site on the barrier island, 8OK151, even produced crab remains (Thomas et al. 2008b).

Vertebrate faunal remains in Weeden Island collections include white-tail deer, unidentified mammal, unidentified avian, freshwater turtle, and pond/cooter turtle. Acorns and hickory nuts were actively collected as were various plant species, such as yaupon, wild grape, edible palmetto shoots, and gallberry, which attract bees. Today, gallberry honey is prized for its rich taste and resistance to granulation (i.e., it keeps well) and palmetto honey is considered a gourmet product. At the present time, there is no evidence of agriculture by Weeden Island groups on Eglin.

Ceremonialism is represented by the ritual mound burial tradition, which reached its peak in the Eglin area during Weeden Island times. Milanich and Fairbanks (1980) observe that it is only in northwest and north Florida that patterned burial mounds with east-side deposits are observed. Within the Eglin area there are 15 Weeden Island mounds, two of which are on Eglin proper (8WL13 and 8OK85). One of these, 8WL13, has an extensive village that could be a ring midden (Thomas et al. 1995); it has not been investigated sufficiently to make the determination.

4.1.2.7 Fort Walton/Pensacola Culture

The Eglin project area, like much of the northern Gulf Coast, witnessed a replacement of Late Woodland culture (Weeden Island) by the Fort Walton and Pensacola Mississippian culture variants no later than A.D. 1200 and probably somewhat earlier. As Tesar (1980b), Brose and Percy (1978), and others have pointed out, a general Weeden Island sand-tempered ceramic tradition appears to metamorphose into Fort Walton in both the Choctawhatchee and St. Andrew Bay areas without much evidence of an evolutionary transition. While this is probably not entirely true and does not argue for instantaneous Mississippianization or invasion, there is no clear evidence to characterize the period of 200 to 300 years of late Weeden Island to Fort Walton transition. Knight (1984) also points out that the transition lacks clarity for the Pensacola variant. If a Terminal Weeden Island phase can be recognized, the transition may be better explained.

The late prehistoric culture of northwest Florida had at least two regional expressions: Fort Walton and Pensacola. Fort Walton and Pensacola share traits with each other as well as with other Southeastern Mississippian groups. Willey (1949) defines the Fort Walton culture and

appends the Pensacola ceramic series to it. However, investigations have demonstrated that Fort Walton and Pensacola are distinctive expressions, or variants, of a more generalized Southern Mississippian cultural development. Artifact assemblages, mound and community settlement system patterns and behavioral norms inferred from the archaeological data "leave no doubt they were Mississippian peoples with social and political systems that were more complex than those that had previously evolved in northwest Florida" (Milanich and Fairbanks 1980:193).

In terms of ceramics, Fort Walton is generally characterized by distinctively incised and punctated as well as plain grit- and/or sand-tempered pottery found in both coastal and inland riverine sites (Willey 1949:452–488). The Pensacola variant (Fuller 1985; Fuller and Stowe 1982; Stowe 1985) is distinguished from Fort Walton by its shell-tempered decorated and plain ceramics (Willey 1949) that dominate assemblages with minor sand-tempered components (Fuller and Stowe 1982).

Both Fort Walton and Pensacola series pottery are found at sites in the Eglin area. At some of the sites on base only a few sherds were recovered; these are little more than occurrences of minimal interpretive value. The remaining sites, however, provide useful data. While many of the sites also exhibit evidence of earlier prehistoric occupations, several are single-component sites.

The most striking aspect of the settlement distribution is the resurgent selection for coastal locations to the almost complete exclusion of interior settings. This pattern of distribution represents a marked departure from that seen during the Weeden Island occupations. Very few sites are located well into the interior, although a few are found on the Yellow River, at the headwaters of south-flowing tributaries or on creeks at settings inland from Choctawhatchee Bay.

The village plan of Fort Walton/Pensacola sites is documented by Lazarus (1971:45) in his overview of areas west of the Apalachicola River. The principal type of village in the area of Choctawhatchee Bay is represented by 8WL51, an off-Eglin site on the west side of Hogtown Bayou, which he describes as "...six or seven small midden piles of shell ...arranged in a pattern" (Lazarus 1971:45). The data from the Eglin study are consistent in that almost all major villages are characterized by accumulations of shell that are deposited as individual heaps.

Major villages were likely occupied year-round by at least limited populations, while the smaller hunting, gathering, and horticultural loci were occupied seasonally by only small groups. If horticulture was an economic concern, it may have occurred only at small, scattered sites where arable soils were present (Larson 1980:206–219) or it may have occurred at both small sites and near villages, as well.

Smaller Mississippian coastal sites on Eglin are less intensively utilized and non-nucleated. These could represent dispersed households and resource exploitation or special function sites (camps). Examples of probable coastal hamlets have been found at a number of sites and there are others in the interior that may be the remains of hamlets. Camps may be related to population fissioning and dispersal on a seasonal or periodic basis. As with Curren's (1976) and Larson's (1980) models for late prehistoric coastal subsistence adaptations, the Eglin settlement system implies that there was a scheduled population movement both between villages and smaller sites

and likely between villages themselves. These population movements must have been scheduled to take advantage of optimal exploitation conditions.

Although there were fewer mounds than in Weeden Island times, there is clear evidence of ceremonialism in Fort Walton/Pensacola culture. Six Mississippian mounds exist in the Eglin area, although none occur on Eglin proper. The mounds contain a variety of Fort Walton/Pensacola ceramics. The most impressive of the mounds is clearly 8OK6, the Fort Walton Temple Mound, a large platform mound that measures 12 ft in height, 223 ft by 220 ft at the base and 90 ft by 150 ft at the summit (Florida Master Site Files, n.d.). Over 80 burials are reported to have been interred in the Fort Walton Temple Mound; it must have been a regional center of Fort Walton/Pensacola activity. The site has been the subject of several investigations that have produced evidence of multiple burials, shell and bone tools, shellfish, and vertebrate fauna, lithics, and mica.

In addition to the mounds, four Mississippian cemeteries are located in the study area, although, again, none are found on Eglin proper. The cemeteries occur in areas of Fort Walton/Pensacola site concentration, although no cemetery accompanies the concentration of sites at the Narrows where the Fort Walton Temple Mound was constructed. The cemeteries contain human burials and grave goods, most notably a number of ceramics. Although not confirmed as a cemetery, Eglin forest rangers have reported that a burial was uncovered at 8SR17 on East Bay, a site that produced a pipe from a shoreline collection effort by Eglin CEVSH personnel.

Mikell (1990) compiled radiocarbon dates to develop two phases. Mikell's (1990) formulation of phases is based on the increasing frequencies of Pensacola series pottery in Late Fort Walton sites. The Indian Bayou phase sites are dominated by Fort Walton series pottery with small frequencies of Pensacola series sherds. The Four Mile Point phase is characterized by relative frequencies of Pensacola pottery that range from around 30 to 40 percent to as much as 70 percent of the collections. Examining the ceramic assemblages from area sites and radiocarbon dates, Mikell (1990) was able to place Choctawhatchee Bay area sites into one of the two phases. The phases were initially supported by data from Eglin (Thomas and Campbell 1993), but as more large-scale excavations take place, there are indications the relative percentages of different tempering may not be as meaningful as once believed. What is required is an attribute analysis of some detail from a sample of Fort Walton/Pensacola sites that also have produced absolute dates from sealed proveniences. 8WL68 may provide some information to advance this topic as may 8WL119, both on Eglin property (cf. Thomas et al. 2008a; Campbell et al. 2008b).

4.1.2.8 Historic Period

The reconstruction of historic developments in the Eglin region represented in Thomas and Campbell (1993) is extremely detailed and based not only on the archaeological work, but an exhaustive review of documents, archives, and old maps; as such, it cannot be summarized adequately here. The discussion below provides some of the highlights, but the reader is again referred to the Eglin HPP (Thomas and Campbell 1993) for a thorough presentation.

4.1.2.8.1 Contact and Colonial Eras

At the time of contact with Europeans, the Fort Walton/Pensacola culture was flourishing in the areas around Choctawhatchee and East bays. Although the historic tribal identity of these populations is not known, the Pensacola and the Chatot may have been their descendants. They were joined by the Yuchi (or Chicsa as some refer to them) by 1639. These tribes lived in the region until the early eighteenth century when many of the Chatot and Pensacola began to migrate westward after the destruction of the Spanish missions in Florida. Possibly some remained with the Yuchis, who, with other Creek allies like the Seminoles, continued to live in the area until the early nineteenth century. The Seminoles remained until they were expelled during the Second Seminole War. There is also oblique reference to a group of Louisiana-based Coushatta living in the area sometime during the nineteenth century.

There is little documentation to suggest that the Spanish explorers made much of an attempt to explore or, much less, settle the area. Most of the evidence indicated the Spanish were focused on the Pensacola Bay area. None of the early explorers' maps illustrated the Choctawhatchee or Yellow rivers. In the 1690s, Dr. Carlos de Siguenza y Gongora submitted an initial evaluation of Pensacola Bay and its surrounding area to the Viceroy of New Spain and in the preparation of this evaluation, the expedition had mapped Pensacola Bay, showing the mouths of both the Yellow and Blackwater rivers, in addition to identifying encampments on East Bay, but outside of the Eglin area.

Chronicles of the maritime contingent of the next expedition did, for the first time, describe Santa Rosa Island and East Pass and mentioned the bay and river on the other side. This expedition, documented by Captain Francisco Mila Tapia, was composed of a small fishing smack with a crew of 14 seamen, seven infantrymen, and two Native American pilots who reportedly arrived at east pass on June 28, 1693.

The next detailed discussion of Choctawhatchee Bay, Santa Rosa Island, and the coastline was made in 1699, not by the Spanish, but by a Frenchman, Pierre Lemoyne, Sieur d'Iberville. At the time, the French were seeking to link their Canadian provinces to the Gulf of Mexico through the Mississippi and claim the intervening lands. The accounts made reference to East Pass as *Cape Blanc* (white cape) and the Choctawhatchee River as *Riviere des Indios*.

There is no documentary evidence that the French, during their tenure in Pensacola, ever settled on Eglin property. Throughout the exploration and colonial period, the Spanish, French, and British all focused their activities on Pensacola. However, a major Native American trading path has been reported as crossing land now encompassed by Eglin and having been extensively used by members of the Creek Confederacy. The path's route would have taken it into the Tallahassee area, where secondary well-traveled paths connected to St. Augustine. The possibility exists that, because of the continued troubles with the Creeks and Seminoles, the Spanish did not view the path as a secure overland route. This may be one reason for the seeming avoidance of the Eglin area. The precise location of this route is not known.

However, while there is more extensive evidence of occupation in the Pensacola area, there is one site from the British colonial period that has been identified on base. Recent testing

investigations at 8SR1251 revealed a historic home site dating to the period of British occupation of northwest Florida between 1763 and 1781 (Thomas et al. 1995). This site on East Bay produced evidence of two structures as well as a button from the 16th regiment of foot, a British military unit assigned to Pensacola from 1767 to 1776. This site represents the only known British period occupation yet identified on Eglin property.

In addition, well-known British and American naturalists did describe the interior lands and water courses now encompassed by Eglin. First, in 1775, Bernard Romans journeyed through the region, describing the country between the Yellow River and the Apalachicola as favorable for cattle.

In 1783, Thomas Hutchins traveled up both the Yellow and Choctawhatchee rivers. He noted aspects of the rivers channels, vegetation, and soils, but with the exception of one comment about an aboriginal settlement on the Choctawhatchee River, there is no mention of area inhabitants—whether by omission or lack of presence is unknown.

The waning years of the last Spanish colonial administration in west Florida were fraught with conflict. Though Spain retained control of west Florida east of the Perdido River until 1821, twice in the 10 years prior to that date Andrew Jackson occupied Pensacola, first in 1814 and then in 1817. While the route of his 1814 campaign has been attributed to the route of the so-called Military Road, which crosses what is today Eglin property, documentation indicates that his troops skirted to the north of the Yellow River, approaching Pensacola from the northeast rather than the southeast.

4.1.2.8.2 Pioneer Period

In the early years of the nineteenth century, classified as the Pioneer Period, settlement in the Eglin area was restricted because of the lack of good roads. Although the Military Road and the other paths enabled some east-west movement, they were narrow and poorly maintained. Despite profound problems associated with land transportation, which hindered interior settlement well into this century, settlement did occur. Most of the settlers lived near the coastline or along the deeper creeks and drainages such as Alaqua, Choctawhatchee, and Yellow rivers. By the late 1830s, there was also a small settlement at East Pass in the location of present-day Destin.

This settlement, however, can be characterized as sparse and isolated. The settlers were initially oriented toward agriculture, but the soils present over much of the Eglin area are not suitable for large-scale agricultural production. The bottomlands along the Alaqua and Yellow rivers were, however, engaged for the cultivation of vegetables, and outside of the Eglin area near eucheeanna, cotton and sugarcane were produced.

Although not as important before the Civil War as after, lumbering was a major economic enterprise. As early as 1838, the Forsyth and Simpson Company (later the Bagdad Land and Lumber Company) established the Arcadia and Blackwater Railroad northwest of Eglin on the Blackwater River. Within the Eglin area, sawmills were also present, but the lack of roads hampered the movement of timber out of the interior and there is no evidence that any locations on Eglin were serviced by the above railroad. In many instances the timber was dragged by mule

to the nearest principal stream where the logs were lashed together and floated raft-like to coastal embarkation points. Where creeks were of insufficient width or depth to handle a raft structure, the logs were free-floated individually. Because of the restrictions to transportation, timbering was limited to the vicinities of the larger and deeper streams and creeks.

There were, however, no such restrictions on stock ranching. In the years before the Civil War, between 1840 and 1860, the business of cattle ranching was a major enterprise in the Eglin area. The cattle were range-fed and then herded to markets in Pensacola, Florida; Mobile, Montgomery, and Eufaula, Alabama; and Columbus, Georgia.

Despite the close ties maintained with southern Alabama from the early 1830s through the post-war years, the Eglin area suffered virtual isolation; this situation was little altered by the events of the Civil War. In fact, Walton County had very few slaves, voted against secession, and refused to sign the articles of secession. As a result, Walton County was branded as "Lincoln County" by the secessionists; once the fighting war started, a militia company called the Walton Guards was established. Their first assignment was to establish a post on the narrows of Santa Rosa Sound, Camp Walton, to prevent enemy passage through the East Pass and the sound to Pensacola. Although no major battles took place in the Eglin area, there were skirmishes between the confederate and union soldiers; one took place at the narrows.

Sites dating to the pioneer period on Eglin are far fewer in number as compared to later historic sites. The majority of these are homesteads; one permanent mill, Milligan's mill, 8OK97, has also been described and its dam documented (Thomas and Campbell 1993).

4.1.2.8.3 Rural Industrial Expansion Period

During the Rural Industrial Expansion period, after the Civil War, the growing importance of Southern forest resources and the coming of the railroad led to large-scale settlement of the region. The Eglin area supported huge tracts of longleaf pine that could be exploited for lumber. Organized communities developed at Milton, Marianna, Crestview, Niceville SE, and DeFuniak Springs, north or northwest of the base, Destin, Mary Esther, Camp Walton, Freeport, and Niceville (i.e., Boggy), south of the base, and Howell, Holley, Bolton, and New Home (i.e., Shaw's Still), within or partially within what was to become Eglin property.

In order to accommodate the demand for timber and naval stores and to support general growth in the area, it was necessary that some form of adequate transportation be introduced. The need was partially met by the Pensacola and Atlantic Railroad, constructed between 1881 and 1883. The railroad skirted what is now Eglin, running along the north side of the Yellow River-Shoal River-Titi Creek channel. By 1887, timbering and its associated activities, such as turpentine extraction, became the mainstay of the local economy.

Though the transport of products from the interior was still hampered by the limited rail lines and the generally poor quality of the local roads, major sawmill and turpentine camps were developed within the area between the mid-1890s and the 1910s. Included were the Metts Turpentine Camp, Bolton Lumber Company, Garnier Turpentine Company, and the Milligan Lumber Company.

In the decades following 1900 when turpentining was at its peak, the industry was undergoing a transformation as new collection cups and gutters replaced the primitive wooden boxes previously used to collect pine resin. However, the story of pine extraction in the Eglin area cannot be told without reference to the origin and subsequent development of the Choctawhatchee National Forest, which was the direct precursor to Eglin.

In 1906, the Federal government regained jurisdiction over the patchwork of lands that had been leased to private concerns by the State of Florida and the railroad companies. These lands were those that had remained undeveloped over the years. They were the basis of the Choctawhatchee National Forest, established by presidential proclamation by Theodore Roosevelt in November of 1908.

For the first time, many of the timber and turpentine extraction companies and private entrepreneurs came under the jurisdiction of a controlling agency, the United States Forest Service (USFS), whose summer headquarters were located on Garnier Bayou at Camp Pinchot, now on Eglin. Though conservation practices, including reforestation, reseeding, and controlled cutting, were not common until the 1930s, USFS officials tried to limit and control the timber and turpentine industries to some extent.

However, both industries persisted throughout the early twentieth century. In particular, the naval stores industry in northwest Florida became more competitive when companies switched from the destructive box cut method to the cup and gutter method for collecting resin (Mikell et al. 2003). Another improvement involved decreasing the depth and width of the cuts or streaks on pine trees (Dyer n.d.:16–17; Thomas 1975:5).

The turpentine industry owed the cup and gutter collection method to Dr. Charles H. Herty, a chemist at the University of Georgia whose 1901 research near Ocilla, Georgia in 1901 resulted in him making the statement that “turpentine gathering as now conducted in the United States, is needlessly destructive of the forests and needlessly wasteful of the product” (Herty 1903:9).

Herty created a simplified cup and gutter system based on a model in use in France, and the result was a decrease in forestry expertise and labor (Reed 1995). Herty’s first system used two v-shaped galvanized iron gutters to collect the rosin, and eventually he patented a ceramic cup (Reed 1995; Butler 1998). The use of the cups prolonged the life and productivity of turpentine trees, which in turn extended the life of the naval stores industry in the region and their competitive position. According to Martin (1942), as late as 1919, 25 percent of the Georgia turpentine producers had not switched from the box-cut system, whereas operators in the Eglin region were quick to adopt the new Herty methods, gaining an immediate technological advantage over their competitors.

The extended life of turpentine trees kept the timber industry in business as well, and evidence is found in the archaeological record in the form of saw mills and associated transportation corridors. Other evidence of the Rural Industrial Expansion Period on Eglin include homesteads, mills, turpentine side camps, naval stores industrial complexes, commercial enterprises, bridges, shipwrecks, roads, and cemeteries among others.

4.1.2.8.4 Military Proprietorship

The period of Military Proprietorship had its roots in the initial utilization of the Eglin area as early as 1931; through the 1930s the military presence increased. In 1931, the Commanding Officer of Maxwell Field, Alabama initiated action to obtain a portion of the Choctawhatchee National Forest to be used as a gunnery and bombing range for the Air Corps Tactical School, which was moved from Langley Field, Virginia later that year. In 1935, a local entrepreneur, James Plew, donated 137 ac for an auxiliary field and 1,460 ac for a bombing and gunnery range. The range was named Valparaiso Bombing and Gunnery Base.

In 1937, Valparaiso Bombing and Gunnery Base was renamed Eglin Field after Colonel Fred I. Eglin of Maxwell Field who died in an air crash (Angell 1989). Initially the facilities were limited, but political events in Europe and the Pacific led the War Department to seriously consider the military potential of the area. As hostilities grew in the late 1930s, the need for a large base to test and develop a host of new weapons and munitions was an important priority, and the vast contiguous acreage of the Choctawhatchee National Forest was seen as a logical choice.

In 1939, the Plans Division of the Office of the Chief of the Air Corps recommended that the War Department acquire the lands encompassed by the Choctawhatchee National Forest. Correspondence concerning the potential transfer indicates that the USFS acknowledged the necessity of the transfer. From the inception of the plan for the initial transfer until its completion on June 27, 1940, under Public Law 668 (76th Congress), the USFS and the War Department worked in close association in order to smoothly handle the transition. Once the transfer was official, all homesteading within the forest came to an abrupt end. The residents were removed, and a military pattern of settlement was ushered in. Auxiliary fields and testing and target ranges were designated, and the construction of military housing and base facilities began.

During World War II, Eglin was designated as an Air Corps Proving Ground and played a primary role in the testing of new weapons and tactics. Initial priorities involved testing of aircraft suitability and methods of ordnance delivery (Angell 1982). One of the first concerns was to produce aircraft that could compete with the agile Japanese Zero. Eglin's part in this was to trim the weight of existing fighter models (Kessler 1982 Part 2:5).

Another priority was climatic testing of aircraft since America was involved in a global war and aircraft would potentially be subjected to a range of climatic extremes, from Arctic conditions in Alaska and deserts in the Middle East to tropical rain forests in the Far East. The gathering of data from these areas, climatic testing of machines, development of adaptive equipment, and the expedient acclimatization of personnel were critical to the successful completion of missions in these regions. To accomplish this task, the Arctic, Desert, and Tropic Information Center was established at Eglin in late 1942 (Kessler 1982 Part 2:7–11). This center served as a clearinghouse for data and was responsible for the testing of machinery used in warfare in extreme climates.

In June of 1943, the Japanese conducted a feint attack on the Aleutian Islands as part of the Midway operation. The Arctic, Desert, and Tropic Information Center at Eglin collected and

supplied data to this theater. Moreover, the cold weather testing unit stationed in Alaska was transferred to Eglin in 1943, and plans were made for a climatic testing hangar, which was completed after the war (Kessler 1982 Part 2:26–27).

Eglin was also a training site for Lieutenant Colonel James Doolittle and his Special Aviation Project No. 1, which was the historic air attack on Tokyo. The Doolittle raid was one of the few positive events in the first year of U.S. involvement in World War II, securing a venerable place in the history of Eglin, the Air Force, and the entire country.

As the strategic bombing offensive in Europe was gearing up, Eglin completed testing of six heavy bombers and began experimenting with electronic warfare equipment. Final tests of the B-17, which was to comprise the main arm of the heavy bomber strike force in Europe, were completed, and evaluations of the B-29, which was to excel in the Pacific Theater, were initiated. Electronic warfare techniques, such as radar and radio beam target acquisition, were becoming increasingly important to air operations, both offensive and defensive, and would play a major role as the war progressed. In response to this need, the 1st Proving Ground Electronics Unit began in February of 1943 to test and develop equipment and tactics. These were code named the "Florosa Project" because of their proximity to that town a few miles west of Hurlburt Field, which was utilized expressly for this purpose (Kessler 1982 Part 2:26–58). Hurlburt Field was then Eglin's Auxiliary Field #9. It was then and is now a separate entity from Eglin and is designated as an Air Force Special Operations Command.

Another project conducted at Eglin during 1943 was the development of tactics to surmount the German beach defenses of Western Europe. A full-scale model of beach defenses was constructed for this purpose, including underwater and above-water obstacles, mines, and wire. This mock-up was attacked with several types of ordnance delivered from aircraft and underwater demolition teams to determine the most expedient means of breaching these defenses (Kessler 1982 Part 2:29). These tests resulted in tactical changes that were successfully executed in the assault on Normandy's beaches the next year.

Eglin was also called upon to devise efficient tactics for destroying the sites of Hitler's Vengeance or "V" weapons, generally called the V-1 and the V-2, and in the testing of similar devices. The V-1 was essentially a cheap, crudely guided, jet propelled missile that was the forerunner of today's cruise missile. The V-2 was a liquid fueled rocket bomb. The Proving Grounds' experience with the destruction of missile sites began with Operation Crossbow in December of 1943. The name "Crossbow" was a code word referring to Anglo-American operations against all phases of the German long range weapon program in World War II. It was a far-reaching, top priority project of the Allied forces that involved both the evaluation of tactics for the elimination of V-1 and V-2 launching facilities and concurrent research and development of similar models for Allied use. As early as January 1944, Eglin began construction of a full-scale replica of V-1 launching sites. These sites consisted of a long launching ramp, thick concrete bunkers to protect the missiles, a fuel depot, and quarters.

During training runs, the mock-ups were attacked by over 1,200 sorties of heavy bombers, medium bombers, and fighter bombers from varying altitudes and approaches. Attacks by P-47s

were found to be the most accurate and effective, and this tactic was later successfully utilized in Europe to deal with this very serious threat (Kessler 1982 Part 2:31–33).

By late 1944, the Proving Grounds were also engaged in the development of U.S. versions of the V-1 as part of Operation Crossbow (Project MX-544). The primary mission in this respect was the evaluation of performance and experimentation with launching techniques. The U.S. version, the JB-2 (Jet Bomb), was essentially a clone of a captured, ground-launched V-1, and the first production in the guided missile group of weaponry (Kessler 1982 Part 2:75). In all, 598 service tests were completed during 1944 and involved 705 officers and 7,615 enlisted men (Kessler 1982 Part 2:59–60, 30).

By mid-1945, JB-2 launches were routine and a squadron was created to deliver the U.S. version of these weapons to Japanese targets from the Philippines. However, the war ended before this weapon could be utilized. Other projects undertaken by the Proving Grounds in 1945 included the suitability testing of six fighter aircraft, the RAZON (RAnge AZimuth ONly) radio-controlled bomb and cold water exposure tests. The RAZON bomb was the precursor to the GBU-15 laser-guided "smart" bomb, which was also developed at Eglin.

During this time, construction began on the massive cold weather testing hangar, with construction authorized in 1944 and completed in 1947. The research, design, and development of the climatic laboratory were an outgrowth of the Arctic, Desert, and Tropic Information Center established in World War II.

In July of 1953, the Air Proving Ground Command reorganized to establish the Air Force Operational Test Center. The center was charged with the responsibility of conducting operational suitability testing for the command. Colonel Paul W. Tibbets, Jr., under whose command the atomic bomb had been dropped on Hiroshima from the Enola Gay during the waning days of World War II, was named commander of the test center. During the 1950s, Eglin was involved in the suitability of several missiles, including the Atlas, Titan, BOMARC (named for Boeing and University of Michigan Air Research Center, where this missile was developed), Snark, Genie, and Rascal types (Massoni 1989:35).

In the 1960s and 1970s, a new generation of advanced technology weapons systems and tactics were tested at Eglin. Suitability tests were made on the AIM (Air Intercept Missile), AMRAM (Advanced Medium Range Anti-aircraft Missile), Hell Fire, and various models of cruise missiles and the laser guided smart bombs, to name a few (Massoni 1989). During the Vietnam War, Eglin became the home base for the 33rd Fighter Wing, and the role of Hurlburt Field was greatly increased from its beginnings as an auxiliary field used in conjunction with the electronic warfare tests (Florosa Project) in the 1940s.

During the 1970s, Eglin was a key operative in a number of memorable events. Training for the unsuccessful raid on Son Tay, a suspected prisoner-of-war camp in North Vietnam, took place in the northern part of the reservation and included production and practice assault on a scale model of the camp. The 1970s also witnessed the dedication of the climatic laboratory, which was named the McKinley Climatic Laboratory in honor of Colonel Ashley C. McKinley, a pioneer in climatic research who was instrumental in the development of the laboratory in the 1940s.

In recent years, Eglin has continued testing military hardware, including the B-1B Bomber and the F-117 stealth fighter. The base provided humanitarian aid in the form of temporary housing to Vietnamese refugees in 1975 and Cuban refugees in 1980. The training of the Nicaraguan Contra rebels at Hurlburt Field in 1988 resulted in a series of demonstrations by dissenting factions.

The base has also played an important role in recent military events. Units from Eglin and Hurlburt were involved in the aborted Iranian hostage rescue attempt in 1980, the Panamanian campaign in 1989, Desert Shield in 1990, Desert Storm in 1991, Restore Hope in Somalia in 1992, Southern Watch in Saudi Arabia in 1992, the Hurricane Andrew relief effort in 1992, Uphold Democracy in Haiti in 1994, the Bosnia effort in 1996, and most recently, Operation Infinite Justice in Afghanistan and Operation Iraqi Freedom (Eglin Air Force Base history fact sheet).

Today, troops from Eglin are deployed throughout the world, working as part of a global force to fight terrorist threats, to liberate suffering populations, and to continue peacekeeping efforts. The forces are also working to bring medical supplies, food supplies, and education to other countries so the leaders of those nations can provide ultimately for their own populations and take a stronger role in the global community. At home and abroad, in partnership with associate units, Eglin's missions cover the complete weapon-system life-cycle from concept through development, acquisition, experimental testing, procurement, operational testing and final deployment in combat.

4.2 SITE LOCATION AND HISTORY: FORT DRUM

Fort Drum is under the jurisdiction of the U.S. Army Installation Management Command (IMCOM), Northeast Region and is located in upstate New York. Camp Hughes, the precursor to Pine Camp, was established at Felt's Mills (and partially on what is now the Fort Drum Cantonment) by the New York National Guard between August 31 and September 7, 1907. The cavalry returned the following year, establishing an encampment on the Hogsback north of the Black River. It was first established as a military reservation in 1940 during the mobilization run up to World War II. Pine Camp became Camp Drum in 1951, named after Lieutenant General Hugh A. Drum who commanded the First Army during World War II. During and after the Korean Conflict a number of units were stationed and trained at Camp Drum to take advantage of the terrain and climate.

The post was designated Fort Drum in 1974, and a permanent garrison was assigned. In January 1984, the Department of the Army announced it was studying selected Army posts to house a new light infantry division. On September 11, 1984, the announcement was made that Fort Drum would be the new home of the 10th Light Infantry Division. The first division troops arrived at Fort Drum on December 3, 1984, and the unit was officially activated on February 13, 1985. The name was changed to the 10th Mountain Division (Light Infantry, LI) at that time.

The division reached full strength in 1989. Between 1986 and 1992, 130 new buildings, 35 mi of roads, and 4,272 sets of family housing units were built at a cost of $1.3 billion. The mission of the 10th Mountain Division (LI) is to be manned and trained to deploy rapidly by air, sea, and

land anywhere in the world, prepared to fight upon arrival and win. Today, Fort Drum consists of 107,265 ac. Its mission includes command of active component units assigned to the installation, provide administrative and logistical support to tenant units, support to tenant units, support to active and reserve units from all services in training at Fort Drum, and planning and support for the mobilization and training of almost 80,000 troops annually.

4.2.1. Site Location and Characteristics

Fort Drum is located in northwestern New York, east of Lake Ontario, north of the Tug Hill Plateau and in the western foothills of the Adirondack Mountain region (Figure 4-5). The reservation encompasses portions of Jefferson and Lewis Counties and is entirely in the Ontario-Saint Lawrence drainage basin. Glacial push, melt-water deposition, and isostatic uplift are the primary factors that shaped the region's current landscape during the final phase of the last ice age (Figure 4-6). Much of the northern U.S. was covered by continental ice sheets that flowed southward from eastern Canada in four major periods of glaciation within the past two million years. According to current information, the final retreat of glacial ice-sheets during the Wisconsin Stage around 12,500 years ago in New York marks the first entrance of people into this part of North America.

Figure 4-5. General location of Fort Drum in upstate New York, east of Lake Ontario.

Figure 4-6. Fort Drum topography and vegetation.

The Pleistocene Epoch, which began about 1.6 million years ago, was the last of the Earth's four glacial periods. Glacial progression in the final stage of the Pleistocene is referred to as the Wisconsin advance in northeastern North America. This stage reached its maximum in New York State about 21,750 B.P. This advance covered virtually all of New York State and the northeastern portion of Pennsylvania, effectively erasing most of the pre-Wisconsin landscape. By 10,000 B.P., the ice advance retreated northward into present day Canada. The retreat released millions of gallons of melt-water, which further altered the landscape. Icebergs and glacial debris dammed valleys and formed large glacial lakes. As the blockades diminished, many of the lakes drained and rebound caused the shorelines to rise.

The ice mass that encompassed New York State was termed the Laurentide. It began in the Quebec uplands and Labrador and progressed southward to the central section of Long Island, northeastern Pennsylvania and the Salamanca Re-entrant in southwestern New York State. This glacial progression is complex and the term ice sheet is rather ambiguous. The Laurentide advance was not a homogenous event. Rather, multiple ice streams or lobes migrated in many different directions including from south to north on occasion. These lobes advanced and retreated seasonally and regionally during the terminal phase of the Pleistocene epoch and had comprehensive variations depending on ice thickness, annual climatic conditions and elevation.

Obviously, a comprehensive geomorphological study is needed to truly understand geological features at Fort Drum. However, in the meantime, GIS modeling and cultural resource surveying has identified several geological formations that may contain data regarding the higher elevation sands of the northern Pine Plains region. Understanding these geological features and their associated landforms is proving to be critical for predicting prehistoric site locations.

A number of known Paleoindian archeological sites along fossil beaches of the glacial lakes in the Great Lakes region indicate that human occupation began immediately as the glaciers were

melting. Contour lines following the fossil beaches at Fort Drum have proven to be an excellent predictor of archeological site locations.

Pollen data indicate that a warming trend prevailed throughout the Holocene over most of North America (e.g., Antevs 1955; Bryant and Holloway 1985). Climates in this area have changed considerably over the past 10,000 years, and have had significant influences on the distribution of plant and animal species as well as human behavior. Analysis of pollen samples collected during the 1999 field season may provide new insight into past environments on Fort Drum.

Fort Drum lies within the Canadian Biotic Province is made up of four physiographic regions or zones. Oak and white pine forest/grassland mosaics characterize the landscape of the Pine Plains zones (Figure 4-7). Sand erosion subsequent to deforestation has resulted in dune formations and blowouts in the Pine Plains area as well. The Upland zone contains coniferous and deciduous oak hickory forest, with marshes and perennially and seasonally inundated palustrine wetlands (Figures 4-8 and 4-9). The Lake Plain zone consists of intermittent wetlands and scrubland (Figure 4-10 and 4-11). Early Holocene climates supported white spruce, balsam fir, jack pine, paper birch, and aspen. As climates warmed, those that were more tolerant of warmer climates replaced these plant species. Today, red oak, hemlock, hickory, and chestnut dominate the forest landscape (Isachsen et al. 1991). The riparian and lacustrine habitats of the Black and Indian Rivers and lakes and wetlands would have provided an important source of food resources such as fish and aquatic plants to native populations (U.S. Army 1997). White-tailed deer are abundant in areas around Fort Drum and would have provided a primary large-game resource to native inhabitants. Other economically important resources also consisted of fur bearing mammals and waterfowl. Economically important plant food resources probably included knotweed, goosefoot, raspberries, blueberries, acorns, beechnuts, huckleberries, blackberries, Indian cucumber root, leeks, and skunk cabbage.

Figure 4-7. Typical Pine Plains environment and vegetation within Fort Drum. This landform is a sand delta from the proto-Black River when the Pleistocene-age lake shore was at the Frontenac level, ca. 11,000 years B.P.

Figure 4-8. Typical setting of an upland terrace site on Fort Drum.

Figure 4-9. Typical upland terrace site on Fort Drum.

Figure 4-10. Intermittent wetlands and wetland vegetation within Fort Drum.

Figure 4-11. Typical Lake Plain scrubland environment within Fort Drum.

4.2.2. Culture History[6]

4.2.2.1 The Paleoindian Complex

The earliest dates for the first Americans in the Northeast are controversial. The deepest feature at the Meadowcroft Rockshelter in western Pennsylvania has produced dates of more than 17,000 B.P., 6000 years earlier than the most accepted date. Once thought to be spurious findings or the results of poor excavation controls, the Meadowcroft chronologies are receiving strong support from recent site excavations at the contemporaneous Cactus Hill site in Virginia and South Carolina's Topper site (Anderson 2000). These sites are beginning to produce assemblages that hope to characterize early Paleoindian or pre-Clovis horizons in the Northeast and, equally, they have the potential to demonstrate settlement patterns continentally.

The 1999 Fort Drum cultural resource survey recovered a single artifact from site FDP 1146 that has the potential of representing a pre-fluted projectile point horizon. A residual core found in the second and third glacial interface was submitted to the Holland Lithic Laboratory for analysis. It was determined to be a bipolar quartzite core with further analysis pending. This discovery is significant for two reasons. First, quartzite blades seem to be an important component at Topper and Cactus Hill. Second, although found in a surface context, two fluted projectile points were recovered well above the glacial interface in a landform identical to the one where the core was discovered. As a result, there is a possibility that the core could predate Clovis context materials on Fort Drum.

Paleoindian culture in the Northeast is traditionally recognized as spanning from 10,800 years ago to approximately 9000 B.P. An exception would be the Saint Lawrence Valley where occupation continued until approximately 8,000 years ago (Dincauze 2000). Diagnostics for the earliest phase of occupation in this region date between 10,800 B.P. and 10,500 B.P. Concave fluted points known as Gainey and Bull Brook are found north of Pennsylvania. In the far north, Nova Scotia to Vermont, Debert and Vail types are found, having an extremely deep concavity. Shoop style points prevail as the dominant early type in the Middle Atlantic States, while the somewhat later (10,500–10,100 B.P.) Barnes, Parkhill, and Neponset varieties are distributed pan-regionally. The latter types are similar to the Late Pleistocene Cumberland point of the Midwest and appear more frequently than other varieties in the Northeast (Dincauze 2000). Unfluted varieties of lanceolate projectile points continue into the Early Holocene in and around the Saint Lawrence Valley. Agate Basin (Gramly 1992; Justice 1987), Holcombe, and Turkey Swamp are the predominate types of the final phase of Paleoindian occupation in this region (Dincauze 2000).

Two components of the PaleoIndian tradition are represented on the Fort Drum Military Installation. The earliest component of this complex is FDP 1025, located in TA 5B along a relict shoreline of Glacial Lake Iroquois. Whether the occupation was associated with a glacial lake phase or of the Gilbert Gulf marine epoch is currently unclear. The assemblage includes a fluted point that is constructed of Normanskill chert. Trait characteristics of this artifact and analysis by

[6] This section on Fort Drum's Culture History is taken from the background section in the 2007 Survey Report for Fort Drum (U.S. Army 2007) and Amici and Wagner (2003), *The Prehistory Archaeology of Fort Drum, New York*, Fort Drum Cultural Resource Series, No. 1, as updated by Margaret Schulz (2012).

Smithsonian Paleoindian expert Dennis Stanford, suggest that it is a Barnes type without the characteristic fishtail. The distal section of a large fluted point was also recovered. A small portion of the flute is still apparent and has retouch along the fractured edge. The reworked projectile point is constructed of Nedrow Onondaga chert, possibly of Divers Lake origin. An abrading stone, Normanskill and Morehouse Onondaga primary and secondary flakes and a Morehouse Onondaga trianguloid end scraper comprise the remaining assemblage from this site.

A later phase of Paleoindian occupation is located in TA 6B and has been designated FDP 1019. The site produced a well-made unfluted lanceolate point constructed of high quality quartz. The projectile point has a slightly concave base that demonstrates fine basal grinding. Unfortunately, only the medial and proximal portions have survived. The projectile point has a strong affinity to Agate Basin types found in the Upper Great Lakes Region. Little data is available for these projectile point types, however; their presence on Fort Drum may represent a continuation of Paleoindian traditions into the region's Early Archaic period as previously discussed (see Dincauze 2000).

This idea may also be supported by the identification of two early Archaic/late Paleoindian hearths at the FDH 512/FDP 1198 site in Training Area 7B. The first hearth was identified at approximately 30 cm below the surface and produced the ^{14}C determination of 8010 ± 60 B.P. (Beta-168145). The second hearth, approximately 5 cm lower, produced the ^{14}C determination of 8090 ± 60 B.P. (Beta-168146). The site is located along a relict river that links the Saint Lawrence and Black River Valleys. Broken adze bits found in and around the two hearths may suggest a maritime adaptation in later Paleoindian contexts or may simply be a continuation of long established maritime traditions.

Discoveries during the 2004 field season seem to support the latter possibility. First, an unusual artifact assemblage from FDP 1208 was identified as being morphologically similar to an assemblage from Sam Clemente Island in California where a Paleoindian maritime context has been established. Experimental use-wear analysis showed that the artifacts had probably been used for the building of bark boats or canoes. One artifact from the site was identified as a polyhedral microblade core, indicative of Paleoindian traditions. Artifacts similar to those from FDP 1208 were recovered from FDP 1152 at an elevation of 600 ft AMSL (Figure 4-12). An ochre-stained pestle had been recovered from this site in 1999. This landform would have been an island in Glacial Lake Iroquois during the late Pleistocene and early Holocene Epochs. In addition, a quartz artifact recovered in 1999 from a similar hilltop was identified as a prismatic macroblade, further establishing the Paleomaritime context.

4.2.2.2 The Archaic and Transitional Complex

William Ritchie (1965) originally placed the Archaic stage in New York between 4500 B.C. and 1300 B.C. However, recent excavations at the Haviland and Blue Dart sites clearly demonstrate a much earlier date for occupation. Several ^{14}C assays attempting to date small bifurcate projectile points produced consistent dates of ca. 8300–8200 B.P.

The Fort Drum Cultural Resource Survey of past years has identified several Archaic Projectile points (Brewerton, Otter Creek, Lamoka, Normanskill, Snookhill, and Genesee) from isolated surface contexts. Only two sites that produced Archaic-period points yielded associated features.

Figure 4-12. Typical "fossil island" landform within Fort Drum. Today it appears as a small hill with cultural material at its summit. The depicted landform is being used as a borrow pit. Small islands existed in Glacial Lake Iroquois between 8000 and 11,000 yrs B.P.

A Genesee Stemmed projectile point was recovered near a circular fire-cracked rock feature at FDP 1150. Test Unit Investigations have not yet been initiated at this site. In addition, the 1992 cultural resource survey crew near Indian Lake in TA19D found a Brewerton Corner-notched projectile point. They reported that the point was found in a stratified context with features and lithic debitage. This site also requires further investigation.

Steubenville, Susquehanna Broadspear, and Orient Fish Tail projectile points are artifacts representative of the Transitional Phase of the terminal Archaic, ca. 2000–1000 B.C. These projectile point types have been found on Fort Drum in isolated non-stratified contexts. They possibly overlap into the Woodland Period and may represent a contemporaneous component on some Fort Drum Point Peninsula sites. These possibilities will be presented in more detail in the discussion of Early and Middle Woodland below.

Archaic traditions in New York State are chronologically and typologically undefined. A clearer view of the Archaic-period landscape of northeastern North America has begun to emerge in recent years. However, more research is needed to adequately understand temporal and spatial placements during this long phase of prehistory.

4.2.2.3 The Early and Middle Woodland Complexes

The vast scope of Early and Middle Woodland sites on the Fort Drum Military Installation, compared to the dearth of similar sites in other Eastern Woodland regions, provides tremendous opportunity to begin synthesizing settlement and subsistence patterns, establish geopolitical boundaries and augment the temporal taxonomies of these cultural horizons.

Between approximately 1500 B.C. and A.D. 600, highly complex hunting and gathering cultures occupied the Great Lakes Region and river valleys of the Northeast and Midwest. In the northern, central, and western regions of New York State, along the Saint Lawrence River Valley into the Maritime Provinces of Canada, a unique side-notched projectile point—the Meadowood type and undecorated thick grit-tempered Vinette I pottery characterized the earliest phase of Woodland culture. In the Upper Great Lakes Region, Turkey-tail projectile points and similar thick grit-tempered pottery with straight sides and globular and conoidal bases are representative trait characteristics of this phase. Robbins and Adena stemmed projectile points with thick crude ceramics are found throughout the Midwest into the Northeast and represent early manifestations of Early Woodland culture there. Variations in material culture, especially projectile points, have led scholars to surmise that Early Woodland culture pan-regionally comprised fairly distinct autonomous groups.

The majority of Early and Middle Woodland archeological investigations in the Northeast and Midwest have been burial components, which radiate around the Great Lakes Region and its attendant river systems, clustering in religious/ceremonial centers. Traditionally, archaeologists have grouped these cultures together regionally and built taxonomies and chronologies based on burial trait characteristics of each center. In terms of archaeological analysis, due to the paucity of domestic components, the relationship between Early Woodland burial components and habitation districts is largely unknown. For example, several decades of fieldwork at Adena sites in the Ohio Valley region have produced little information regarding domestic contexts (Clay 1996). Similarly, in western, central, and northern New York State, Meadowood burial components are numerous, yet domestic sites are only infrequently found and ephemeral (Ritchie 1965). Likewise, in the Upper Great Lakes Region, Red Ocher Culture burials are typically identified by the “diagnostic” Turkey-tail projectile points. Although Red Ochre Culture burials are commonly encountered, their associated habitation sites also are rarely identified (Ritzenthaler and Quimby 1962).

If mortuary traditions in the Early and Middle Woodland are viewed as highly symbolic with profound cognitive significance, then interment practices may be a product of changes through time, different programs for different individuals, or perhaps negotiated by family members (Clay 1996). Variability of interment practices through time and space can provide a clear understanding of regional burial practice development based on material culture. However, the usefulness of mortuary practices to understand subsistence or settlement patterns is limited at best. Features of mortuary sites have limited comparative value for understanding domestic components on Early and Middle Woodland archeological sites. Therefore, observations and interpretations based on such comparisons have a propensity to be obscured and fragmented. Past attempts to show lucid views of Early and Middle Woodland culture based only on mortuary activity has resulted in some temporal and spatial ambiguities. As a result, opportunities to investigate domestic sites from this time period are highly significant.

4.2.2.3.1 Red Ochre Culture

Robert E. Ritzenthaler, Curator of Anthropology, Milwaukee Public Museum and, George I. Quimby, Curator of North American Archaeology and Ethnology, Chicago Natural History Museum, first identified the Red Ocher Culture in publication on March 27, 1962. This culture

was temporally placed in the terminal Archaic and Early Woodland transitional phase of North American prehistory. As the name suggests, the bearers of this culture sprinkled powdered red ocher (hematite) over the bodies of their dead. The locus for this culture is centered in the Upper Great Lakes Region and adjacent areas. Ritzenthaler and Quimby (1962) particularly found a significant presence for this culture in the states of Wisconsin, Michigan, Illinois, Iowa, Indiana, and Ohio. The two curators investigated nearly 50 archaeological sites in these states and Ontario before developing a comprehensive set of common characteristic traits for the Red Ocher Culture. The two archaeological curators divided the characteristics into primary and secondary categories that they termed nuclear and peripheral traits. The former were characteristic of all sites investigated, and the latter appeared sporadically and inconsistently through time and space. The set of nuclear traits were identified as follows:

- The ceremonial use of red ocher in human and animal burials
- Flexed pit burials in sand as the primary method followed by cremation and bundle interment as a secondary mode
- Large white flint blades sometimes "killed" (i.e., broken)
- Various forms of Turkey-tail "projectile points" predominately constructed of bluish-gray Indiana hornstone. These points usually occur in small caches
- Large caches of unnotched ovate-trianguloid bifaces
- Presence of worked copper beads and tools
- Tubular marine shell beads
- The following secondary traits occurred on sites occasionally:
  - Interment in mounds
  - Use of cremation or bundle burial
  - Occurrence of galena cubes
  - Circular or ovate shell gorgets
  - Birdstones
  - Bar amulets
  - Three whole rectanguloid gorgets
  - Tube pipes
  - Grooved axes
  - Celts
  - Early Woodland pottery

Ritzenthaler and Quimby (1962) assigned three sites as temporal determinations for the Red Ocher Culture. The earliest—the Andrews site in Saginaw County, Michigan—was dated at 1210 ± 300 B.C. The date was obtained from human bone that was in association with red ocher burials. The site's artifact assemblage included birdstones and copper and chert tools. The second sequential determination—Sny-Magill Mound 43 in Clayton County, Iowa—dated 470 ± 250 B.C. and 540 ± 250 B.C. Finally, the third determination—K.B. 1 Mound at Killarney Bay—dated to approximately 80 B.C.

The traits outlined by the two curators are of extreme significance because they characterize burial components in all of the regions being discussed. Efforts of contextual seriation should, therefore, cross-mend trait characteristics pan-regionally. If Clay (1996) is correct in that interment practices are either negotiated or change over time and space, or both, then interments

can be an indicator of spiritual or religious variation. Similar interments are then likely to reflect ethnic homogeneity. Therefore, the Red Ochre Culture trait characteristics apparent in Adena and Meadowood burials in this region of New York State are important. These characteristics remain evident into early and middle phases of Point Peninsula and terminate abruptly with the introduction of Port Maitland and Long Bay projectile point traditions.

If the character of burial traditions suggests pan-regional ethnic similarities, then it is reasonable to expect that the habitation districts and resource extraction patterns of these groups may also share similar trait characteristics. This concept may be demonstrated when comparing a series of sites where small stemmed projectile points, Vinette I ware, and rocker-dentate ceramics are found in association with Meadowood artifacts. When the association between the artifacts and pottery is documented, it will be possible to identify a series of domestic occupation and resource extraction sites in and around Fort Drum as being associated with the Meadowood complex.

In the past, both U.S. and Canadian archaeologists, when encountering sites of this nature, have described the sites as being Point Peninsula and the ceramics as being out of context with the Meadowood artifacts. In addition, small stemmed Kramer points found in these contexts (Gumbus 1997) are frequently misidentified as Lamoka varieties. If misidentified, these Kramer points are sometimes described as being isolated and insignificant when they are found in association with Vinette I ware and Meadowood projectile points. Garret Cook (1985) grappled with this dilemma in his investigation of the LeBoeuf Site in Saint Lawrence County, New York. This site produced Meadowood projectile points and Vinette I pottery with rocker-dentate and cord-impressed crisscross surface treatments. In addition, he recovered several Kramer projectile points in the same sub-plow zone context.

The character of Fort Drum's FDP 1093 site is similar to sites excavated and discussed by Cook. Further, the 1999 Cultural Resources Crew at Fort Drum discovered FDPs 1151 and 1154. At FDP 1151, they recovered several Meadowood points and a Saugeen type point in a surface context with contemporaneous ^{14}C determinations. At FDP 1154, they discovered a possible Meadowood butchering tool kit. The addition of an Adena biface to the collection from FDP 1, one of the Iroquoian Village sites, and the presence of Point Peninsula pottery at FDPs 1021, 1004, 1015, and 1036 mean that these occupations also have the potential to yield information contributing to our knowledge of prehistoric occupation throughout the Northeast and Great Lakes.

4.2.2.4 Point Peninsula Culture

The Meadowood tradition gradually gave way to the Point Peninsula culture in the Fort Drum area. Point Peninsula people continued the trend toward more elaborate grave offerings, as well as increasingly complex pottery decoration. The Point Peninsula culture created unique pottery designs influenced by the Hopewell people who inhabited the Ohio and Illinois Valleys. This period also saw the introduction of pipe smoking as an integral part of ritual and everyday practice.

The change to subsistence agriculture introduced a new social paradigm that called for labor division, segregating sex and age and thereby encouraging a culture that supported the rise of the

individual. Burial traditions also indicate that a hierarchy or class structure was beginning to develop. Acquisition of resources that were in demand throughout the region raised the status of the controlling group. During the Middle Woodland Period descendants of the Early Woodland people began abandoning the practice of seasonal migration and developing extensive trade networks.

By the Late Woodland period, reliance on agriculture had increased. The agricultural fields adjacent to villages began to become a permanent feature of the landscape as domesticated flora became a staple food source. Prime agricultural lands in proximity to village sites were sought out for cultivation.

As agricultural technology increased, so did the production of surplus food and the ability to store food for the winter. With this agricultural success, it was possible to sustain a village community year round. Villages became larger and more heavily populated. Hostilities erupted between neighboring peoples, so that by A.D. 1000, some groups found it necessary to defend their villages with palisades and ditches.

4.2.2.5 Saint Lawrence Iroquois Period (A.D. 1300–1550)

The people known as the St. Lawrence Iroquoians, who are distinct from, but related to, the *Haudenosaunee* (Iroquois) people, inhabited a large number of villages in the Jefferson County area, including villages in what is now Fort Drum. Defensibility in times of war appears to have been a major consideration in village placement as evidenced by trenches, palisades, and earthen works.

A striking cultural development of the late prehistoric era was the intensive cultivation of maize (Indian corn), squash, and beans. The rise in agriculture was accompanied by the “slash and burn” system, where forested land was burnt and cleared in order to make room for crops and fertilize soils. Hunting, fishing, and gathering of wild plants continued to be important.

The St. Lawrence Iroquois people used two types of settlement: large, heavily defensible villages, and small fishing camps. Villages could accommodate up to 2,000 people. The fishing settlements were probably satellite settlements to the main villages. Each village contained up to 40 large, multi-family longhouses and was protected by a tall, defensive palisade of closely set vertical poles enclosing an area of up to 8.5 ac.

The village longhouses were similar to those built by other contemporary Iroquoian people. Longhouses were oval in shape and usually 20 to 30 m long and 6 to 8 m wide and housed multiple families. A number of central hearths were used for cooking and warmth. Pits dug through the floor were used for storage of corn and personal belongings. These pits often filled up with refuse once they went out of use. St. Lawrence Iroquois longhouses were multiple dwellings occupied by members of related families.

Remnants of one fortified St. Lawrence Iroquois village are located on Fort Drum. Research indicates that there may also be a second village located on the Fort Drum installation. In 1534, when Jacques Cartier explored the St. Lawrence River Valley, he encountered the St. Lawrence

Iroquoian people along the way. Sixty years later, when Samuel de Champlain traveled the same route, he found the villages abandoned and the people gone. Whether they fell prey to European diseases, were wiped out in wars with their neighbors the Algonquin tribes, or some combination of the two, is unknown. What is certain is that by the late sixteenth century, the once powerful and numerous St. Lawrence Iroquoians no longer existed as a distinct people.

4.2.2.6 European and Native American Contact Period (A.D. 1540–1768)

The first encounters in the Fort Drum region between Native American governments, societies, and residents and European explorers, missionaries, and settlers are grouped under the context of the Contact period. This period ranges from the mid-sixteenth century (ca. 1540), following the abandonment of the St. Lawrence Iroquois fortified settlement at Camp Drum 1, until the Treaty of Canandaigua opened the area for Euro-American land speculation and settlement after 1797. To date, direct evidence of one Contact-period site has been found on Fort Drum, following examination of significant artifacts, namely a French gunflint and glass trade beads. Little is known about French contact in Northern New York between the years 1534 to 1603, meaning that the site on Fort Drum could write an important chapter in the archaeology of New York State and the history of the nation. Opportunities for contact in the Fort Drum area came with Jesuit missionaries and French fur traders, although no direct mention of contact within the Fort Drum boundaries has yet been discovered in maps or in archival documents.

Several sites on Fort Drum could be classified as multi-component sites. This term simply means that people have inhabited the same area of land at various times throughout history. Fort Drum's Contact-period site is a good example of a multiuse site. In 2002, field crews' unearthed 8000-year-old hearths and post molds next to artifacts and hemlock structural remains dating to the 1650s. Later, this site became the home and farm of the Ford family until the land was bought by the federal government in the 1920s.

Finding additional Contact-period archaeological sites remains an exciting possibility for future training area archaeological surveys.

In fact, trade beads from the 1700s have been found at another farmstead site on Fort Drum. Evidence of eighteenth- and nineteenth-century trade with the Indians coincides with oral history information. Residents of Woods Mills, New York, now in Fort Drum's impact area, remember Indians coming every year to Fort Drum to fish and sell baskets as late as 1941 when the U.S. Army acquired the land.

4.2.2.7 Euro-American Settlement, James LeRay de Chaumont, and the LeRay Mansion[7]

Few attempts were made to settle the vast majority of Northern New York until the end of the Revolutionary war. At the close of the War for Independence, the Iroquois or *Haudenosaunee*, ceded their lands in New York to the American government. Alexander McComb, an ambitious land baron acquired 1,920,000 ac of land in 1791. The large tract encompassed all of today's Jefferson and Lewis Counties, as well as large portions of Franklin and Saint Lawrence counties,

[7] This section of Fort Drum's early history is taken from Wagner (2004), *The LeRay Mansion: Home of James LeRay de Chaumont, the "Father of the North Country,"* Fort Drum Cultural Resources Series No. 2.

with the exception of a small square of land known as Penet's Square. [Penet's square was a 10 sq mi parcel, with one corner extending to the St. Lawrence at French Creek, reserved by the Oneida Indians in the treaty of 1788 for Peter Penet]. McComb went bankrupt shortly after purchasing the large tracts of land and allowed his partner, William Constable, to sell the land in order to recover some of the money owed in debt.

The two largest land companies with which James was associated were the Castorland Company and the Antwerp Company, both of which were located in northern New York State. James LeRay de Chaumont owned approximately 350,000 ac with these two land companies. The majority of land was located in four northern New York Counties; Lewis, Jefferson, Saint Lawrence, and Franklin.

The Castorland Land Company was formed in 1792 when a group of French investors, with the financial backing of some Swiss creditors, purchased a 630,000-ac lot in upper New York State near the present day town of Carthage, to create a colony for upper class French families fleeing the tribulations of the French Revolution. The name “Castorland” was in tribute to the area's history with the French fur trade, since "castor" is another name for beaver. The "Compagnie de New York" adopted a seal depicting a beaver chewing on a tree and the name Castorland. The Antwerp Company was a proprietary land company in northern New York. Gouverneur Morris became the first agent, and later, James Le Ray de Chaumont extensively invested in the company. Under his ownership much of the land in Jefferson, Lewis, and St. Lawrence counties were settled.

In 1802, James returned to America for two years. According to historian Thomas Wood Clarke in his book, *Émigrés in the Wilderness*, James LeRay de Chaumont traveled into the wilderness of northern New York State in 1803 to survey his newly purchased lands in Jefferson County when his canoe party “was obliged to stop at Gravelly Point [today's Cape Vincent], two miles above Putnam's [on Point Peninsula] where they pitched their tent” (Clarke 1941). Also according to Clarke, it was during this trip that James became soaking wet and caught pneumonia soon after, an illness he would barely survive. This trip was not without other consequences to James’ party. One evening Gouverneur Morris, founding father and signer of the Constitution, slept too close to the fire and his wooden leg was incinerated.

Returning from France in 1807, James commissioned the construction of a home near LeRaysville, New York. Dr. Baudry, a Frenchman, was sent to Jefferson County by LeRay to choose a location for his residence and land office. Dr. Baudry, after seeing Mr. Brown's mill operations in the village later known as LeRaysville, and having made a thorough examination of the area in LeRay's purchase, decided at once the location of the first mansion. LeRaysville, originally called Brown’s Mill, was first settled by Benjamin Brown, brother to General Jacob Brown, the founder of Brownville and the hero of the Battle of Sackets Harbor. General Brown was the most important of LeRay’s early land agents, serving in that capacity until a land office was established in LeRaysville in 1808 (Clarke 1941).

In October 1807, a land survey recorded the presence of the LeRay Mansion and associated outbuildings (Survey of LeRay's Mansion Farm, October 1807, Jefferson County Bar Association). Other records indicate that the LeRay family did not live in the first mansion until

1808 when James' son Vincent arrived from France (Kellogg 1932). In May of the following year, James LeRay wrote to David Parish from his home near LeRaysville stating that he was negotiating construction of a road he believed would greatly enhance the likelihood of attracting settlers to the northern New York region (LeRay to Parish May 3, 1809, Jefferson County Historical Society [JCHS]).

In the fall of 1806, timber for the first mansion was cut and processed at Brown's mill. Ethni Evans, whom history has assumed was the master carpenter in charge of erecting the first mansion, began construction in 1807. When the LeRay family came to the area in 1808, the house was not finished but was ready to be occupied. According to Holice Young, the first mansion was at the head of Brown's millpond in a broad opening amongst the forest at the crest of the hill overlooking the pond.

Federal census records in 1810 indicate that LeRay listed himself as a resident of Jefferson County, presumably at the mansion now contained on Fort Drum. LeRay reported a household comprised of 35 people: 1 male under 10, 11 males between the ages of 16–26, 10 males ages 26–45, 8 males over 45 and 2 women ages 26 and 45. Three other household members were not reported under any specific heading. The age and predominant gender of the household indicates the presence of laborers. Though their status as slave or free was not recorded, it is significant to note that LeRay was a slave owner.

When James returned to France in late 1810, he left his estates in his son Vincent's charge (LeRay to George Parish, February 25, 1818, JCHS). Vincent, the eldest son of James and Grace LeRay de Chaumont, was educated in Paris at the Ecolé Royal Polytechnique. Upon finishing his studies in 1808, Vincent left to join his family in LeRaysville, New York. James often remarked to others in his personal and business letter of the pride he felt in Vincent's business prowess. At the time of M. LeRay's departure to France, Moss Kent, the first agent in charge of the land office at LeRaysville, stayed in the area to assist Vincent in his management needs. Mr. Kent resided with the LeRay family at the first mansion. Kent remained in the service of LeRay until his retirement in 1816, at which point Samuel C. Kanady succeeded him.

In the LeRay era, the mansion became a stopping point and destination for various famous people including fifth President James Monroe, New York Governor Dewitt Clinton, Robert Livingston (who represented New York State at the Continental Congress, served as Secretary of Foreign Affairs (the equivalent of today's Secretary of State), and was a negotiator for the Louisiana Purchase), Albert Gallatin (U.S. Secretary of the Treasury from 1801 until 1814 under presidents Jefferson and Madison), as well as other French dignitaries and LeRay contemporaries.

The history of the mansion under LeRay's ownership is somewhat uncertain. Historian and author Hamilton Child (1890) argued that the original LeRay home was an unfinished frame house on a rise overlooking the Village of LeRaysville that was demolished in 1825 to make room for a new stone mansion. The new mansion, said to have been finished in 1825 (other historians claim 1827) according to Child, measured 60 ft in front with a wing and portico on the south side.

Some accounts have claimed that the original mansion was destroyed by fire in 1822 or 1823. A letter from Vincent LeRay describes the first mansion as a total loss. The letter to his agent requesting insurance for the new house, written on January 17, 1827, tells that the workmen are still building the home and have used “the window sashes of the old house which was pulled down” to use in the new construction (Bonney 1985). What does seem certain is that a fire never occurred at the present mansion, according to a Crawford and Stearns architectural study of the LeRay Mansion complex in 1988. The Crawford and Stearns study also concluded that the entire mansion was built at the same time, discounting other historical claims that the existing mansion is an addition to the original mansion.

What is known is that on December 31, 1823, James LeRay, in the midst of serious financial difficulty, bequeathed all of his holdings to his son Vincent, except for the LeRay Mansion and its outbuildings and grounds. These he leased to Vincent. In the following year, Vincent married Cornelia Juhel, the daughter of John and Cornelia Juhel of New York City. Mr. Charles Durham, past historian for Jefferson County, contends it was this match that allowed LeRay to remain solvent and thereby build the current LeRay Mansion. The five years preceding the completion of the current mansion were said to be a period of elegant hospitality before LeRay's return to France in 1832. M. LeRay returned to America in 1836 and spent just a few months at his home near LeRaysville. He made his final return to France in 1840. On the final day in 1840, at the age of 80, full of health and vigor, his mind unimpaired, he was suddenly taken with an inflammation of the chest, which caused his death in five days.

James LeRay de Chaumont has earned the title of Father of the North Country. He was one of the original backers of the Saint Lawrence Turnpike, a roadway that connected Sackets Harbor with Plattsburg. During the War of 1812, this road proved to be invaluable to the transportation of arms and supplies for defending the new American nation against British invasion from Canada. His agricultural interests encouraged growth and settlement in the area. However, it was this same entrepreneurial spirit that lead to his financial ruin. His backing of the Erie Canal was an outstanding financial failure.

James LeRay de Chaumont was respected and beloved by the people in Jefferson County and in all accounts has been remembered in affectionate and respectful tones. He was a man of vision and liberal encouragement, generous to a fault in sponsoring public improvements and the promotion of schools, churches, and community centers. LeRay philanthropically donated land for the construction of both Catholic and Protestant churches. He was a protector over the people who settled on his lands. Stories still persist of LeRay's kindness and benevolence, giving him a place in the permanent memory of the North Country.

After James’ death in 1840, the property passed through many hands. After Mabel and Fred Anderson lost the property during the Great Depression in 1936, the mansion was sold to Harold and Margaret Remington at auction. The Remington's were responsible for much of the restoration and preservation of the mansion prior to the federal government acquiring the property in 1940. The LeRay Mansion district was placed on the National Register of Historic Places in 1974. Today the LeRay Mansion is used as housing for visitors to the Fort Drum Military Installation. Its present use has allowed for the continued preservation and upkeep of the

mansion. The Army continues to do an excellent job of saving the mansion and associated buildings for the American people.

4.3 CULTURAL RESOURCE MANAGEMENT PROGRAM HISTORIES

As explained previously, four installations were initially selected and agreed to participate in this demonstration project. These were: Eglin AFB, Florida; Fort Drum, New York; Saylor Creek Range, Idaho (SCR, administered by Mountain Home AFB); and Utah Test and Training Range Utah (UTTR, administered by Hill AFB) (Figure 4-13). Selection criteria included military service and mission, geographic distribution, and status of model development. During the course of the demonstration project, UTTR and SCR withdrew from the formal archaeological predictive modeling effort and chose to pursue different modeling objectives (see Appendices D and E). The following sections present CRM program histories for Fort Drum and Eglin AFB, which then became the focus of the project.

Both installations have well established CRM programs and large numbers of recorded archaeological sites. Eglin's current manager has been there since prior to 1998 and the primary contractor completing the inventories and evaluations has worked on the installation for more than 20 years. The USAF has spent over $12.8 million on the CRM program since 1998 to conduct Section 106 consultation, archaeological inventory, archaeological site evaluations, and site monitoring and protection. Fort Drum has retained the same CRM manager since 1998. The U.S. Army has spent over $5.5 million on the CRM program since 1998 to complete Section 106 consultation, archaeological inventory, archaeological site evaluations, and site monitoring and protection on an annual basis. Fort Drum also monitors or protects over 30 archaeological sites per year. Some contractual support is utilized for Section 106-compliance efforts.

Both installations are actively pursuing completion of the inventory and site evaluations, inventorying many thousands of acres and evaluating dozens of archaeological sites per year. Whereas contractors conduct the majority of Eglin's Section 106 consultation efforts, in-house staff conducts most of Fort Drum's Section 106-related activities

Both installations had previously developed predictive models of archaeological site location. The predictive models for Eglin AFB and Fort Drum were initially evaluated as part of Legacy project #01-167 (Altschul et al. 2004) and the issues identified during that evaluation were addressed as part of model validation. Summary data collected from the CRM programs at Eglin AFB and Fort Drum is presented below.

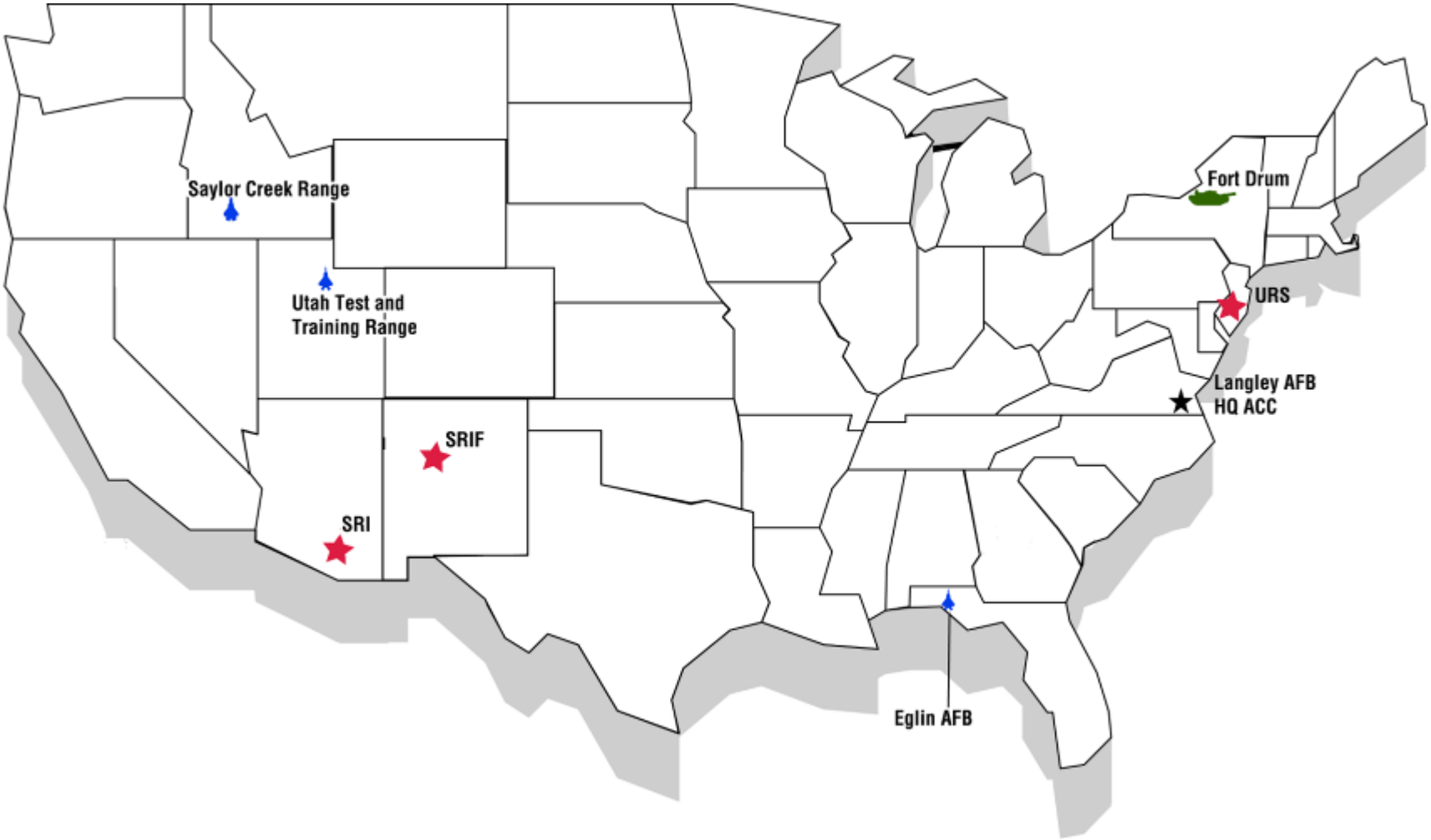

Figure 4-13. Location of four demonstration installations, DoD lead agency, and contractors participating in this study. Key: Headquarters Air Combat Command (HQ ACC); URS Corporation (URS); SRI Foundation (SRIF); Statistical Research, Incorporated (SRI).

Table 4-4 presents summary statistics on the CRM program at Eglin AFB for the years 1994 to 2008. Cost data for some years are missing because Eglin AFB conducts most of its CRM investigations using private contractors and decided not to reveal proprietary information. Over a 15-year period beginning in 1994 and ending in 2008, Eglin AFB inventoried and cleared[8] almost 194,000 ac representing approximately 42 percent of the installation. Of this total, 172,480 (88.9 percent) represent newly surveyed acres and 21,501 (11.1 percent) are acres that have been resurveyed. During this 15-year interval, Eglin AFB recorded a total of 1,945 archaeological sites classified as either prehistoric or historic, or sites containing both prehistoric and historic components. The rate of archaeological discovery—the number of sites recorded (1,945) divided by the number of acres surveyed (193,981)—is 0.010/ac. Financial information for the years 1999 to 2007 indicate that Eglin AFB expended $7,226,000 over a nine-year period during which it surveyed 115,933 ac for an average cost of $62.33 an acre. The average cost for detecting and recording each site, including the cost of resurveying old acres and re-recording old sites is $3,715.16. Not shown in Table 4-4 are summary statistics on the number of shovel test pits (STPs) excavated at Eglin AFB. STP numbers extracted from the GIS data Eglin AFB and shared with the demonstration project team indicate that between 1994 and 2007, 119,808 STPs were excavated to locate and record cultural deposits. Of these 119,808 STPs, 93,105 STPs were excavated to locate sites and an additional 26,703 STPs were excavated to record the nature and extent of archaeological deposits.

Table 4-4. Eglin AFB CRM Program Statistics, 1994–2008

Year	Total Survey Acres	New Survey Acres	Old Survey Acres	Survey $ in 1000s	Total Sites	New Sites	Old Sites	Sites Evaluated	Site Evaluation $ in 1000s
1994	2,945	2,759	186	—	20	14	6	—	—
1995	9,386	9,059	327	—	143	130	13	—	—
1996	18,870	18,472	398	—	289	276	13	—	—
1997	20,150	19,352	798	—	153	144	9	—	—
1998	11,341	10,091	1,250	—	110	103	7	—	—
1999	10,297	9,094	1,203	$770	78	76	2	63	$297.5
2000	11,575	11,087	488	$720	78	72	6	41	$300
2001	20,894	19,896	998	$720	249	238	11	13	$150
2002	10,113	10,000	113	$720	115	110	5	20	$200
2003	6,688	5,983	705	$788	80	62	18	19	$200
2004	7,223	6,464	759	$844	56	46	10	21	$200
2005	16,664	12,841	3,823	$897	109	98	11	1	$215
2006	14,387	12,694	1,693	$887	114	99	15	16	$215
2007	18,092	15,280	2,812	$880	146	113	33	12	$212
2008	15,356	9,408	5,948	—	205	144	61	—	—
Total	**193,981**	**172,480**	**21,501**	**$7,226.0**	**1,945**	**1,725**	**220**	**206**	**$1,989.5**

[8] These 193,981 acres include lands accurately survey (i.e., shovel tested for the presence of cultural deposits) and lands exempted from survey because they are inundated, inaccessible, or in a low-sensitivity zone. Only about 102,497 ac in the high-sensitivity zone have been physically tested.

Table 4-5 presents information on the level of effort invested in archaeological survey and testing at Eglin AFB based on a representative sample of reported surveys for the years between 1996 and 2010. Because Eglin does not record statistics on the number of crew members and the number of crew hours in its CRM database, we devised a different method to estimate level of effort. We reviewed a sample of inventory reports prepared for Eglin AFB between 1996 and 2010 that included both large and small projects to derive approximate estimates. Review of the survey reports required examining the individual Survey Shovel Test Forms and daily field notes for each of the selected survey projects in order to characterize level of effort. Two of the nine projects reviewed for this report, X Unit 938 and X Unit 1046, were conducted for the purpose of locating historical-period archaeological sites and required excavation of only a small number of STPs (≤ 30 STPs). Other projects, such as X Unit 380, involved excavating thousands of STPs.

A total of 4,292 ac were surveyed during these projects requiring the combined efforts of 874 crew members to excavate 4,689 STPs (see Table 4-5). Approximately 1,400 person hours of labor was required to perform the fieldwork. Not included in this time estimate is the labor required for post-fieldwork tasks associated with CRM survey, such as artifact processing, analysis, and report production. Eglin AFB surveys those areas that their model indicates have a high sensitivity for prehistoric sites. Within these areas, however, field crews make decisions about where to survey and at what intensity depending on local field conditions. Standard survey transect intervals range from 20 m to 60 m wide, whereas areas believed to have lower potential for human settlement and land use are investigated less intensively with transects ranging from 40 m to 100 m in width (see Table 4-5).

This sample of nine surveys resulted in the location of 31 archaeological sites (see Table 4-5). Of these 31, 14 prehistoric sites and 6 historic sites were newly recorded, and 6 prehistoric sites and 5 historic sites were re-recorded. Based on their content, extent, and integrity, field archaeologists recommended that only 10 of these 31 sites are eligible or potentially eligible for listing in the National Register. Field archaeologists also reported finding 46 Isolated Occurrences, consisting of small numbers of artifacts found in isolation. Using the data in Table 4-2, we can represent level of effort as a series number of ratios: Hours/STP, STPs/Crew and STPs/Acre. On average, it took about half an hour to excavate a STP, each crew member excavated almost five STPs in an eight-hour day, and approximately one STP was excavated per acre.

The data contained in Table 4-6 indicate that the amount of land inventoried annually changes dramatically after 2001. At that time, Fort Drum changed its survey standards to increase the number of STPs excavated per acre by reducing the interval between STPs, which resulted in fewer acres being inventoried per year. This change was instigated by Fort Drum to meet the New York State standards and focus on lands with higher site density. In addition, survey coverage reported for 2006 and 2007 is unusually low relative to annual survey data before and afterwards due to a focus on timber surveys during those two years (Margaret Schulz, personal communication, October 2010). Funding levels, however, were consistent with funding for previous years; these monies may also have been used for other purposes not reflected in the data.

Table 4-5. Level of Effort for a Sample of Archaeological Surveys at Eglin AFB

Year	X-Unit	Acres	Crew Total	Hours	Shovel Tests	Survey High	Survey Low	New Sites	Old Sites	Isolated Finds	Eligibility	Hours/ST	ST/Crew	ST/Acre
1996	297, 316, 320, 321	589	207	287.5*	974	20-25	50-100	1H, 7P	0	15	2E, 6NE	.29 hrs/ST	4.70 ST/Crew	1.65 ST/Acre
1997	380	1177	232	337.75	1220	25-30	40-100	1P, 1H	1H	4	2E, 1NE	.27 hrs/ST	5.25 ST/Crew	1.03 ST/Acre
2000	473	958	147	242.75	958	20-30	40-11	4P, 1H	1H	6	2E, 4NE	.25 hrs/ST	6.51 ST/Crew	1.0 ST/Acre
2003	668	220	25	38.25	220	20-30	50-100	0	2H,1P	0	2NE,1E,	.17 hrs/ST	8.80 ST/Crew	1.0 ST/Acre
2007	939	102	12	13.5	7	20-30	50-100	0	0	3	0	1.92 hrs/ST	0.58 ST/Crew	.06 ST/Acre
2008	863	307	79	184.05	457	20-30	50-100	1P	1P,1H	4	2E,1NE	.40 hrs/ST	5.78 ST/Crew	1.48 ST/Acre
2008	916	622	121	226.95	648	20-30	50-100	1P, 1H	4P	9	1E, 5NE	.35 hrs/ST	5.35 ST/Crew	1.04 ST/Acre
2009	1046	115	15	22.2	26	20-30	50-100	1H	0	2	1NE	.85 hrs/ST	1.73 ST/Crew	.22 ST/Acre
2010	1068	202	36	49.5	179	50-60	75-100	1H	0	3	1NE	.27 hrs/ST	4.97 ST/Crew	.88 ST/Acre
Total		**4,292**	**874**	**1,402.20**	**4,689**			**14P, 6H**	**6P, 5H**	**46**	**10E 21NE**	**.53 hrs/ST**	**4.85 ST/Crew**	**.92 ST/Acre**

* Numbers are estimated based on incomplete field data.
m = meters
H = Historic
P = Prehistoric
E = National Register eligible (includes potentially eligible)
NE = Not National Register eligible
Hrs = Hours
ST = Shovel tests

Table 4-6. Fort Drum CRM Program Statistics, 1994–2008

Year	Total # of Crew*	Crew Hours**	Survey $ in 1000s	Surveyed Acres***	Total # of New Sites Found	New Prehist. Sites	New Historic Sites	Total STPs	Phase 2 Projects	Phase 2 Sites Tested	Phase 2 Costs in 1000s
1994	6	5,760	–	2,693	18	16	2	3,521	2	–	–
1995	25	24,000	–	3,396	39	29	10	14,642	13	–	–
1996	25	24,000	–	5,938	32	22	10	18,252	0	–	–
1997	16	15,360	–	5,079	26	15	11	19,181	2	–	–
1998	20	19,200	$284.5	4,578	40	20	20	17,544	8	50	$125.0
1999	26	24,960	$145.0	2,442	34	20	14	14,909	15	77	$192.5
2000	42	40,320	$242.0	7,804	87	6	81	35,405	6	91	$240.0
2001	36	34,560	$589.0	1,879	34	11	23	26,147	14	30	$225.0
2002	27	25,920	$427.0	981	14	3	11	10,278	11	14	$175.0
2003	32	30,720	$203.0	568	26	13	13	6,664	26	26	$65.0
2004	25	24,000	$270.0	804	16	4	12	11,030	19	16	$40.0
2005	14	13,440	$188.0	700	8	4	4	8,264	4	8	$20.0
2006	9	8,640	$158.5	277	17	13	4	3,571	2	17	$42.5
2007	10	9,600	$185.5	113	22	20	2	2,403	6	21	$52.5
2008	27	25,920	$259.0	735	12	8	4	10,329	7	–	–
Totals	**340**	**326,400**	**$2,951.5**	**37,988**	**425**	**204**	**221**	**202,140**	**135**	**350**	**$1,177.5**

* Not all crew were working on survey
** Assumes 8 hr/day, 40 hrs/wk for 6 mo
*** Total acres surveyed during 1998–2008 (20,881 ac) used to calculate survey cost per acre

Table 4-6 also shows that Fort Drum identified 425 new prehistoric and historic sites between 1994 and 2008, augmenting information on 566 previously recorded sites. The total number of STPs excavated as of 2008 is 202,140. The archaeological discovery rate—the number of sites (425) divided by the number of acres surveyed (37,988)—is 0.011. Phase 2 testing, conducted to evaluate National Register eligibility, is shown by the number of test units excavated and by the number of testing projects conducted per year—although each testing project may have involved multiple sites. Further, Phase 2 testing can be conducted in the field at the time of site discovery or somewhat later, after a site has been identified and given a site number. Because of this complexity, we chose to use site evaluation estimates collected from Fort Drum in 2007. Overall, the data indicate the level of effort invested in supplementary excavations during survey. In an 11-year period between 1998 and 2008, Fort Drum invested a total of $2,951,500 in identifying its archaeological resources for an average cost of $6,944.71 per newly recorded site. To find that archaeological site, Fort Drum expended on average $141.34 per acre to conduct archaeological survey using total STP coverage at 15 m intervals. It cost on average $3,364.28 per site/project to test that site for National Register eligibility.

Table 4-7 provides a side-by-side comparison of Eglin AFB and Fort Drum showing the status of site inventory and site count as of 2008. Table 4-7 presents several metrics on inventory and archaeological site evaluation efforts derived from the data presented in Tables 4-4, 4-5, and 4-6

Table 4-7. Status of Site Inventory and Site Count for Eglin AFB and Fort Drum as of 2008

Installation	Total Acreage	Inventoried Acreage	Disturbed Acreage	Unsurveyed Acreage	Total Sites
Eglin AFB	463,128 (100%)	193,981 (41.9%)	10,000 (2.1%)	259,147 (56.0%)	1,945
Fort Drum	107,625 (100%)	37,988 (35.3%)	28,263 (26.2%)	41,374 (38.4%)	991

Note: Disturbed Acreage is land that cannot be inventoried because of the presence of the cantonment, airstrips, large bodies of water, and so forth.

The two installations have similar CRM program histories. Eglin AFB and Fort Drum have well-developed CRM programs that have been in operation for more years and with less staff turnover than at other installations evaluated through Legacy project #01-167 (Altschul et al. 2004). Expenditures for NHPA Section 106 compliance, inventory, evaluation, monitoring, and protection vary, which suggest that archaeological preservation, resource visibility, field methods, political realities, and management challenges greatly influence the cost and time of CRM endeavors. DoD has yet to develop a strong, objective, and systematic approach for discovering, recording, evaluating, and managing cultural resources on military reservations in the United States. What constitutes adequate inventory at one installation is not the same as another.

Table 4-7 clearly indicates that both installations are well on the way to inventorying their respective land holdings for archaeological sites and other cultural resources. Eglin AFB has surveyed approximately 42 percent of its land base and Fort Drum has investigated approximately 35 percent. Both have large areas of disturbed acreage that will not be surveyed in the future including their cantonments. Eglin AFB has 259,147 ac that have not been inventoried for cultural resources, much of it in low-sensitivity zones, which do not

require inventory per their management policy. Fort Drum has a smaller amount of unsurveyed land at 41,374 ac, with a portion of this remaining land area cleared through sample testing.

Table 4-8 presents in summary form the statistics discussed above. As would be expected, the contrasting cultural histories and environmental settings of coastal Florida and upstate New York produce different comparative discovery rates between Eglin AFB and Fort Drum. The rate of discovery at Eglin AFB (0.010/ac) signifies that roughly one site is found for every 100 ac surveyed. At Fort Drum this rate (0.011/ac) is only slightly higher; on average one site is found every 89 ac. Average cost of survey per acre at Eglin AFB is lower by a factor of two, which is probably due to a combination of circumstances including differences in the nature of the archaeological record, soil conditions, geomorphological setting, and field methods between Eglin AFB and Fort Drum. The cost of testing sites for their eligibility for listing in the National Register differs substantially, averaging almost three times as much per site at Eglin AFB than at Fort Drum. This, too, is likely a product of differences in physical conditions and the archaeological record of western panhandle Florida and northern New York State.

Table 4-8. Metrics Using Data Reported from Eglin AFB and Fort Drum

Installation	Historic Discovery Rate: Sites per Inventoried Acre	Historic Average Cost per Inventory Acre	Historic Average Evaluation Cost per Site/Project
Eglin AFB	0.010	$62.33	$9,657.77
Fort Drum	0.011	$141.35	$3,364.28

The two installations have similar CRM program histories. Eglin AFB and Fort Drum have well-developed CRM programs that have been in operation for more years and with less staff turnover than at other installations evaluated through Legacy project #01-167 (Altschul et al. 2004). Expenditures for NHPA Section 106 compliance vary, which suggest that archaeological preservation, resource visibility, field methods, political realities, and management practices, including the use of in-house labor versus private contractors to do field work, greatly influence the cost and time of CRM endeavors at Eglin AFB and Fort Drum.

Figures 4-14, 4-15, and 4-16 show bar graphs of inventory coverage per year, inventory cost ($), and cost per inventory acre (cost/inventory ac) for each installation. Although trends are apparent, interpreting these metrics is not straightforward. Inventory cost and cost/inventory ac, for example, are based on costs exclusive of installation personnel income and do not account for whether the work is performed by contractors or in-house personnel. These metrics also do not take into account variation in the level of effort within each installation.

Inventory coverage (inventory ac/installation ac) is a metric that can be used to interpret variation in inventory cost and cost/inventory ac and other metrics. As with other metrics, inventory coverage accounts only for how much acreage was surveyed in a given year. It does not account for how much acreage was resurveyed or how much acreage was inventoried according to different levels of effort or within different sensitivity zones.

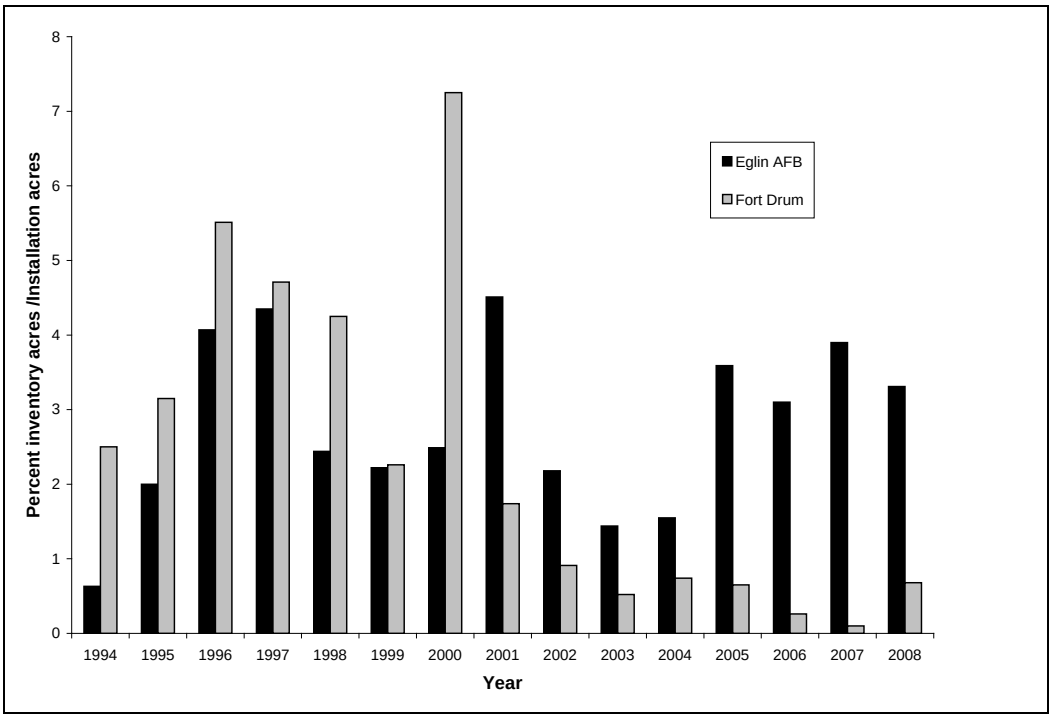

Figure 4-14. Inventory coverage for each installation for the years 1994–2008.

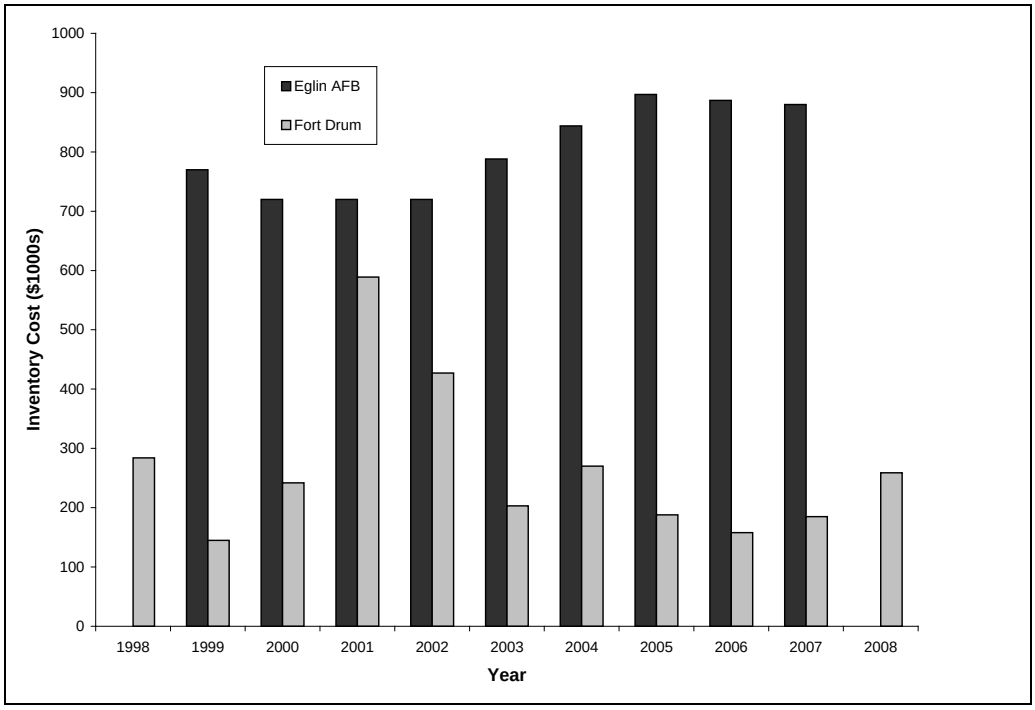

Figure 4-15. Inventory costs for each installation for the years 1998–2008 (Eglin AFB data missing for 1998 and 2008).

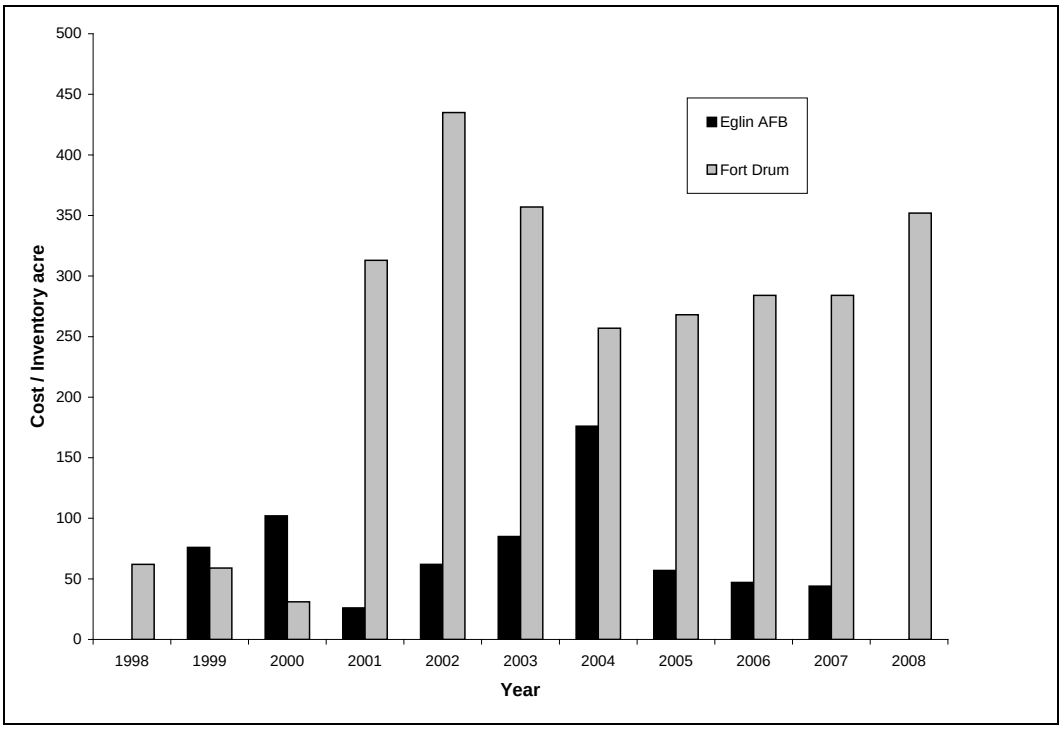

Figure 4-16. Per-unit costs for each installation for the years 1998–2008 (Eglin AFB data missing for 1998 and 2008).

Preliminary interpretation of these metrics is possible when CRM history is taken into account. Several interesting trends are apparent. Variation between the two installations can largely be accounted for by differences in environmental conditions. Eglin AFB is located on a coast plain, characterized by sandy soils and dense vegetation. In contract Fort Drum is located in a glacial landscape, characterized by lacustrine deposits, glacial tills, and forested upland soils.

Inventory coverage, presented in Figure 4-14, shows patterning over time. Prior to 2001, Fort Drum conducted survey at a substantially higher rate than at Eglin AFB. After this time their respective survey rates were more similar, although Fort Drum consistently surveyed more of its installation per year. As previously mentioned, in 2001 Fort Drum adopted a new survey strategy shifting where and how survey was conducted, which explains, in part, the results shown here.

Inventory cost data for Eglin AFB and Fort Drum presented in Figure 4-15 show that funding has been more consistent at the former than at the latter. Nonetheless, relative funding levels have been higher at Fort Drum than at Eglin AFB. This may reflect differences in inter-service or installation-specific funding priorities.

Per-acre survey cost (see Figure 4-16) indicates that Fort Drum experiences higher costs for survey than Eglin AFB. The cost difference in per-acre archaeological survey is also captured in Table 4-5. Survey at Eglin AFB averages $62.33 per acre and the same activity at Fort Drum costs $141.34. These contrasting estimates may reflect differences in survey intensity. Excluding planned STPs that could not be excavated due to disturbance, vegetation, health hazards, and other factors, Eglin AFB on average excavates one STP per acre, whereas in recent years Fort

Drum excavates more than eight test pits per acre. Note that the Fort Drum survey data for 2006 and 2007, as presented in Table 4-6, appears to be anomalous in relation to funding levels for those years. To prepare Figure 4-16, we adjusted the data for years 2006 and 2007 to address anomalies in cost per acre. Here we substituted an average cost per acre using the average cost per acre for the years 2002 through 2005, and 2008.

5.0 TEST DESIGN

This project demonstrates that (1) predictive models developed for DoD installations can predict with acceptable accuracy the locations of archaeological materials, and (2) the modeling process can be successfully integrated into programmatic approaches to cultural resource compliance. To accomplish the first component of the demonstration, we systematized, refined, and validated predictive models for two demonstration installations—Eglin AFB and Fort Drum. For the second component of the demonstration, we worked with Eglin's and Fort Drum's CRM staff and stakeholders to integrate the models into the installation's cultural resource compliance programs. The latter will be accomplished through the use of Section 106 PAs.

5.1 CONCEPTUAL TEST DESIGN

Our conceptual test design focuses on three aspects of the modeling process: validation, refinement, and integration. Below, we provide a general description of the modeling process. Next, we discuss specific aspects of validation, refinement, and integration.

Our approach recognizes that modeling is a process. As new data are incorporated, models become better predictors of site location. It follows that models need to be repeatedly tested, refined, and validated using appropriate statistical techniques and the latest, quality-controlled data. Still, the most sophisticated and accurate model will not be useful if it has not gained user-acceptance or not been integrated into an installation's cultural resource compliance efforts. Predictive models will only be successful components of programmatic approaches to cultural resource compliance once a minimal level of accuracy and reliability is achieved and accepted by concerned stakeholders.

The modeling process for the project is presented in Figure 5-1. Predictive models are divided into surface and subsurface models. We have further divided surface models between those that model *all* prehistoric sites (regardless of site type), termed an *all-sites model*, from those that model only a subset of prehistoric sites—intensively used residential sites—that we have identified as cultural resource compliance *red flags*. Surface and subsurface models are commonly presented as sensitivity maps in which the study area is divided into areas of low-, medium-, or high-archaeological sensitivity. Most predictive models developed for DoD installations are surface models of all sites based on the results of traditional surface survey. Less often, installations have constructed subsurface models based on geomorphic variables; rarely are red flag models developed. Combining subsurface and surface models into integrated, zonal management models will be essential for accurately predicting the relative importance of site types and the three-dimensional distribution of archaeological resources, assuring stakeholder buy-in and streamlining compliance.

Our general procedures for each demonstration installation involved a variety of steps (Figure 5-2). The first step is to gather all existing modeling and inventory data for each installation. This is followed by evaluation of data quality, reconstruction of the original models in a GIS, and preliminary assessment of the models using validation techniques and exploratory data analysis. Once we had the opportunity to assess the models, we worked with installation personnel to

develop a plan for systematizing the baseline models, refining the baseline models, and validating the refined models. An acceptable model was a model that met or exceeded the performance objectives described in Section 3.0 and discussed more fully in Section 6.0.

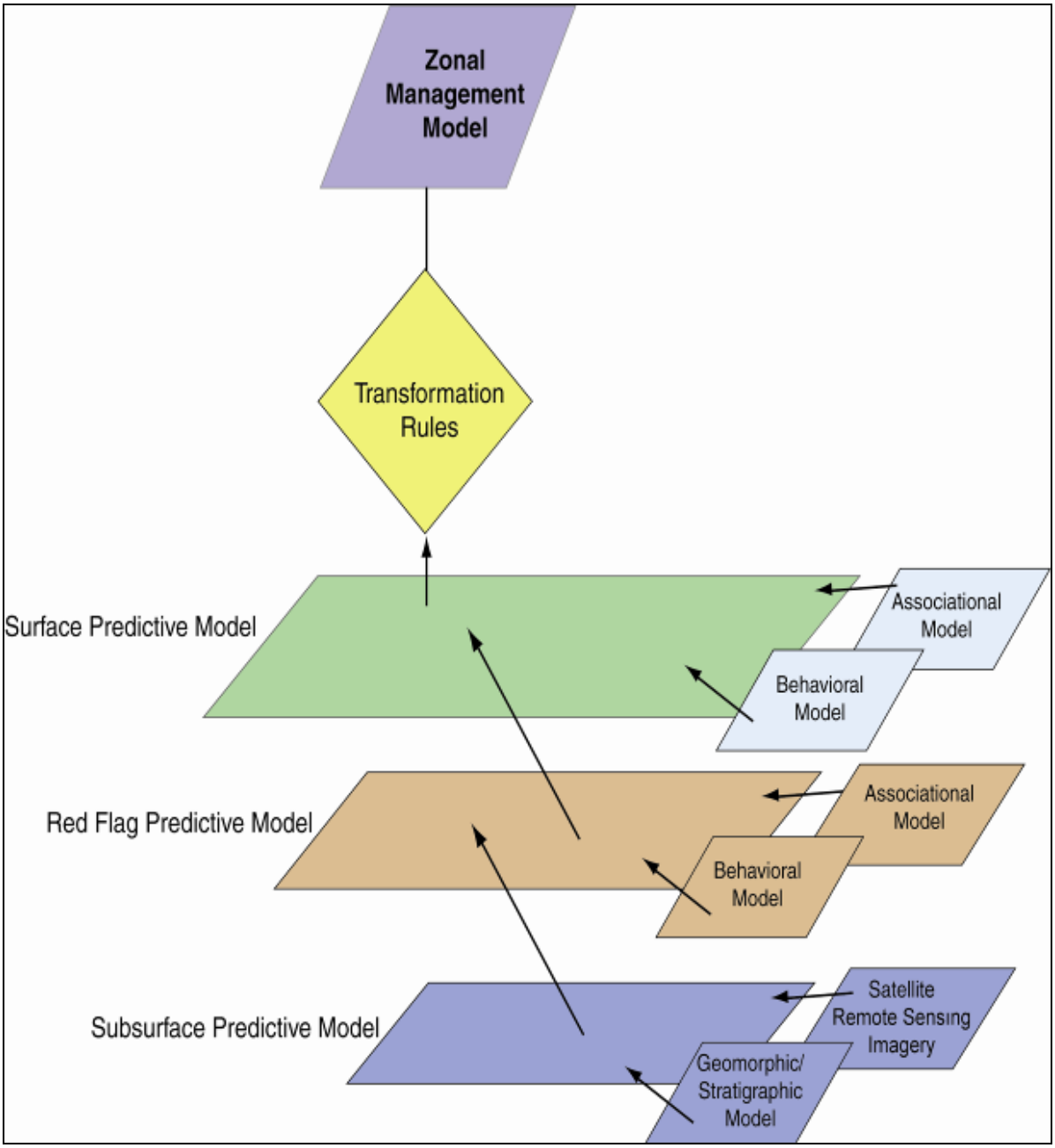

Figure 5-1. Conceptual project design for integrating archaeological modeling in DoD resource compliance.

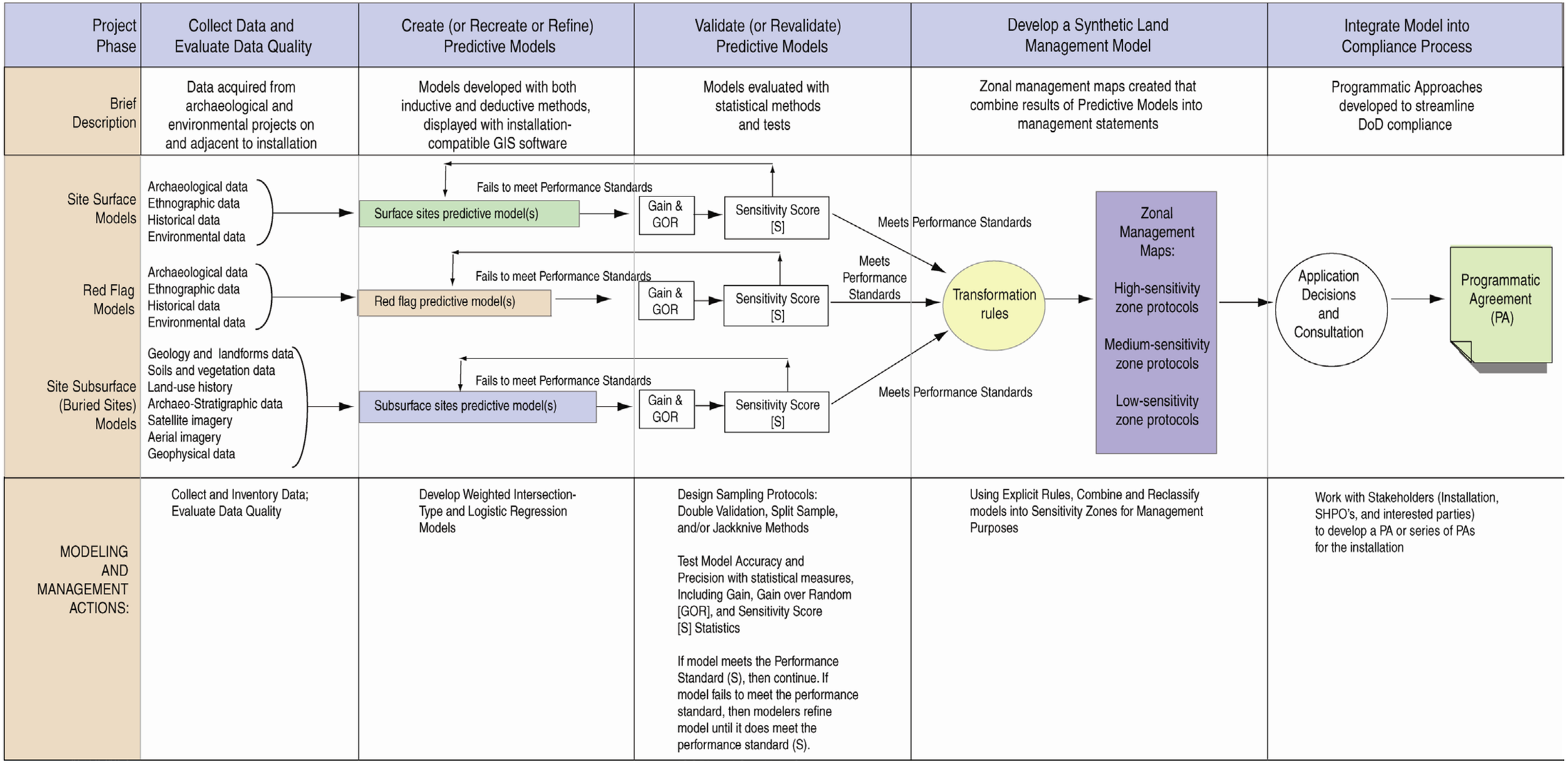

Figure 5-2. Annotated flow diagram illustrating the demonstration technology process.

5.2 BASELINE CHARACTERIZATION AND PREPARATION

The baselines for this project are threefold: (1) predictive models prior to systematization, (2) the performance of systematized predictive models prior to validation and refinement, and (3) CRM program performance prior to model integration.

5.2.1 Predictive Models Prior to Systematization

Many military installations claim to have predictive models of archaeological site locations. In most cases, these predictive models are based on professional judgment or theoretical constructs. Variables often have not been systematically defined, and they cannot be rigorously tested. In other cases, the variables are crudely defined, such as dichotomous variables, which lead to poor or imprecise predictions. These models cannot be used effectively in CRM compliance or project planning. The baseline models of the demonstration project from which we have measured cost, effort, and effectiveness of predictive modeling consist of models in use at the demonstration installation prior to the inception of the project.

5.2.2 Systematized Models Prior to Validation and Refinement

Our first step was to systematize the baseline models. Variables were formally defined so that they can be measured and replicated. Elements of the model were placed in GIS formats. Sensitivity scores (S) were calculated prior to refinement as a baseline measure of model performance.

5.2.3 Cultural Resource Management Programs Prior to Model Integration

Baseline CRM performance is the performance of NHPA 106 and NEPA compliance *without* predictive models. Inventory level of effort, inventory cost per acre, number of evaluated sites, and effective value of the compliance process are the measures used for baseline characterization of CRM programs lacking model integration.

5.3 DESIGN AND LAYOUT OF TECHNOLOGY AND METHODOLOGY COMPONENTS

Predictive modeling technology implemented in this demonstration consists of surface models (all-sites models and red flag models), subsurface models, and zonal management models. Surface models needed to be refined in order to meet the standards accepted for model performance. Preliminary subsurface models needed to be developed to account for buried site potential. These models were incorporated into zonal management models. In the case of Eglin AFB, where site type information allowed the development of a red flag model, a red flag model was also incorporated into the zonal management model. The general characteristics of surface and subsurface models are discussed below, including steps required to systematize and refine predictive models and combine surface and subsurface models into zonal management models. Integration of models into installation cultural resource compliance programs requires a series of steps to be performed for each installation. These steps are discussed in Section 5.3.6. Validation procedures are discussed in a later subsection section (Section 5.5) as part of our sampling protocol.

5.3.1 Surface Models

Surface models predict the distribution of archaeological materials expected in near-surface landscape contexts (i.e., artifacts, features, and other cultural deposits located on the modern ground surface or buried in sediments less than 1 m in depth). Surface models are often inductive models based on the association or correlation of environmental variables with the location of sites discovered through traditional surface survey. If sufficient data exist, separate models can be developed for each site type or time period. If information on site type or time period is not available, models can be constructed for all sites in a geographic area. For compliance purposes, it is often helpful to distinguish models of all sites from models of particular site types that planners want to avoid (red flags). Overall, inductive surface models have been shown to work well in predicting the likelihood of discovering surface and near-surface sites. This is because environmental variables serve as proxies for variables that influenced how people used past landscapes. One criticism of inductive models is that although they can accurately predict where sites are likely to be found, they cannot explain in behavioral terms why sites formed where they did. Explanation of the associations or correlations among site location and environmental variables for these models is, therefore, *ad hoc*.

Deductive models, by contrast, are grounded in behavioral theory that can be used to explain why sites formed where they did. Many archaeologists employ some form of deductive reasoning in determining which environmental variables influence site location. Since deductive models are highly dependent on working assumptions and frequently require extensive revision to be useful as a management tool, purely deductive models are rarely shown to be accurate predictors of site location. Nonetheless, the ability of deductive models to explain site location in terms of behavior can be a crucial aspect of the modeling process, particularly if it helps to secure stakeholder buy-in.

From a practical standpoint, we believe that models are most likely to be accepted by stakeholders if they combine the best aspects of deductive and inductive models. Models should include careful consideration of the variables that intuition, behavioral theory, or ethnography suggest are important, but the relationships between those variables and site location should be demonstrated as having strong empirical support.

5.3.2 Subsurface Models

Since they do not incorporate data on the age and depth of subsurface deposits, surface models are generally unsuccessful in predicting the likely locations of buried sites (i.e., artifacts, features, and other cultural deposits buried in sediments more than 1 m below the modern ground surface). Instead, a second type of model, termed a subsurface model, must be created to predict areas that are likely to contain buried sites, which may or may not have any surface indication. These models are based on data developed by geomorphologists using stratigraphic information obtained through cores, probes, or trenches combined with observations about landform evolution inferred from surface observations. Often, the data used for subsurface models are based on data developed by geologists or soil scientists for reasons other than archaeological study. Subsurface models are presented qualitatively as a GIS layer when based on geomorphormic data or quantitatively if remotely sensed satellite imagery is used. In either case,

archaeologically relevant geomorphic zones are combined with archaeological excavation data in order to develop a subsurface model of archaeological sensitivity.

5.3.3 Model Refinement

We must emphasize again that modeling is a process. As Judge and Martin (1988:580) note, "modeling is a cyclical process of ongoing refinement, rather than a one-time event, and thus models cannot be developed by outsiders and then simply 'turned over' to agency field office archaeologists for 'application.'" The installations selected for this demonstration plan were chosen because they were in different stages of the modeling process, not because they had exceptionally successful models requiring additional validation. We worked with the installations to refine and validate their existing models, so that their models stand a better chance of being incorporated into programmatic cultural resource compliance.

For some installations, multiple iterations of models have been developed during a long history of modeling efforts. Unfortunately, the history of modeling efforts—including how models were built, tested, or refined—is not transparent. For most installations, models consist mainly of paper or digitized maps and limited description of model-building efforts in written documents.

Complete and accurate information on how models were developed or tested is not often available for any particular installation. Even in cases where narrative descriptions of models are available, information on how variables were defined and related to site locations is not often explicit enough to reconstruct an exact copy of the original model. Developing further information on model-building procedures requires interviews of staff and thorough review of existing documentation, including papers, reports, and metadata. Since validation and refinement were performed in a digital GIS software environment, models that were built originally on paper maps or according to unspecified transformation rules were operationalized by the demonstration project team in order to be reconstructed in GIS. For instance, environmental variables that were visually estimated on paper needed to be derived from existing digital data coverages or themes of proxy environmental data using logical criteria. Secondary themes that were derived from primary digital themes needed to be derived again using either the same transformation rules or proxy rules that we reconstructed using available information. In cases where information on model building procedures could not be obtained through interviews or review of existing documents or data, we had to infer the most likely procedures based on the logic of the model, insofar as it could be determined from existing information.

5.3.3.1 Refinement of Surface Models

In most cases, models for the demonstration installations were built using a combination of subjective and objective criteria. All are either Boolean or weighted intersection-type models. For nearly all of the models, the initial validation tests involved calculating validation statistics using double-validation techniques (see Section 5.5 below). For these tests, we used data from independent test units or from survey conducted after model development. We also used all the available data for a test of overall model performance.

Split-sample or resampling techniques require development of a formalized model that can be objectively recalculated using samples of the available data set. Prior to systemization, none of the existing models was in the state it needed to be to apply split-sample or resampling approaches. Systematizing the model required a thorough review of all written documents, metadata, and data layers, as well as consultation with installation managers and other staff involved in the modeling process.

Split-sample and resampling techniques are best applied to refined versions of the models, particularly ones based on multivariate regression methods. Split-sample or resampling techniques are not impossible to apply to intersection models but are better suited to multivariate regression models (see Section 5.5). Regression models evaluate the relative contribution of each variable to the predictive success of the model and focus on the most powerful predictors. The result of the analysis is an equation that calculates the probability that a given grid cell will contain an archaeological site. The resulting probability scores are used to generate a probability surface that can be translated into a sensitivity map. Regression models are popular among archaeological predictive modelers because they can be quite powerful. Of the more common multivariate techniques (e.g., multilinear regression, discriminant function analysis, principal components analysis, and logistic regression), logistic regression is often a preferred option for predictive modeling. Logistic regression makes few assumptions, handles continuous (ratio, interval, and ordinal scale values) and categorical (nominal scale values) variables equally well, and is designed for binary dependent variables, such as site presence/absence (Rose and Altschul 1988). When applied to Fort Drum and Eglin, however, logistic regression alone did not work particularly well. As a consequence, we experimented with recently available approaches to statistical modeling that take advantage of the increased processing power and statistical computing capabilities now available: Artificial Neural Network modeling and Random Forest modeling.

5.3.4 Development of Subsurface Models

Because of the dynamic nature of landscape change during and prior to human occupation, it is especially important to consider subsurface sites as part of the predictive modeling process. Previous research shows that landscape evolution has been rather dramatic during the Pleistocene and Late Holocene, due largely to the effects of changes in sea level at Eglin AFB and glacial lake levels at Fort Drum. Substantial effort has been expended on geoarchaeological studies at military installations. To date, however, the degree to which geoarchaeological studies have been incorporated into predictive models is rather uneven.

Subsurface modeling efforts aimed to delineate Holocene and late Pleistocene deposits in a variety of landforms that are likely settings where archaeological sites may be buried. A variety of geologic processes can bury archaeological sites. Examples of these processes include: (1) deposition of sediments on floodplain along streams, (2) formation of sand dunes and sand sheets, and (3) accumulation of sediment in the lower parts of hill slopes caused by gravity. Unconsolidated materials deposited by water, wind, and gravity are known as alluvial, aeolian, and colluvial deposits, respectively. Colluvial deposition can be caused by sheetwash, soil creep, debris flows, and landslides. For the purpose of this study, we are defining buried sites as ones buried at least 1 m deep that may lack overlying cultural deposits that extend to the surface. Sites

can be buried more shallowly than 1 m, but these sites have the potential to be identified by using shovel tests or test pits; we consider these surface or near-surface sites.

Methods for constructing subsurface models followed accepted practices in soil-geomorphological research, especially those studies based on previously published literature and reconnaissance visits rather than field investigations. Brown (1997), Goldberg et al. (2001), Holliday (2004), Onken et al. (2004), Waters (1992), and Wegmann et al. (2010) provide numerous examples of investigations of buried archaeological sites and the potential for such sites in a variety of geomorphic settings. The same basic steps were undertaken for each installation, including: (1) compiling and reviewing geological and soil data for areas on and near the four installations, (2) making reconnaissance visits to each installation, (3) meeting with other archaeologists and geoarchaeologists at each installation, (4) using or modifying existing geological and soil maps as overlays to predict locations where archaeological sites may be buried, and (5) working with GIS specialists on the research team to operationalize the model in a GIS.

Landforms that may be associated with buried sites were delineated using existing geologic maps and reports, previous landscape reconstructions, digital elevation models, hydrographic data, and soil survey maps and reports. Geological maps that differentiate Holocene and late Pleistocene units were especially useful. Similarly, high-resolution soil maps (e.g., at a scale of at least 1:24,000) were used to assess the age of soils and thus the likelihood of buried sites. The degree of soil development associated with different soil map units was used to identify and differentiate the approximate ages of different surfaces. For example, older surfaces are typically be underlain by B horizons (i.e., horizons with color and/or structural changes from the soil parent material or with illuvial accumulations of translocated clay, calcium carbonate, or other materials). By contrast, younger surfaces such as those on active flood plains typically lack a B horizon or have only very weakly developed B horizons.

The major goal of subsurface modeling for this project is to demonstrate the utility of modeling buried site sensitivity for CRM compliance.

5.3.5 Development of Management Models

A zonal management model is a map that integrates the results of validated surface and subsurface models of archaeological site location on the basis of transformational rules of assigning sensitivity to given polygons. It is this map that is used to establish priorities for survey coverage, level of effort, and other management decisions. As revisions are made to the underlying surface, subsurface, and red flag models, the zonal management model can and should be updated so as to provide installation staff with the most accurate and precise information with which to make management decisions.

A zonal management model was created for Eglin AFB and Fort Drum by intersecting the validated surface models (including red flag models, if prepared) and validated subsurface model in a GIS. The results map divides the entire installation area into multiple, non-overlapping polygons and identifies the sensitivity zone assigned by each of the underlying models. For example, a given polygon common to all the models could be designated as a low-sensitivity

area in the subsurface model, medium sensitivity in the surface model, and medium sensitivity in the red flag model. Thereafter, rules are consistently applied to different possible combinations of sensitivity levels (low, medium, high) from the underlying models in order to assign a single sensitivity level to each polygon on the map.

An example from Eglin AFB illustrates the transformation rules that allow us to develop a single but integrated layer useful for management. If a given polygon in the refined and validated surface model was defined as high sensitivity, in the validated red flag model as either medium or high sensitivity, and in the validated subsurface model as high, medium, or low sensitivity, then the same polygon will be defined as *high sensitivity* in the zonal management model. Similarly, if another polygon in the surface model was defined as low sensitivity, in the red flag model as low sensitivity, and the subsurface model as high or medium sensitivity, then the same polygon will be defined as *medium sensitivity* in the zonal management model. All remaining polygons in the zonal management model will be defined as *low sensitivity*.

5.3.6 Development of Section 106 Programmatic Agreements

As defined in 36 CRF 800, Part 16(t), "a programmatic agreement means a document that records the terms and conditions agreed upon to resolve the potential adverse effects of a Federal agency program, complex undertaking, or other situations in accordance with §800.14(b)." In other words, a Section 106 PA is a legally binding contract prepared to address potential adverse effects to National Register-eligible or -listed historic properties. It is developed by a federal agency in consultation with other parties as an overall plan that specifies what management actions will occur regularly and in what manner (e.g., inventory, evaluation, and nomination of archaeological site properties to the National Register), and what will occur when a number of possible situations arise (e.g., unanticipated discoveries encountered during federal undertakings, recovery of human remains).

Both NEPA and NHPA (Section 106) require that installations carry out planning and compliance activities in consultation with other parties who are referred to as "stakeholders" in NEPA and "consulting parties" in NHPA. These other parties include the ACHP, SHPO, THPOs, federally recognized Indian tribes, and others with a demonstrated interest in the effects of installation actions on historic properties. Although the laws and regulations do not require the federal agency to accede to the requests of these parties, a good-faith effort to secure and consider their input is required.

At the installation level, non-military stakeholders and Section 106 consulting parties are concerned with ensuring that historic properties have been properly identified and evaluated, that every attempt has been made by the military to avoid impacts to these resources, and if the resources cannot be avoided, that appropriate types of mitigation treatments are implemented. In order for stakeholders to accept the use of models in support of these planning and compliance efforts, they must be confident that the models themselves are sufficiently precise and accurate. Stakeholder also must be assured that the particular uses to which the models will be put are appropriate and consistent with the spirit and intent of the NHPA and NEPA. Ultimately, stakeholder buy-in will be demonstrated when the DoD installation secures the signatures of the ACHP (if participating) and the Section 106 consulting parties (e.g., the SHPO, tribes.) on a PA.

This PA will establish how the installation will incorporate models into its compliance with NHPA and NEPA (see Appendices E and E for draft examples).

Previous attempts to incorporate predictive models into the compliance have largely failed because they have been one sided. Without consulting non-military stakeholders, the installation typically develops a predictive model and presents it as a *fait accompli*. Given their lack of involvement in model development, it is little wonder that non-military stakeholders view these models skeptically. A better approach is the one used by the Minnesota DOT in the development of MnModel. In that case, stakeholders were brought into the process at the very beginning; model development took into account the various concerns of DOT and non-DOT parties. Buy-in for the model, then, was relatively easy.

Following the Minnesota example, we intended to secure stakeholder buy-in through a consultation process that involves the following steps, carried out by the installation CRM staff working with demonstration project team:

1. Identify installation-specific stakeholders/consulting parties.
2. Introduce the stakeholders/consulting parties to the concept of using archaeological models in compliance. Secure initial information on ideas and concerns.
3. Facilitate discussion among stakeholders/consulting parties on appropriate uses of models in planning and compliance.
4. Work with the parties to identify compliance problems and other preservation issues being experienced at the installation that could be ameliorated with more effective use of models.
5. Invite the parties to participate in developing a PA to incorporate models into installation archaeological resource management.
6. Explain the process by which a PA at each installation will be developed and solicit initial input from the parties in drafting an agreement.
7. Draft an agreement document that expresses the greatest consensus achievable among the parties on how models should be used in compliance.
8. Execute and implement the agreement document.

The project team met with the CRM staffs at Eglin AFB and Fort Drum and frequently discussed the PA and the use of modeling to meet their compliance needs initiating steps 1–4 above. Consultation occurred with the New York SHPO, and to a lesser degree, consultation with the Florida SHPO, as did discussions with the ACHP in Washington D.C. The CRM staff at Fort Drum informed their tribal partners of the PA's development and shared with them an outline of the agreement; however, no other parties were included in preparing the first drafts. Consultation did not occur in large part because preparation of the PA had to wait until much of the modeling was completed so that the details of using the models in the context of a PA could be discussed; this point was reached towards the end of the contract period. With the submittal of this demonstration report, however, and the first drafts of the PAs developed for Eglin AFB and Fort Drum (Appendix B and C), consultation with the other parties can now begin. Both Eglin AFB and Fort Drum intend to continue the process of developing their PAs, in consultation with all appropriate parties, beyond the end of this demonstration project.

5.4 FIELD TESTING

Testing of Eglin's and Fort Drum's predictive models began in February 2009 and extended through August 2010. For each installation, the baseline surface model was systematized, refined, and validated and a preliminary subsurface model was constructed using available geological and archaeological information. A red flag model was also created for Eglin AFB. A zonal management model integrating surface (including the red flag model, if developed) and subsurface models installation was also created.

Below we discuss the field testing requirements for each installation and model.

5.4.1 Eglin AFB Models

Prior to the demonstration project, Eglin AFB had developed a partially systematized surface model for prehistoric sites and did not have a subsurface model. As part of the demonstration, the Eglin AFB baseline surface model was operationalized in a GIS, validated, and refined. In addition, a newly constructed red flag model representing the location of large prehistoric habitation sites was constructed and validated, and a subsurface model was developed using available geological and archaeological evidence. The refined surface model, subsurface model, and red flag model were subsequently combined into a zonal management model, representing the combined elements of all three models.

5.4.1.1 Eglin AFB Baseline Prehistoric Sites Surface Model

Thomas and Campbell (1993; Prentice Thomas Associates 2005) constructed a predictive model for Eglin AFB that was first developed in the early 1980s. Eglin's surface model was created initially on paper using a set of rules for predicting prehistoric site location irrespective of site type. During Legacy Project #03-167, model evaluators could not reconstruct Eglin's original surface model in GIS with adequate precision or accuracy because: (1) the paper maps had not yet been digitized, and (2) GIS layers used to reconstruct the model had not yet been corrected for errors (i.e., site locations, potable water locations). As a result, they reconstructed the model using proxy variables and somewhat faulty data (Altschul et al. 2004; Prentice Thomas Associates 2005).

As part of this demonstration project, the baseline model for Eglin AFB was reconstructed in a GIS using the formal rules established by Prentice Thomas Associates (PTA) in creating the model. In the baseline model, high sensitivity areas are locations that are less than 200 m from potable water and less than 15.24 m (50 ft) in elevation above potable water. All other areas are considered to be of low sensitivity. To reconstruct the baseline model for this project, a GIS layer representing potable water sources was developed by extracting vector data from the USGS National Hydrography Dataset (U.S. Environmental Protection Agency 2006) on the location of stream networks, springs, seeps, and ponds for an area encompassing the installation. These polygon, point, and line data were converted into raster format and combined into a single raster layer identifying the presence or absence of potable water. Distance to potable water was then operationalized in a GIS by calculating for each raster cell the Euclidean distance to the nearest potable water source.

Calculation of distance above water took several steps. First, raster cells representing potable water were attributed with elevation data, such that each cell representing potable water was assigned the local elevation as derived from the National Elevation Dataset. Then, another raster layer was created wherein each cell was assigned with the elevation of the closest raster cell representing a potable water source. To obtain distance above water, this latter raster layer was subtracted from the local elevation of each raster cell, essentially representing the relative elevation of any cell with respect to the closest potable water source. The baseline model was then calculated by identifying as high sensitivity any cell that was less than 200 m from water in the *distance to water* raster and less than 15.24 m (50 ft) above water in the *distance above water* raster.

The resulting model consists of areas of high sensitivity that mostly hug the drainages and other potential water sources (springs, seeps) and areas of low sensitivity located further away from water sources (Figure 5-3).

Testing of the model using available CRM data and validation statistics revealed that the model works quite well for many areas of the installation as well as for many common prehistoric site types. Following Thomas and Campbell's (1993) important insight that prehistoric sites at Eglin AFB were distributed differently according to watershed, the installation was divided into a series of watersheds using data from the National Hydrography Dataset: Santa Rosa Island, Choctawhatchee Bay, East Bay, East Bay River, and Yellow River. Choctawhatchee Bay was further subdivided into eastern and western watersheds, since there appeared to have been substantial variation between the eastern and western halves of the watershed in site density and in drainage morphology and density. Site types and temporal affiliations were also developed for individual sites using information provided in the Eglin AFB CRM database on descriptive information on occupation type and site function. Site type or temporal affiliation could be assigned for many sites, but cannot be considered comprehensive, as site type information was not available for all sites with prehistoric components.

5.4.1.2 Eglin AFB Refined Prehistoric Sites Surface Model

To be consistent with how Eglin has used their existing predictive model, the surface model developed for Eglin AFB was constructed as a binary model, consisting of high- and low-sensitivity zones, rather than high-, medium-, and low-sensitivity zones. This allowed the model to function according to Eglin AFB's existing protocols for intensive survey in the high-sensitivity zone and also allows a stricter comparison of the baseline and refined surface models. To develop a refined model, a series of additional variables were developed and their association with site location was examined visually with histograms and tested with correlation statistics. Examination of prehistoric site locations suggested that in addition to being located close to streams, prehistoric sites tended to be located in proximity to specific ecological zones, wetland edges, or the edges of soils with thick A horizons (which could represent prior wetland areas). In addition, sites tend to be located near hydrological network junctions (such as springs, confluences, or headwaters), in areas of high vegetation diversity, or were located near the coast, such as in the case of many large habitation sites.

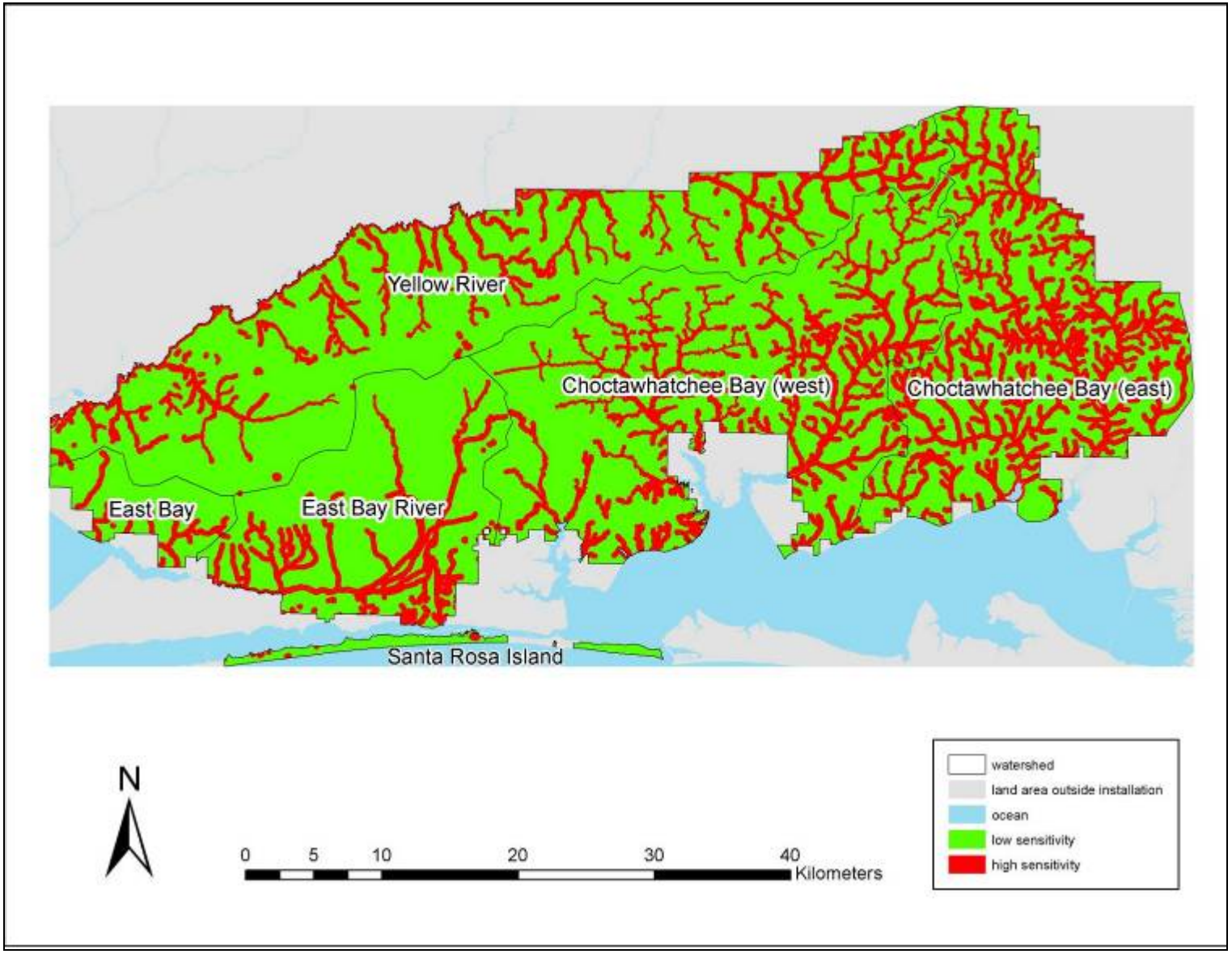

Figure 5-3. The Eglin AFB baseline surface model, operationalized in a GIS.

Predictor variables used in constructing the refined model were derived from data in national environmental mapping datasets. These included:

- National Hydrography Dataset Plus Data (EPA 2006)
- SSURGO Soils Data (NRCS 2009a, 2009b, 2009c)
- Geospatial Wetlands Digital Data (USFWS 2009)
- National Elevation Dataset Data (Gesch 2007; Gesch et al. 2002)
- National Land Cover Data (USGS, NBII, GAP 2010)

Most of the variables that were used in modeling were continuous variables, and many of these were also distance measures, such as distance to potable water. Other measures included a richness measure, elevation, percent slope, the presence or absence of wetland. The variables used to refine the baseline model were the following:

- Elevation above potable water
- Distance to potable water
- Distance to hydronet junction
- Stream level
- Distance to flow accumulation feature
- Wetland presence/absence
- Distance to wetland edge
- Distance to soil facies with a thick A horizon
- Distance to coast
- Percent slope
- Vegetation Richness
- Distance to Sand Pine Forest
- Distance to Galberry/Saw Palmetto Shrubland
- Distance to Mixed Evergreen, Cold Deciduous Forest
- Distance to Mesic-Hydric Pine Forest
- Distance to Swamp Forest Ecological Complex
- Distance to Loblolly Bay Forest
- Distance to Xeric-Mesic Mixed Pine/Oak Ecological Complex
- Percent Sandhill Ecological Complex within 150 m radius

After developing and testing the variables, we experimented with developing a variety of logistic regression models. Applying logistic regression did not result in a model that worked much better than the baseline model, which is a testament to the strength of the original model. We also found that we arrived at different results for individual watersheds. Variables that were associated with site location and their relative importance varied between watersheds, suggesting that separate models needed to be created per watershed.

To experiment with a different approach, we used a new statistical prediction method called Random Forest Modeling. Random Forests are a kind of Classification and Regression Tree (CART) analysis. CART is a non-parametric decision tree statistical learning technique. The technique performs classification or regression analysis depending on whether the dependent

variable that is being predicted is a continuous or categorical variable. In our case, the dependent variable is a categorical binary variable (site presence or absence), and thus the approach that is applied is a classification analysis.

The decision trees developed in CART are formed by creating a series of rules that partition variables in order to differentiate observations with respect to the dependent variable. For instance, if sites were most often located within 200 m of potable water during a given iteration of tree growth, then a node in the decision tree would be formed with a split for that variable at a value of 200, forming two child nodes beneath that node. Those child nodes could be further split into subsequent child nodes based on splits in other variables (Figure 5-4). The splitting of parent nodes into child nodes ends when no further gain in predictive power is attained by the creation of additional child nodes or, alternatively, the tree is developed exhaustively and then pruned in order to optimize gain in prediction.

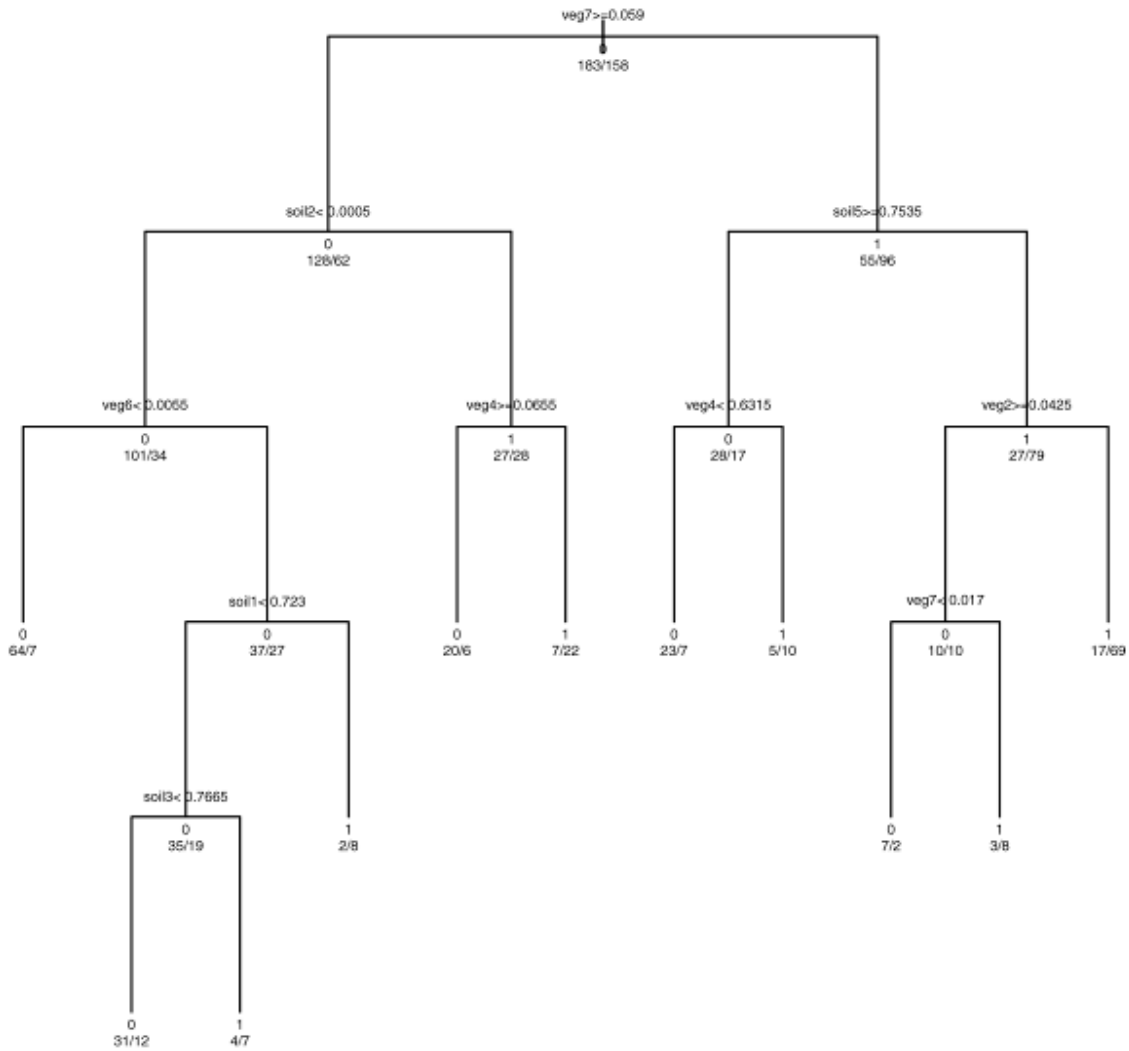

Figure 5-4. Example of a Decision-Tree Diagram.

Random Forests is an approach to CART that was specifically designed to overcome problems with overfitting the data that are common to other statistical modeling techniques. In Random Forests, multiple trees are constructed using bootstrapped samples of both the independent variables and the cases. Bootstrapping refers to a resampling process used in statistics whereby multiple samples are drawn with replacement from a larger sample (an individual case can be drawn more than once). Bootstrapping is often used to calculate the accuracy of sample statistics. In other words, the CART approach is applied numerous times to create hundreds or thousands of trees, with each tree formed using a randomized set of predictor variables and cases. For instance, if there were 20 variables and 600 cases, each tree would be formed using a random subset of variables (e.g., 7 variables) and a random subset of cases (e.g., 200 cases). Each tree is grown to its maximum size without pruning, with error estimates (referred to as "out-of-bag [OOB] estimates") made using the sample of cases withheld from tree formation.

The repeated formation of independent trees using randomized sets of predictors often eliminates the need for creating separate test and training sets, as these sets are continually created hundreds or thousands of times through the bootstrap process. The outputs are averaged by taking a vote across the trees for each node, which results in a model that is robust to overfitting, diminishes problems with intercorrelations between variables, and reduces bias introduced by individual variables or cases. A disadvantage of the approach is that the approach is somewhat of a black box, in that it is not possible to interpret easily how individual trees contribute to the final model, as literally hundreds or thousands of trees are created. However, the approach does provide a number of statistical measures that allow the estimation of the importance of each model variable in creating the model and in estimating the error rate of the model predictions (referred to as the OOB error).

Random Forest models were developed using a program available in R, an open source statistical platform available on the internet, called ModelMap (Freeman and Frescino 2009). ModelMap allows the user to create a Random Forest classification or regression model using a table of cases consisting of a response variable and its corresponding values for any number of categorical or continuous predictor variables. The program then allows the user to run internal validation tests and calculate statistics on model performance, including OOB estimates and the area under the Receiver Operator Characteristics curve, as well as provides graphs of variable importance. Once a satisfactory model has been developed and tested internally, a user can call on ModelMap to create a prediction raster using the Random Forest model file created by ModelMap.

Models were developed using the classification method available in ModelMap with the response variable set as the presence or absence of a prehistoric site in a sample location. Models were first run for each individual watershed using all the variables listed above to determine predictor variable importance. Subsequent models were then created using only the most important predictor variables. Models with promising statistical measures of performance were then developed into prediction maps which were subsequently validated with installation CRM data. Once a satisfactory surface model had been created for each watershed, these models were then combined into an installation-wide surface model, representing zones of low and high sensitivity for prehistoric sites (Figure 5-5).

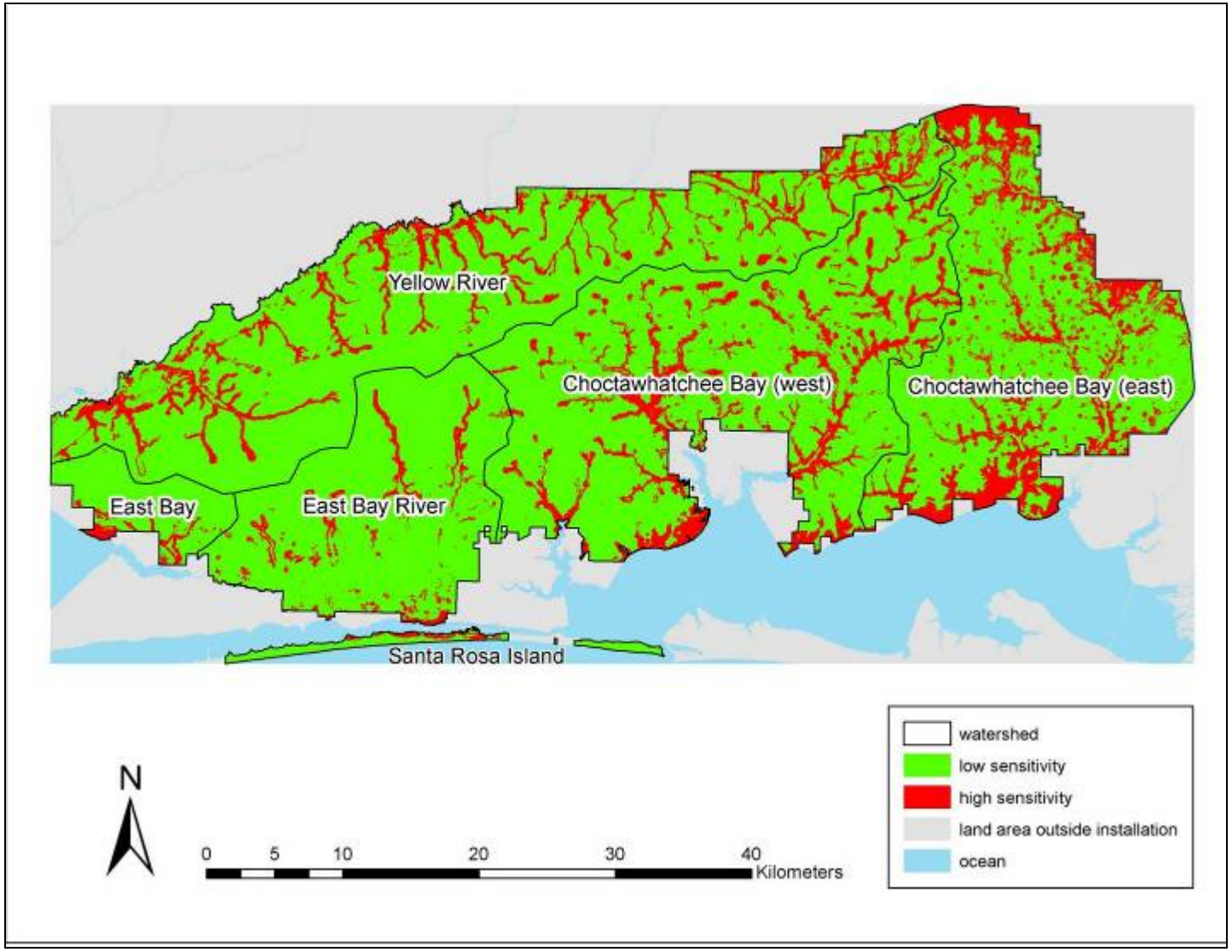

Figure. 5-5. The Eglin AFB refined surface model.

The high-sensitivity zone in the resulting model converges in many respects with the high-sensitivity zone in the baseline model, since many sites are located in close proximity to potable water. However, the high-sensitivity zone comprises a much smaller area in the refined model in comparison to the baseline model (Figure 5-6). Figure 5-6, for example, compares the prediction of the baseline and refined surface model, with the baseline model shown in hachure and the refined model depicted in red. The baseline model identifies 28 percent of installation area as high sensitivity whereas the refined model identifies just 17 percent of installation area as high sensitivity—a nearly 40 percent reduction in the size of the high-sensitivity zone. Most of the high- sensitivity zone in the refined model occurs within the high-sensitivity zone of the baseline model, but the refined model also identifies some high-sensitivity zone outside of the baseline model high-sensitivity zone. This is particularly the case for sites located along the coast, which were generally not predicted well by the baseline model, or in the vicinity of some stream heads and network junctions where a somewhat broader area of high sensitivity was defined in the refined model, in comparison to the baseline model.

5.4.1.3 The Eglin Subsurface Model

Eglin AFB lies in the Coastal Plains Province, which is divided into the Western Highlands and the Gulf Coastal Lowlands. Both of these divisions are the result of higher sea level stands in the past, with the latter forming after sea level dropped during the Pleistocene. The base contains a series of Quaternary marine terraces representing Pleistocene and earlier times (Pliocene-Miocene) and that formed in response to episodic changes in sea level. These terraces include the Undifferentiated Upland (45.7 m), High level terrace (39.6 m), Penholoway (24.4 m), Pamlico (7.6–9.1 m), and Silver Bluff Complex (-1.5 m) (Johnson and Fredlund 1993). Johnson and Fredlund (1993:Figure 13 and Folio 5) mapped the geomorphic surfaces of Eglin. The early Holocene was a time when sea level rose from a Late Pleistocene low stand, with sea level reaching approximate modern conditions about 6,000 B.P. Other major geomorphic features of the base include the barrier island-bay complex (Santa Rosa Island and associated bays and lagoons) and alluvial terraces associated with rivers and creeks.

The previous geomorphological and paleoenvironmental studies by Johnson and Fredland (1993) and Fredlund and Johnson (1993) provide a good basis for interpreting the geoarchaeology of Eglin AFB. These researchers note that between 8,000 and 6,000 years ago there was significant landscape change, as sea level rose and fluctuated, stream systems stabilized, and valleys filled with organic-rich debris. Johnson and Fredlund (1993:78) noted that, “Sites may be buried in the project area through the process of aggradations of low-lying terraces or floodplains, colluvial accumulation, blowing sediments or a combination thereof.” Paleosols were identified in the Yellow River terrace fill, at Indigo Head, and in an exposure resulting from construction activity along State Highway 285. With the exception of a flake found at the latter, no buried cultural deposits were identified in association with the paleosols.

A visit was made to Eglin AFB on July 6–9, 2008 by the demonstration project geoarchaeologist, Dr. Jeffrey Homburg. During the visit, Dr. Homburg met with Mark Stanley (Eglin AFB archaeologist), Joe Meyer (Center for Environmental Management of Military Lands [CEMML] archaeologist), William “Sandy” Pizzolato (CEMML Natural Resources Research Associate),

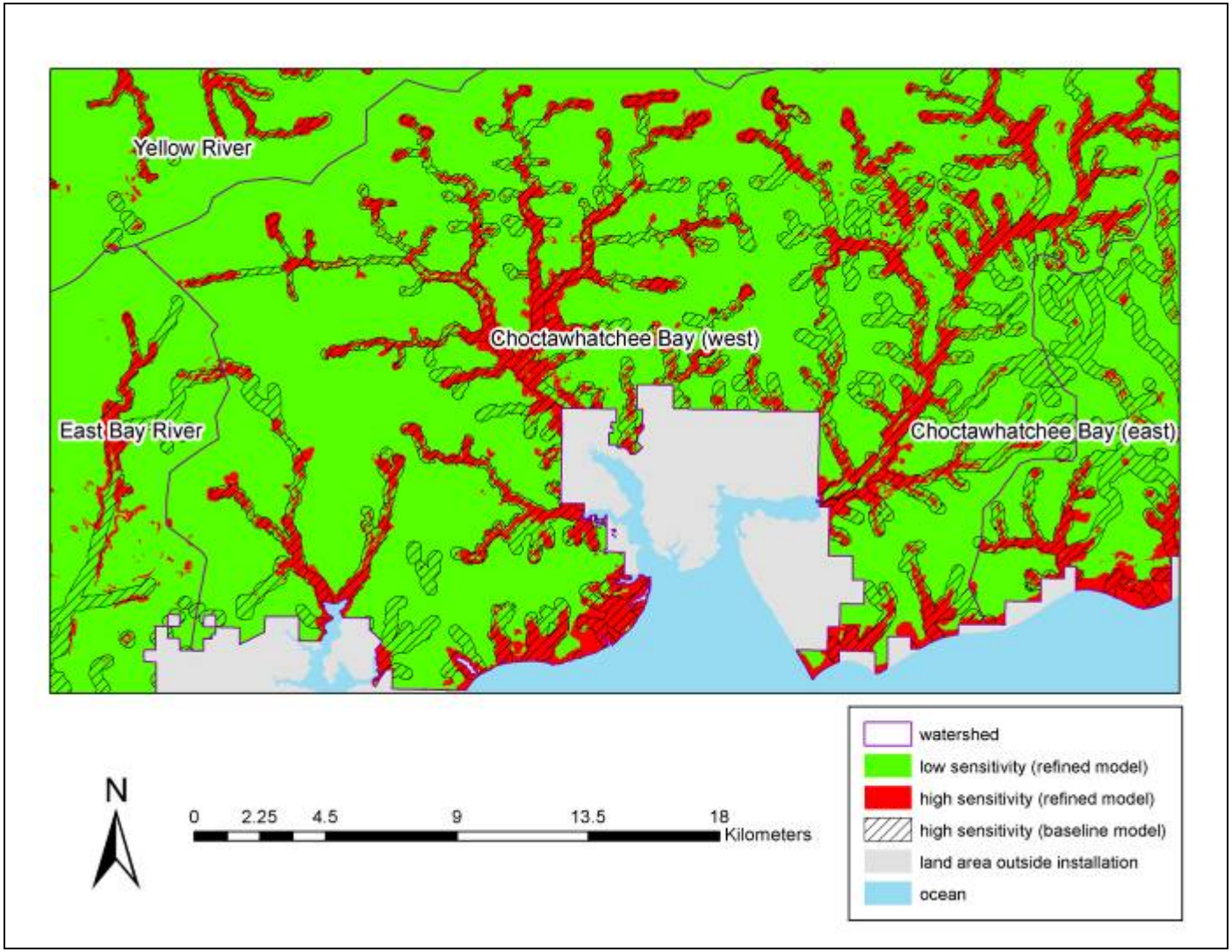

Figure 5-6. A close-up view of the Eglin AFB refined surface model in the western half of the Choctawhatchee Bay watershed.

and three archaeologists with PTA: Dr. Prentice Thomas, Janice Campbell, and James Moorehead. A field reconnaissance was made with Dr. Thomas to visit archaeological sites on Santa Rosa Island and the coastal plain north of Choctawhatchee Bay and with Mr. Meyer to visit sites across a variety of upland and alluvial settings within the installation.

Data for subsurface modeling at Eglin AFB included geologic literature, geologic maps, and soil survey maps produced by the NRCS for Fort Walton, and Okaloosa counties. Pertinent geologic literature includes the following references: Basille and Donoghue (2004), Blum et al. (2002), Coe (1979), Cronin (1981), Donoghue and Tanner (1992), Fredlund and Johnson (1993), Healy (1979), Huddlestun (1984), Johnson and Fredlund (1993), Kwon (1969), Lisecki and Raymo (2004), Otvos (1982, 1992), Scott (2001) Stone et al. (2004), Vernon (1956), and Wang et al. (2006). The archaeological testing report by Moorehead et al. (2001) also was consulted.

There is strong potential for buried archaeological sites to exist in a number of settings at Eglin AFB, but most of the base has low to no buried site probability (Figure 5-7; Appendix F, G, and H). Approximately 82 percent of the installation consists of areas of low sensitivity for buried sites, while approximately 11 percent consists of medium sensitivity zone and 7 percent consists of high sensitivity zone. Settings with a relatively high sensitivity for containing buried sites include: (1) late Pleistocene and Holocene alluvial valley fill deposits in major drainages such as the Yellow River, and the lower reaches of creeks draining into Choctawhatchee Bay such as Alaqua Creek; (3) the Silver Creek Complex, low-lying coastal areas below ~1.5 m in elevation, especially around protected bays where the surface has been buried by tidal surge deposits associated with hurricanes and tropical storms; and (4) between or below stable dunes on Santa Rosa Island. Medium probability areas include colluvial footslopes within dissected valleys of the Western Highlands and the East Bay Swamp, which was much dryer prior to the mid-Holocene sea level rise. For the purpose of predictive modeling, colluvial areas were arbitrarily delineated by a 40-m wide area buffering streamlines in the interior of the installation. Areas with low to no probability for buried sites comprise much of the interior of the installation, areas dominated by undissected Pleistocene and earlier coastal plains of the Western Highlands. Small pockets of colluvium may exist in this area with some potential for buried sites. Areas with no potential include areas of small ponds.

It is important to clarify our interpretations of the high potential for buried sites in aeolian settings at Eglin AFB, especially in consideration that our surface model identifies much of Santa Rosa Island, a setting dominated by dunes, as having a low sensitivity. Because of the dynamic nature of dunes on Santa Rosa Island and other barrier islands of the Gulf coast, they are subject to being reconfigured or removed by hurricane tidal surges. Such storms have adversely affected archaeological sites associated with dune and interdune swales on the island. As observed by Dr. Prentice Thomas during the field reconnaissance of the island, the dunes that exist today have little relation to earlier ones, as recent hurricanes have dramatically altered the distribution and geometry of dunes during the last decade. Nevertheless, sites may be buried either in dunes or in the interdune swales, and that is especially so in and near dunes close to the Santa Rosa Sound, which are stabilized by mature live oak trees. That said, it is likely that sites on the island have low artifact densities and thus may be less detectable archaeologically, unlike those of shell middens along the shoreline of protected bays.

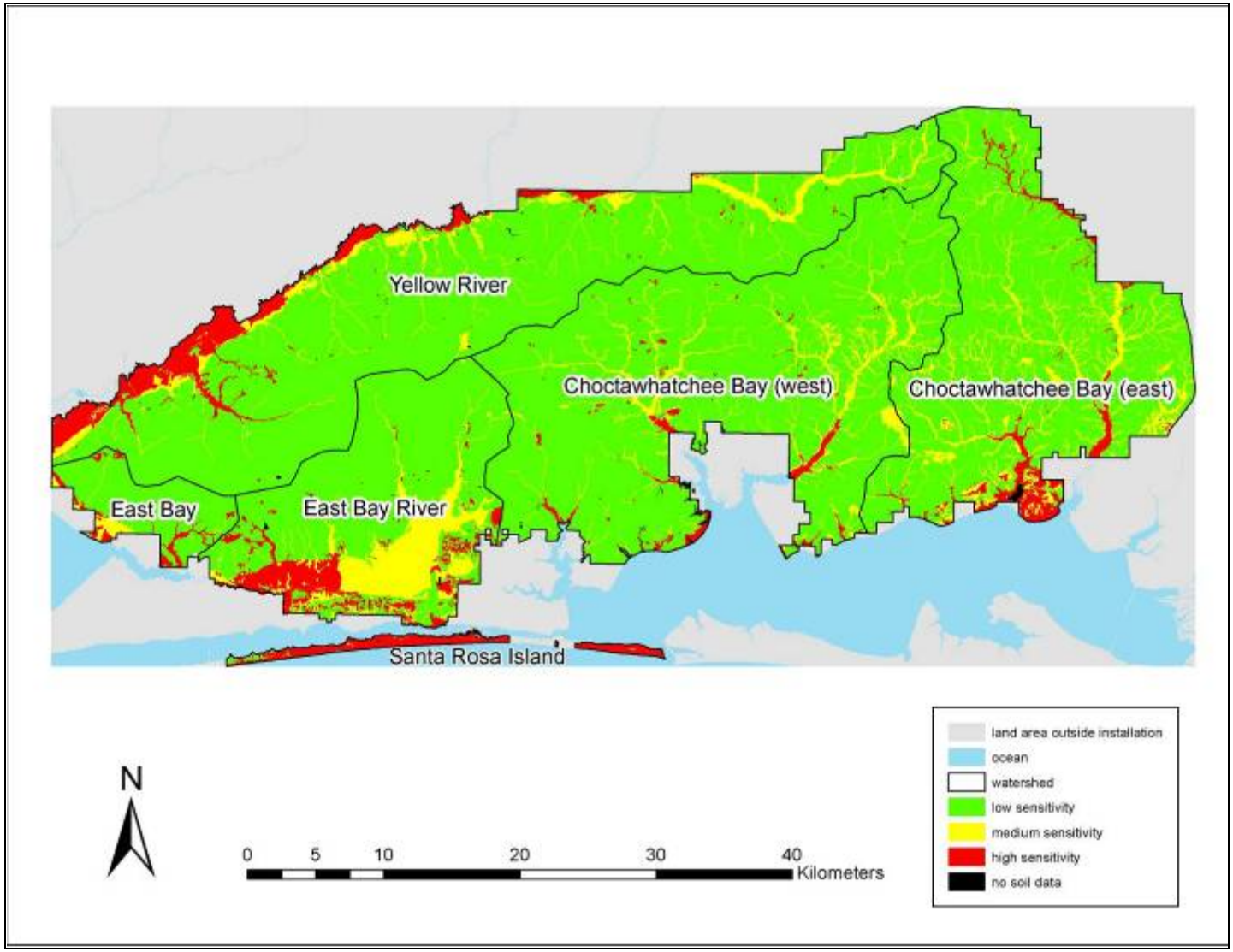

Figure 5-7. The Eglin AFB subsurface model.

Although Johnson and Fredland (1993) dated some Quaternary deposits at Eglin AFB, we recommend more work to improve the geochronology of deposits that may contain buried archaeological sites and to determine the depth to which sites may be buried in different settings. Little geologic data exists for determining the ages of alluvial, aeolian, and colluvial deposits. In all likelihood, few sites are buried much below 5 m or so, but the most deeply buried sites are expected in the alluvium of larger drainages such as the Yellow River and, perhaps, below larger dunes on Santa Rosa Island. Buried sites associated with the alluvium of smaller drainages are likely shallower, perhaps in the range of 1 m to 5 m deep, and those associated with colluvial footslopes are probably less than 2 m. These depth estimates, however, should be tested with trenching and/or coring. Efforts to refine the buried site sensitivity model should focus on dating Holocene and late Pleistocene landforms. In particular, backhoe trenching and/or coring should focus on alluvial terraces, marine terraces associated with the Silver Bluff Complex, and aeolian deposits. This work should be done in order to obtain samples for radiocarbon and optically stimulated luminescence (OSL) dating.

In particular, additional work is needed to map and date aeolian deposits that cap the Pamlico terrace, a marine terrace with underlying sediments that Eugene Otvos, geomorphologist at the University of Southern Mississippi, dated in a similar setting on the Gulf Coast further east Eglin AFB by OSL to the Sangamon (Marine Isotope Stage 5e, approximately 130,000 to 115,000 years before present) (James Morehead, PTA geoarchaeologist, personal communication, October 28, 2011). In similar aeolian deposits near Choctawhatchee Bay on Eglin AFB, Morehead reported a 1 m to 2.3 m deep cultural feature at 8WL68. Here, a Kirk Corner-notched point was recovered along with burned debitage, two hammerstones, biface fragments, and some calcined bone fragments This site highlights the potential to find other sites buried more than 1 m deep in dunes or sand sheets on the Pamilico terrace. Morehead noted that Dr. William Johnson, geomorphology professor at the University of Kansas, plans to collaborate with PTA to obtain a series of OSL dates for dating the early Holocene deposits of aeolian deposits on the Pamlico terrace of Eglin AFB.

5.4.1.4 The Eglin Red Flag Model

Using data available in the Eglin CRM database, the following site types were identified: campsite, collection station, burial site, mound site, village/hamlet site, and site of undetermined function. To develop a red flag model, village/hamlet sites, a burial site, and a mound site were used to represent sites that would be especially costly to mitigate should they be discovered or impacted accidentally during installation activities. The same basic approach to constructing the refined surface model for Eglin AFB was used to construct the red flag model, with the exception that the entire installation was used as the basic modeling unit rather than individual watersheds, since red flag sites are relatively rare and occur in small numbers in any individual watershed. The resulting model predicts red flag sites to be located along the coast near estuaries and inlets, on Santa Rosa Island, in the vicinity of large wetlands along Yellow River and East Bay River, and in the interior of the installation near river headwaters and springs (Figure 5-8).

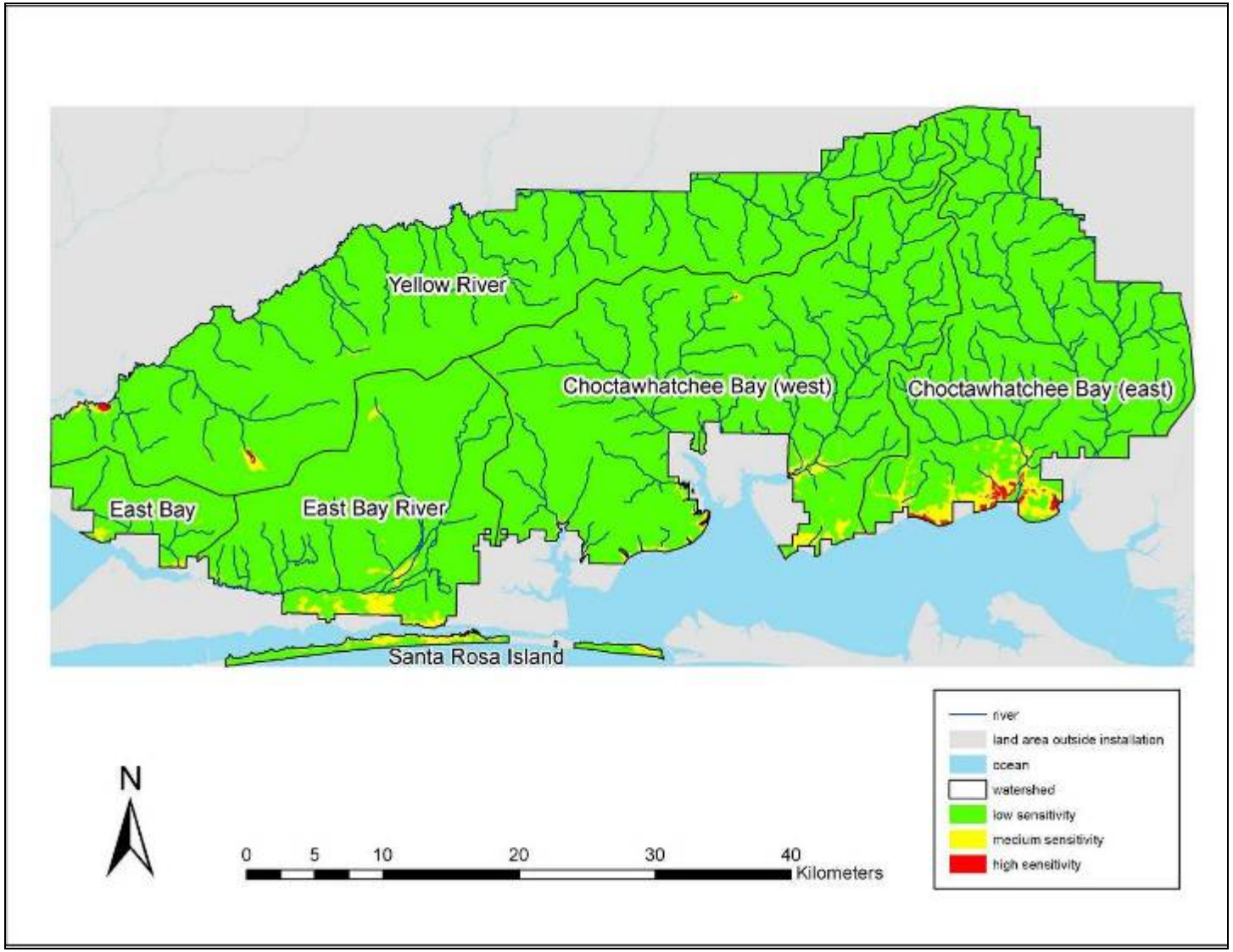

Figure 5-8. The Eglin AFB red flag model.

5.4.1.5 The Eglin Zonal Management Model

A zonal management model for Eglin AFB was created by intersecting the refined surface model, subsurface model, and red flag model in a GIS. The zonal management model consists of three sensitivity zones (low, medium, and high) that were defined based on a set of relatively straightforward transformation rules. Three zones—rather than two zones (low and high)—were used, in part, because three zones were used in the subsurface and red flag models. The revised surface model, by contrast, consists of two zones. This is because the existing surface model at Eglin AFB is a bimodal model, indicating high or low potential for predicting site location; Eglin CRM staff requested that our revised *surface* model also be bimodal. Having three zones in the zonal management model, rather than two, allows the identification of areas that will likely require the application of different survey methods and management strategies. Essentially, the high-sensitivity zone in the zonal management model identifies land parcels where surface sites are likely to be discovered using conventional survey techniques. As such, the zone identifies those areas of the installation that should be subjected to standard survey. The medium-sensitivity zone identifies land parcels where sites with a predominately subsurface expression are likely to be encountered, based on current geoarchaeological information. The medium-sensitivity zone consists mostly of wetland areas where little investigation has occurred to date and where there is a low potential of discovering sites using conventional survey methods, but where geoarchaeological information suggests a medium or high potential for buried sites. In these areas, field methods designed to discover buried wetland sites will need to be applied, in place of conventional survey methods, in order to increase the likelihood of finding buried sites. The low-sensitivity zone identifies areas where surface and subsurface sites of any kind are unlikely to be discovered, based on survey results as well as geoarchaeological information. As such, the low-sensitivity zone identifies those areas that should need to be subjected to no or minimal survey.

The transformation rules used to define the sensitivity zones of the zonal management model were as follows. Land parcels that were high sensitivity in the surface model or either medium or high sensitivity in the red flag model were assigned to the high-sensitivity zone in the zonal management model. Land parcels that did not fulfill the above criteria and were either medium or high sensitivity in the subsurface model were assigned to the medium-sensitivity zone in the zonal management model. Land parcels that fulfilled none of the above criteria were assigned to the low-sensitivity zone in zonal management model. In other words, these were land parcels with low sensitivity for surface, subsurface, and red flag sites.

As currently defined, the zonal management model allows managers to identify unsurveyed areas in the high-sensitivity zone that will likely need to be subjected to conventional survey, since these are areas where prehistoric sites in general or red flag sites in particular are likely to be located (as predicted by the refined surface model and the red flag model). The medium-sensitivity zone identifies areas where there is subsurface potential for buried deposits based on the predictions of the subsurface model, but where neither the red flag nor the refined surface model have predicted sites to be located. Since the vast majority of the medium-sensitivity zone consists of wetlands, surveyed areas within this zone would likely need to be tested according to different discovery methods and sampling strategies than are applied during conventional shovel test survey. The low-sensitivity zone of the zonal management model, as stated above, consists

of areas where the potential for prehistoric sites or buried deposits of an appropriate age is predicted by all of the models to be low. This zone would thus be subjected to a lower level of survey effort and different discovery methods than would be applied in the medium- or high-sensitivity zones of the zonal management model.

The resulting model places approximately 71 percent of land area in the low-sensitivity zone, 11 percent in the medium-sensitivity zone, and 18 percent of land area in the high-sensitivity zone (Figure 5-9). The model performs well for low- and high-sensitivity zones when tested with prehistoric site data obtained through surface survey, but does not perform well for the medium-sensitivity zone. The poor performance is due entirely to the incorporation of the subsurface model, which predicts large areas of wetland as medium or high sensitivity for buried sites and where survey has been minimal.

Poor performance of the model in the medium-sensitivity zone need not be construed as a problem, since the purpose of the subsurface modeling effort and the resulting zonal management model was to better account for the potential for subsurface sites. In addition to indicating where sites are likely to be located based on the surface model and red flag model, the zonal management model identifies areas where buried sites may occur based on lines of evidence independent of where "surface" sites have been found using conventional survey methods.

The subsurface model can be refined in the future with subsequent efforts to test the model. To ignore the predictions of the subsurface model simply because the model is a preliminary one requiring future refinement would be to completely negate the subsurface modeling effort and undermine any value the subsurface model has to offer. Moreover, since few wetland areas have been surveyed and the installation has a commitment to survey wetland areas, it is reasonable to include these areas in the zonal management model as medium sensitivity, since little is known empirically about their potential to contain sites and wetland areas are not captured well by the baseline or refined surface models.

Having a zonal management model that takes account of subsurface sensitivity buffers the installation from risk and indicates areas that should be examined but are not captured well by the other models. One could argue, for instance, that not a lot is known archaeologically about the wetlands areas, but what is known is that the larger wetland areas near the coast were likely to have been substantially drier during the late Pleistocene and early-to-mid Holocene and may have been more extensively used during those times. What the subsurface model contributes to the zonal management model is the expert geoarchaeological opinion regarding where buried sites could exist given an understanding of landscape formation processes. We cannot place much confidence based on current survey data that buried sites do not exist in the wetlands areas given a lack of data, but we can place at least some confidence in formalized expert opinions as to where there is potential for such sites.

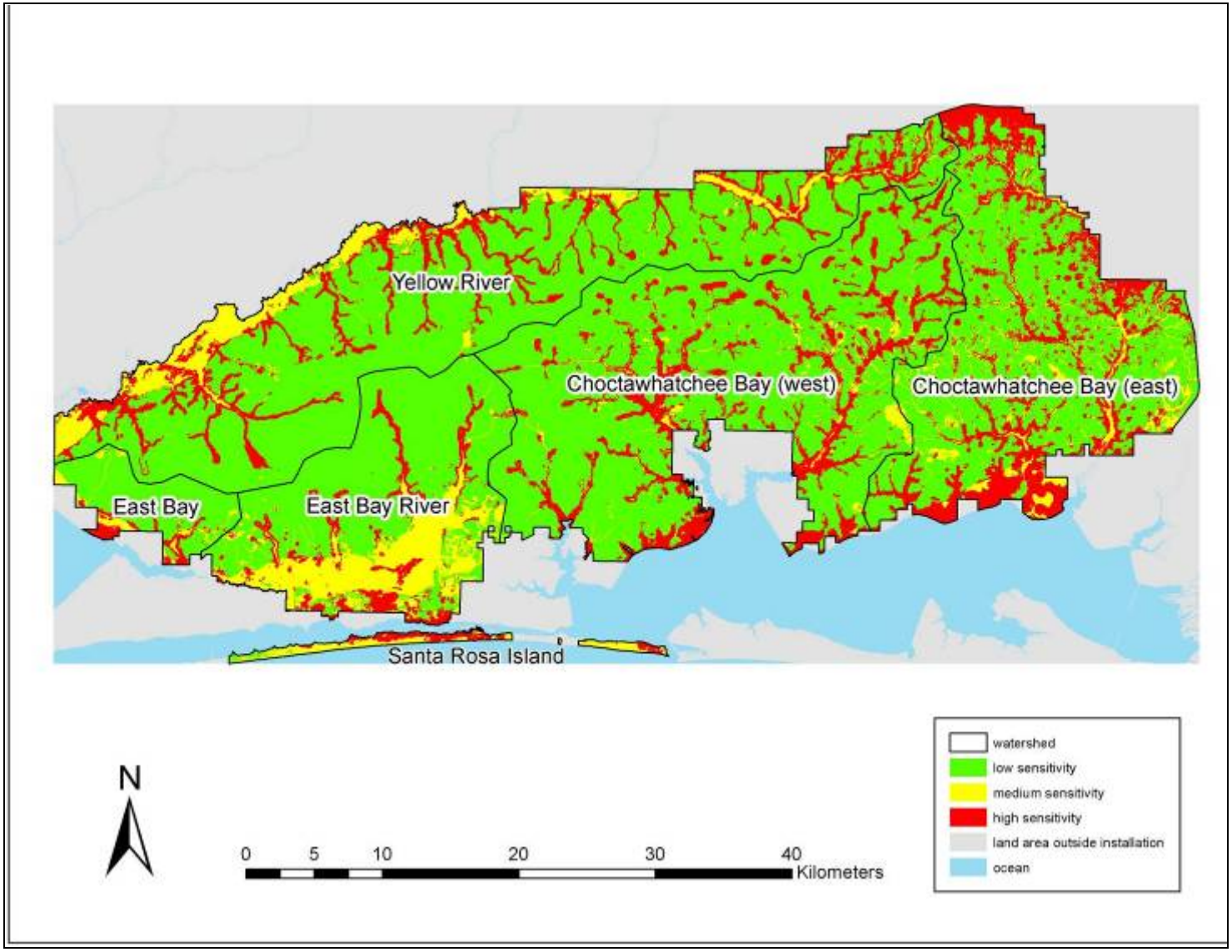

Figure 5-9. The Eglin AFB zonal management model.

5.4.2 Fort Drum Models

Prior to the demonstration project, Fort Drum had developed two unsystematized surface models and did not have a subsurface model. As part of the demonstration, the Fort Drum surface models were systematized, validated, and refined and a subsurface model was developed using available geological and archaeological evidence. A red flag model could not be developed due to a lack of available information in the CRM database on site types. As a consequence, a zonal model was constructed that combined the refined surface model and the subsurface model for Fort Drum, but did not include a red flag model.

5.4.2.1 Fort Drum Surface Models

Fort Drum is located in north-central New York. The base is divided into four main physiographic zones (Rush et al. 2003): (1) Upland—the Greenville and Adirondack foothills; (2) Lake Plains—a relict lake plain comprised of fine-grained glaciofluvial and lacustrine deposits with mucks and peats and scattered gravelly till piles (up to 15 m tall) that overlie Cambrian sandstone and Precambrian granite and gneiss; (3) the Pine Plains—a fan-delta consisting of approximately 30 m of sandy glaciofluvial and lacustrine deposits that mantle Precambrian and Ordovician bedrock, and (4) Alluvial Flood Plain—a small area on the southern edge of the installation consisting of Black River alluvium.

Fort Drum's existing predictive models for archaeological site locations cover different portions of the installation. One model predicts site locations in the lowland portions of the installation based on the complex geomorphic history of Lake Ontario's shoreline and deltas (Rush et al. 2003; Rush et al. 2006). A second model predicts site sensitivity in the uplands based on various environmental variables, including terrace locations, slope, and watercraft portage locations (Wood 2005). Both models were developed to address problems with a model developed in the 1980s, which proved to be a poor predictor of site locations in certain landforms (Hasenstab and Resnick 1990). Neither model had been fully systematized prior to the project. Both models consist of multiple GIS layers with limited to no formal definitions of predictor variables or explicit statements concerning the relationships among variables.

Environmental data used to reconstruct and refine the baseline models and model variables were derived from a variety of sources, including:

- National Hydrography Dataset Plus Data (EPA 2006)
- SSURGO Soils Data (NRCS 2008a, 2008b)
- Geospatial Wetlands Digital Data (USFWS 2009)
- National Elevation Dataset Data (Gesch 2007; Gesch et al. 2002)
- National Land Cover Data (USGS, NBII, GAP 2010)
- Statewide Bedrock Geology (New York State Museum/New York State Geological Survey 1999)

5.4.2.1.1 Fort Drum Glacial Lake Model

During the late Pleistocene, large portions of Fort Drum were inundated by a glacial lake. The Glacial Lake Model is a model developed by Rush and colleagues for identifying areas where sites could have been located with respect to features of the ancient lake. The most important variables for the purposes of predictive modeling include elevation, distribution of glacial landforms, and proximity to ravines and relict waters. Slope gradient and soils were not included in the model, although these variables were identified as ones that should be incorporated in the future. Archaeological sites are concentrated in the Pine Plains, including several Paleoindian sites around the 600 ft (183 m AMSL) contour, which marks a shoreline of Glacial Lake Frontenac (which dates to about 11,200 B.P. according to Pair and Rodriques [1993]); this landform was attractive for human use because it was a shoreline that was stable and thus available for use for a long time (Rush et al. 2003). A series of earlier, but less stable, shorelines of glacial Lake Iroquois have been identified up to 780 ft (238 m), with sites concentrated at 700–740 ft (213–226 m) elevations. Sites have also been found along the 680 ft contour.

In addition to being located along ancient lake margins, prehistoric sites are concentrated next to ravines and along former waterways that would have flowed into these glacial lakes (Rush et al. 2003). By contrast, no sites were found on the lake plain, other than ones associated with flowing or potentially navigable drainages and ones atop till piles that were former islands within glacial Lakes Iroquois and Frontenac. The few sites that do exist in the lake plain are shallow, suggesting they represent relatively recent deposition. The Glacial Lake Model uses this information to predict that most Paleoindian, Archaic, and Early Woodland occupations should occur at or above the various shorelines of the glacial lake. Presumably, the fact that prehistoric occupations post-dating the lake do not tend to occur on the lake plain must have something to do with characteristics of the resulting lake sediments or their associated environments, but the temporal sensitivity of the model requires further evaluation.

The Glacial Lake Model had not been fully systematized prior to the current project and was an informal model that integrated existing geological and paleoclimatological information. To operationalize the model in a GIS, project staff worked with Dr. Laurie Rush to define model variables in a GIS. Fossil islands that would have been within the lake and lake shorelines were identified using elevation data. Fossil islands were defined as discrete areas enclosed by lake shorelines during the lake's history. Drainages flowing into the lake were defined by identifying ravines using a hillshade model and then buffering streamlines centered on these ravines by a distance of 150 m. Lake shorelines were modeled by delimiting zones above and below lakeshore elevations and then expanding the lower elevation zone by 5 raster cells, resulting in a zone of former lake shore five raster cells (or approximately 45 m) wide. In addition, waterbodies above the lake shorelines were buffered by 100 m to identify water sources that may have attracted prehistoric inhabitants of the installation area. Once defined in a GIS, the landscape features discussed above (i.e., fossil islands, ravines, lake shorelines, and relict waters) were identified as being of high sensitivity. Areas of the Pine Plains that were not defined as high sensitivity according to the above rules were defined as medium sensitivity since the Pine Plains area is considered to have been a primary zone of occupation during the prehistoric period. In the Lake Plains zone, by contrast, the medium-sensitivity zone was restricted to locations within 100 m of stream lines, as Fort Drum archaeologists reasoned that streams that formed in the

former lakebed as the lake receded would likely have been targeted for use by prehistoric populations. Remaining areas in the Lake Plains and Alluvial Flood Plain not defined as medium or high sensitivity according to the above rules were classed as low sensitivity (Figure 5-10).

5.4.2.1.2 Fort Drum Upland Model

The Upland Model is a deductive intersection model developed for a Master's thesis on predicting site location in the foothills of the Adirondack Mountains, New York (Wood 2005). The model covers portions of Jefferson, Lewis, and St. Lawrence Counties and includes areas on the eastern half of Fort Drum.

One problem with the Upland Model is that available descriptions of the model were inadequate to accurately reconstruct the model. To develop the original model, environmental variables were visually examined in relation to site location, but exact procedures for evaluating relationships among independent variables and site location were never specified; discussions with installation staff were unsuccessful in determining how variables were related to each other. However, Wood (2005) did identify and define in a GIS a series of three variables that she concluded were most important to determining site location: terraces, portage locations, and areas located within 10 m of a waterway. These variables were reconstructed in a GIS using Wood's (2005) methods. To develop sensitivity zones, a systemization procedure applied to the Glacial Lake Model also was applied to the Upland Lake Model. Raster cells that contained terrace area, potential portage area, or were within 10 m of a waterway were identified as medium sensitivity, while raster cells that contained two or all of these characteristics were identified as high sensitivity. Remaining cells, where none of these conditions were present, were identified as low sensitivity (Figure 5-11).

The resulting model did not perform well when tested with validation statistics. It placed a majority of sites in the low-sensitivity zone and very few in the medium- or high-sensitivity zones.

5.4.2.2.2 Refining the Fort Drum Glacial Lake and Upland Models

In order to refine the Glacial Lake and Upland Models we maintained the distinction between the Upland physiographic zone and the other three lowland physiographic zones on Fort Drum. Although we had planned to model sites according to functional type as part of the refinement process, information in the Fort Drum CRM database was insufficient to define site types. However, since it is often useful to model sites according to type, as different kinds of sites can be distributed differently with respect to the environment, k-means cluster analysis was used to develop site classes according to their environmental associations. These site classes do not necessarily correspond to different site functions as would be inferred from archaeological data, but instead correspond to environmentally distinctive groupings of sites. We defined a total of three site classes for the Upland zone and five site classes for the remainder of the installation.

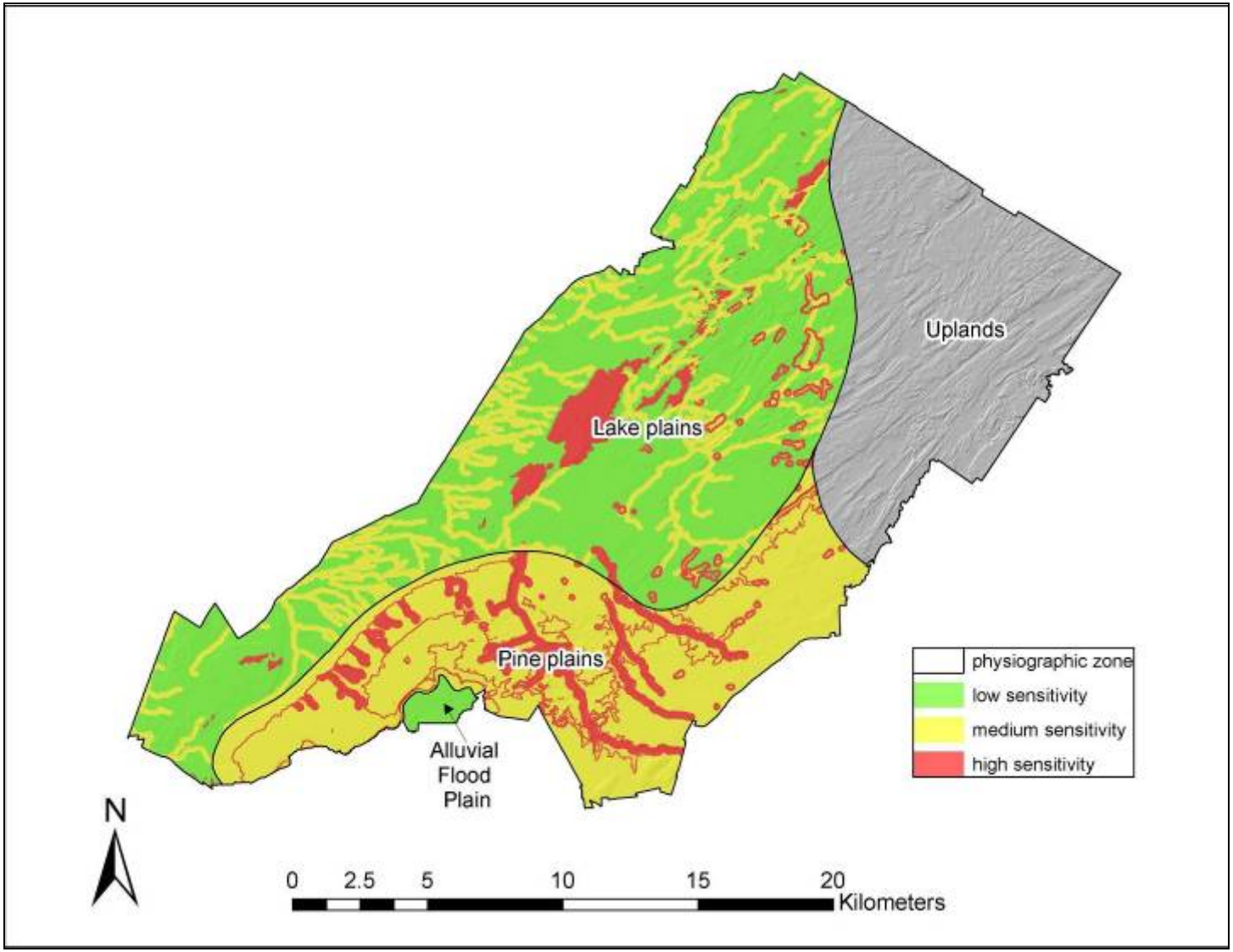

Figure 5-10. The baseline Glacial Lake surface model for Fort Drum.

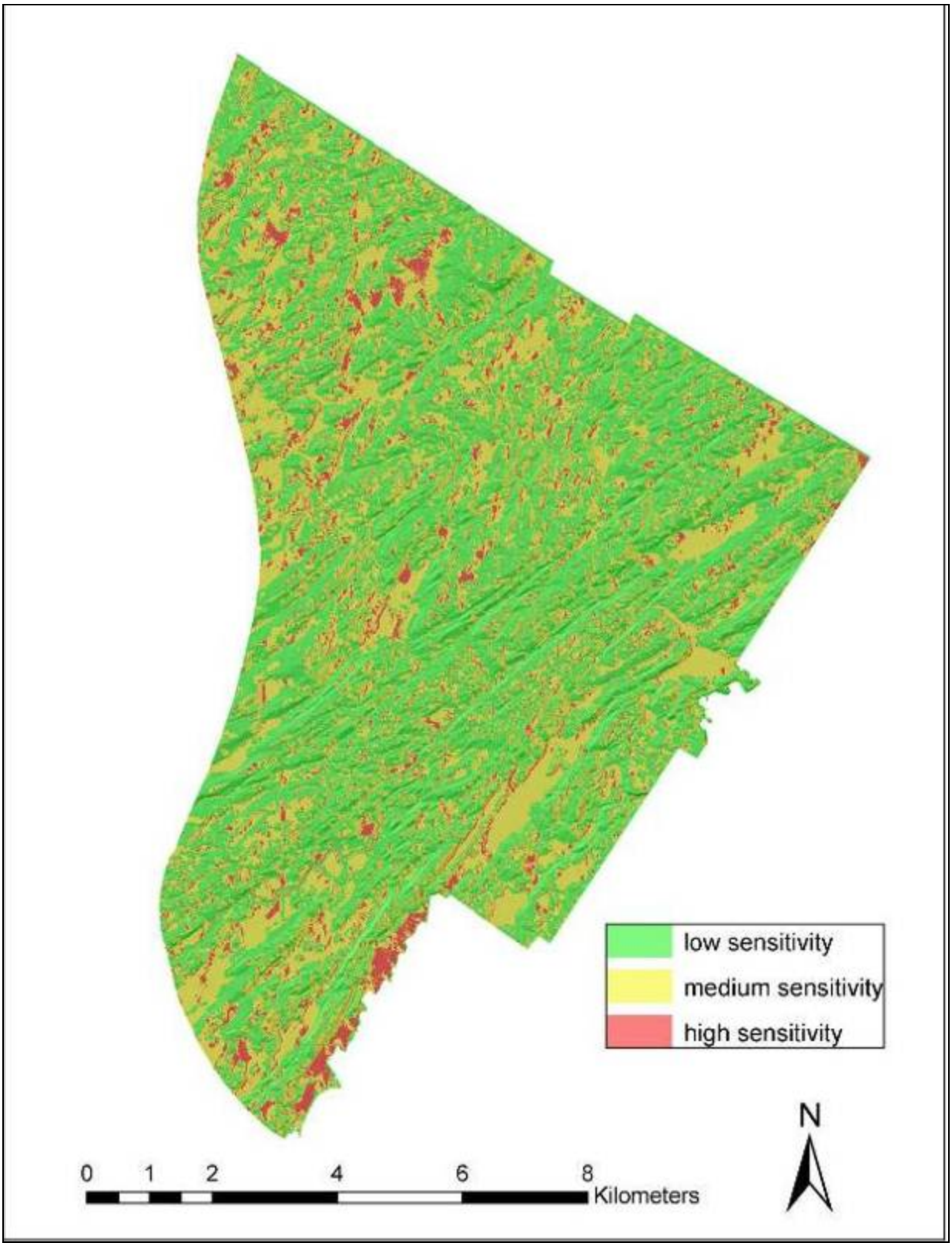

Figure 5-11. The baseline upland surface model for Fort Drum.

Variables used in the construction of both models were used or refined in some cases, and additional variables considered by previous modeling efforts to be potentially important to site location were developed and evaluated. Variables used to develop site classes and to construct the model included:

- Elevation
- Slope
- South-southwest aspect (corresponding to shelter from prevailing winds)
- South-southeast aspect (corresponding to shelter from prevailing winds)
- Distance to the Frontenac shoreline
- Cost distance to the Iroquois shoreline
- Cost distance to potential canoe landing locations
- Cost distance to perennial water sources
- Cost distance to wetlands
- Terraces
- Presence/absence of select soil types (Aquic Udipsamments, Aquic Udorthents, Typic Eutrochrepts, Dystric Eutrochrepts, Typic Dystrochrepts, Terric Haplosaprists)
- Presence/absence of select surface geology types (dune sand, Kame gravel)

The modeling technique used was the multi-layer perception (MLP) neural network classifier using a back propagation algorithm that is available in the IDRISI software package. Artificial neural network (ANN) modeling derives from attempts to create mathematical representations of biological neural networks. Although largely abandoned by neuroscience, ANN has been used to model adaptive systems, including archaeological site locations (Rust 2010). Essentially, an ANN neuron acts like a biological neuron; it receives an input, it transforms this input, and it outputs a response (Figure 5-12). ANN is particularly useful for problems involving patterns or hidden structure to datasets because a network of neurons, trained on a dataset, can often unravel these structures, whereas techniques focused on the analysis of each neuron individually (such as regression-based analyses) cannot. ANN is well suited for our study because the technique can accommodate input variables measured on different scales. Finally, convolutional ANN has the ability to identify patterns in a grid while maintaining the spatial control of the data (see LeCun et al. 1998; LeCun and Bengio 2002; Huang and Lectern 2006).

To use the IDRISI MLP algorithm, the investigator first defines a training raster, consisting of cells that we know have sites and cells that we know do not have sites. This training raster becomes the desired outcome and is conceptualized as the Output Layer Nodes (or neurons) (see Figure 5-12). In our case, there are only two neurons: Non-Site and Site. The set of input variable rasters are conceptualized as the Input Layer, consisting of one neuron for each of the predictor variables.

At this point, the MLP must be trained using a process where connections are formed between the Input Layer neurons and those of a Hidden Layer (the number of neurons in the hidden layer can be varied, but IDRISI and most MLP software suggest an appropriate number). The Hidden Layer neurons are arbitrary and intermediary; they exist to allow more complex mathematical linkages to the Output Layer neurons, and in fact there can be multiple Hidden Layers depending on the kind of process being modeled. The relationship between the Input Layer and the

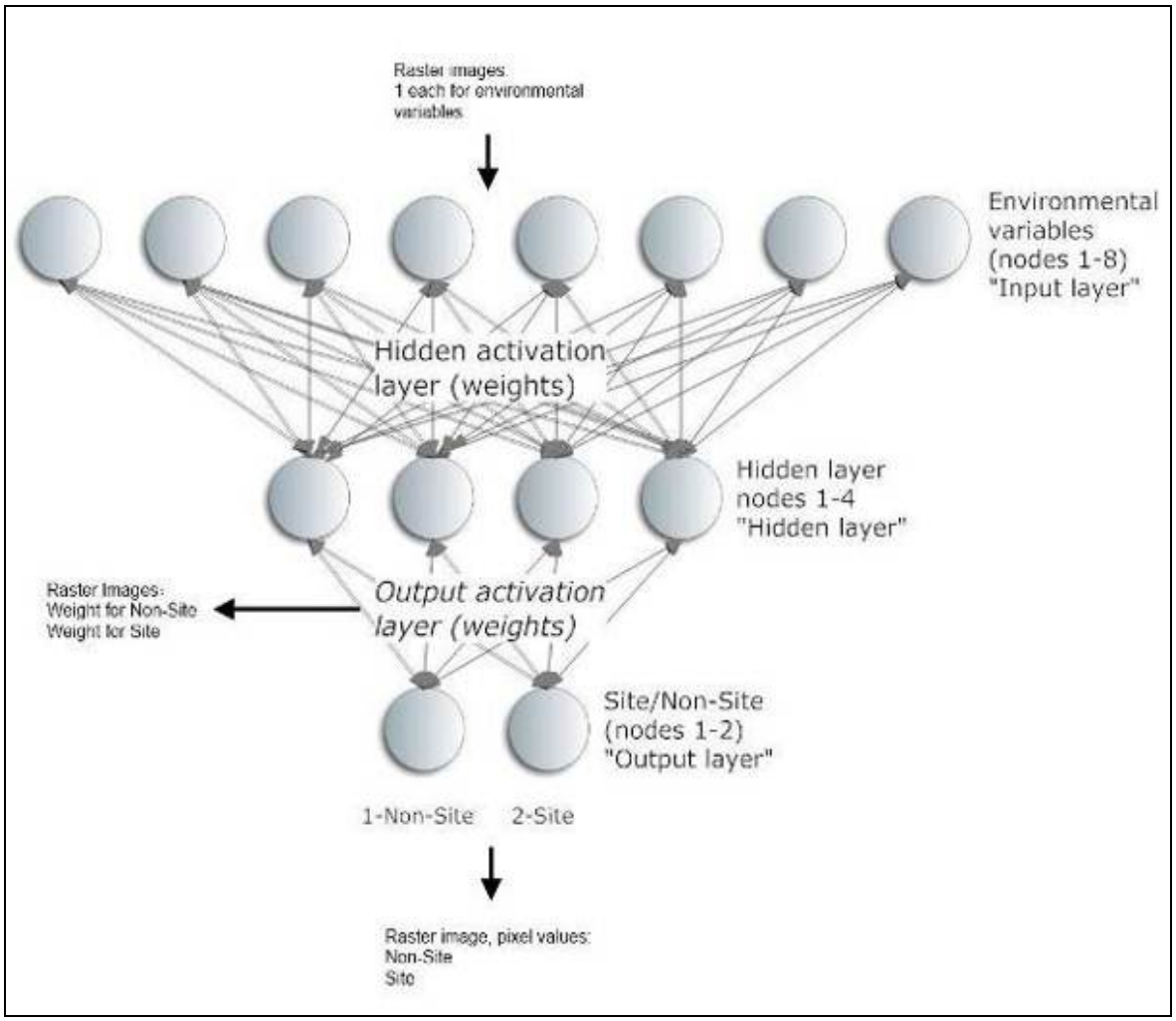

Figure 5-12. Schematic diagram of relationships among input environmental layers, hidden activation layers, and output activation layers in Artificial Neural Network (ANN) modeling.

Hidden Layer is initially formed by assuming random mathematical weights for the connections between all of the Input and Hidden layer neurons. The same process is then repeated to create the initial relationship between the Hidden Layer and the Output Layer. The MLP processes these connections for each cell in the training raster, examining the current state of the Output Layer neurons and comparing them to the known values from the training raster.

Because the initial weights are randomly assigned, these values will not match. The connection weights are all re-evaluated ("back-propagated"). The algorithm first examines the weights between the Output and Hidden Layer neurons. Once complete, it moves on to examine the weights between the revised Hidden Layer neurons and the Input Layer neurons. The connections are all then reprocessed, yielding slightly different results.

The entire process is reiterated thousands of times until the desired accuracy is achieved or a set number of iterations or "epochs" have been processed. The standard number of iterations in

IDRISI is 10,000. We experimented with higher thresholds, but found that iterations over 10,000 did not significantly improve accuracy. Finally, a raster with the highest valued Output Layer neuron for each cell (Non-Site or Site) is created.

IDRISI allows users to create rasters for the penultimate step in the MLP process; each Output Layer neuron can create a raster showing the degree of membership to that class for every cell, referred to as a "fuzzified probability layer." In this case, fuzzified probability layers were created for site and nonsite locations for each of the site classes defined earlier. The site-positive fuzzified probability layers were combined into a single raster by taking the maximum probability for each of the site classes for each raster cell, resulting in one fuzzy probability layer for sites and one for nonsites for each of the lowland and upland zones. To create the final model, these site and nonsites fuzzified probabilities were used as input variables to a logistic regression that computed a "final" probability map.

This process was performed for both of the modeling units (Upland and Lowland) and the resulting models were merged to create an installation-wide model. The refined surface model for the lowland physiographic zones works well, particularly in the Pine Plains zone, placing a majority of sites in a relatively small model area (Figure 5-13). Following the Glacial Lake Model, the model predicts prehistoric sites in the lowland physiographic zones to occur along elevation contours corresponding to former glacial lake shores, along the margins of waterways and waterbodies, in areas protected from prevailing winds, and in proximity to some soil and geologic types. In the Upland physiographic zone, the model does not perform especially well, although the model has predictive capacity and performs better than random. Given the prevalence of surface bedrock geology in the Upland zone and the coarse-grained nature of the available statewide geology data, it is likely that a finer-grained geologic map of the Upland zone would aid in further refinement of the model in the zone. Additional CRM data from the Upland zone would also help to refine the model in the Upland zone.

5.4.2.3 The Fort Drum Subsurface Model

The demonstration project geoarchaeologist visited Fort Drum on June 9–12, 2008. Dr. Homburg met with Dr. Laurie Rush (CEMML archaeologist), Dr. Julieann Van Nest (New York State Museum geoarchaeologist), Dr. Stephen Post (NRCS office in Syracuse, assistant state soil scientist of New York), and Amy Norton (NRCS field office in Lowville, soil scientist). A field reconnaissance was made with Dr. Rush to visit a range of archaeological sites across different geologic settings on the base, as well as to an archaeological excavation that was in progress at the time of the field visit

As discussed above, Fort Drum is divided into a series of four physiographic zones: (1) Lake Plains, (2) Pine plains, (3) Alluvial Flood Plain, and (4) Upland. Landforms with high probability for buried sites include relict shorelines marked by beach deposits of Glacial Lake Fontenac, under dunes that formed after forest vegetation was cleared in the Pine Plain, and the Holocene to latest Pleistocene alluvium of the Black River Valley.

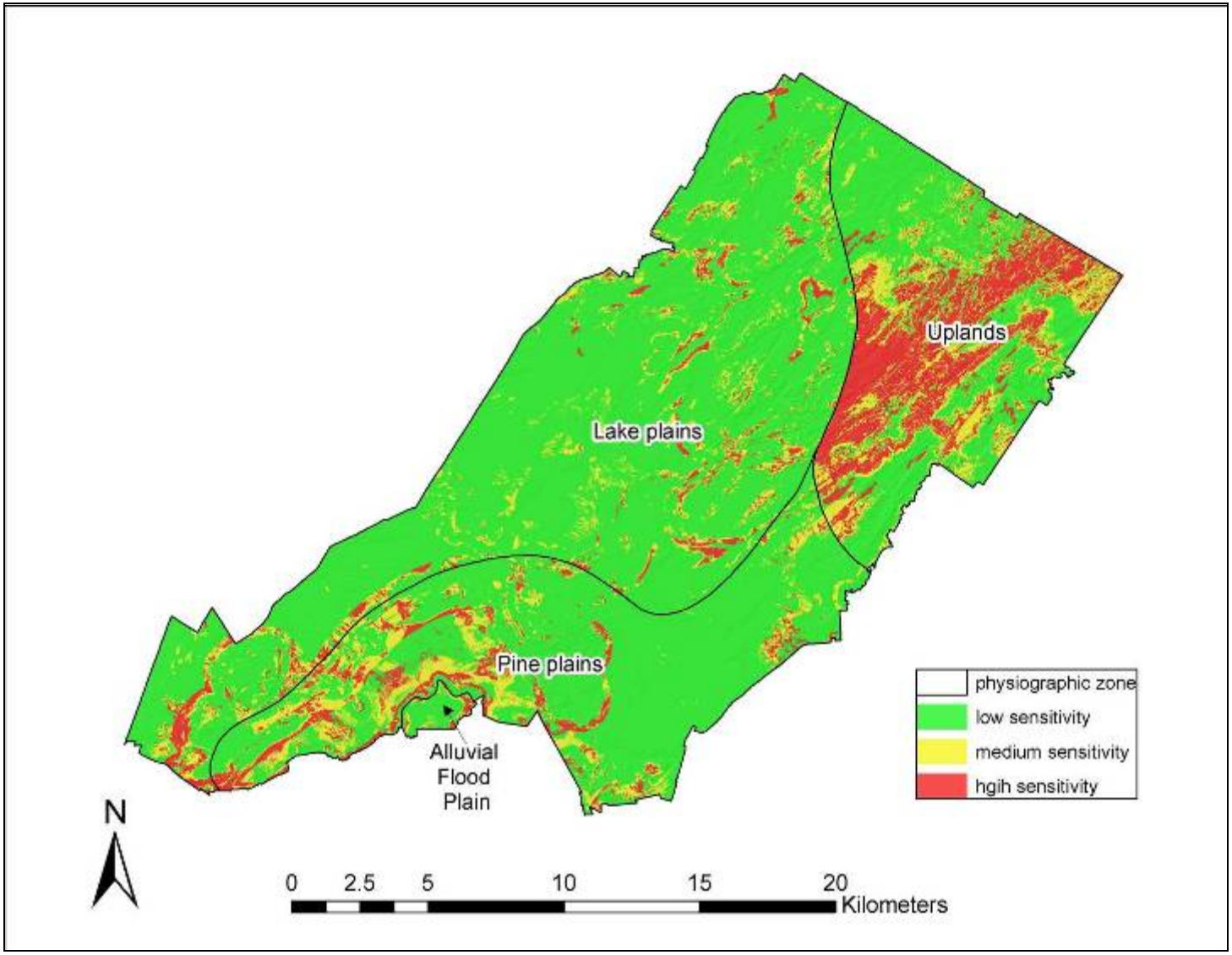

Figure 5-13. The refined surface model for Fort Drum.

Data sources for modeling buried site probability include geologic literature (Pair and Rodriques 1993; Rayburn 2004; Rayburn et al. 2007; and Rayburn et al. 2005) and NRCS soil maps for Fort Drum. The soil maps include those for Jefferson County and Lewis County, New York. Geology and soil layers were then used to define areas according to their probability for containing buried archaeological deposits. As at Eglin AFB, we used a working definition of a buried site as one buried at least 1 m deep. We recognize that buried sites may be less than 1 m deep, but sites buried less than 1 m deep have the potential to be found by shovel testing, and sites deeper than 1 m will likely require mechanical subsurface testing, such as with a backhoe and/or a coring device. Areas of high sensitivity for buried sites consisted of glaciolacustrine beach deposits and Holocene and late Pleistocene alluvium. Areas of medium sensitivity for buried sites consisted of aeolian deposits and miscellaneous organic-rich deposits, such as swamp deposits. Glaciofluvial stream deposition adjacent or in front of the Pleistocene-age ice is considered to be of low-to-medium sensitivity for buried sites while sedimentation of glacier margins (moraine deposition) is considered to be of low sensitivity for buried sites. Because of their antiquity, units classified as either till deposits or bedrock were considered to have no potential for buried sites. In order to create a final subsurface map consisting of three sensitivity zones, the above sensitivity levels were collapsed, such that areas considered to be of medium and low-to-medium sensitivity are identified as medium sensitivity and areas of low sensitivity or no sensitivity for buried sites are identified as low sensitivity (Figure 5-14; Appendix I).

One issue identified by installation staff during the course of the project is that the glacial lake shorelines are not particularly well-defined simply by elevational contours due to the effects of isostatic rebound following glacial retreat. Because areas of Fort Drum and surrounding counties were covered by thick ice during the Pleistocene, causing land masses to be depressed by the weight of the ice, retreat of glacial ice sheets resulted in the rebounding of previously depressed areas and a subsequent tilting of earth surfaces relative to their former position when the glacial lakes were present. To account for this effect in defining lake shorelines, the position of the lake shorelines was adjusted using DEM data and known shoreline locations following methods recommended by Rayburn (2004), Rayburn et al. (2005), and Rayburn et al. (2007). This revised model of the shorelines was anchored to the locations of three Clovis sites located along them. These adjusted shoreline positions were added to the soil- and geology-derived sensitivity zones and were assigned to the high-sensitivity zone. Given the limited data available to adjust the shoreline position, the current estimate of shoreline position should be ground-truthed and refined with Light Detection and Ranging (LIDAR—an optical remote sensing technique) data and additional shoreline locations with associated geochronological data. Trenching and coring are needed to obtain dates for geomorphic settings identified as having a high probability for containing buried sites, especially in places such as the Black River alluvium where sites may be deeply buried (perhaps as deep as 5 m or more). These alluvial settings are particularly important for such work because sites may be buried much more deeply than can be reached by shovel pits on archaeological surveys

Additional work is also needed to better delineate areas of aeolian deposition (i.e., sand dunes and sand sheets). Our model of aeolian deposits is based solely on soil survey maps, but limited field reconnaissance conducted by Dr. Homburg indicates that more work is needed to map these areas more precisely, possibly using remote sensing based on satellite imagery.

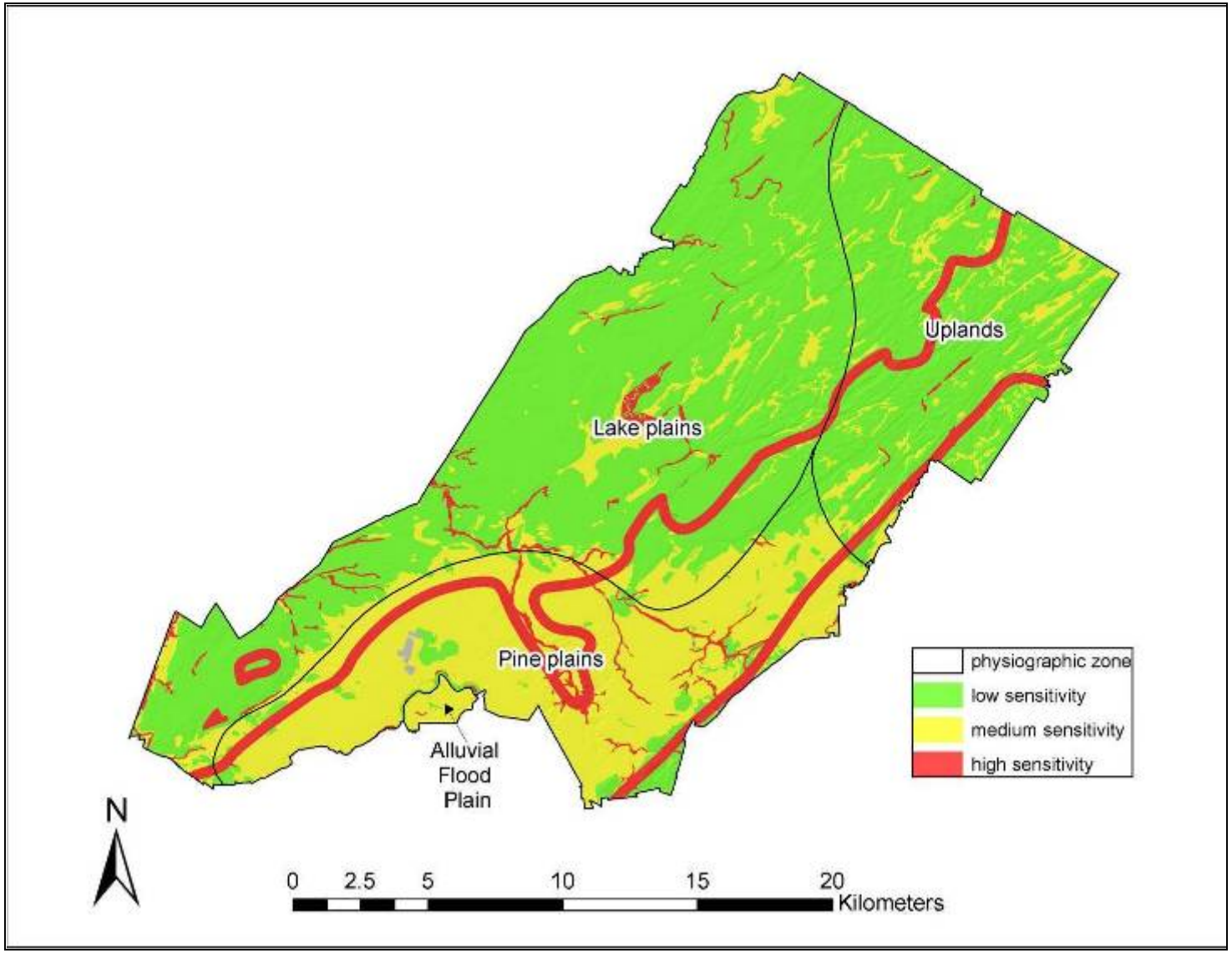

Figure 5-14. The preliminary subsurface model for Fort Drum.

5.4.2.4 The Fort Drum Zonal Management Model

The Fort Drum refined surface model and subsurface model were combined to create a zonal management model. Unlike our efforts for Eglin AFB, we did not develop a red flag model for Fort Drum due to a lack of site type information. Consequently, a red flag model was not incorporated into the Fort Drum zonal management model. Otherwise the zonal management model was created in a manner similar to the zonal management model for Eglin AFB, but with somewhat different transformation rules. For the Fort Drum zonal management model, a high-sensitivity zone was defined as any area that consisted either of high sensitivity in the surface model or high sensitivity in the subsurface model. Once the high-sensitivity zone was assigned, any remaining area that was either medium sensitivity in the surface model or medium sensitivity in the subsurface model was defined as a medium sensitivity in the zonal management model. The remaining installation area was defined as low sensitivity in the zonal management model.

The proportion of each sensitivity zone in the zonal management model varies widely according to physiographic zone (Figure 5-15). Most of the Pine Plains physiographic zone consists of either medium (0.67) or high (0.24) sensitivity in the zonal management model. The large proportion of medium-sensitivity zone in the Pine Plains physiographic zone is due in part to the definition of soil types considered to be of low-to-medium sensitivity in the original buried site potential classification as medium sensitivity in the subsurface model (in order to develop a model consisting of three sensitivity zones). If these soil types were instead classed as low sensitivity in the subsurface model, the proportion of medium-sensitivity zone in the Pine Plains physiographic zone would be considerably smaller. However, since the Pine Plains physiographic zone is the zone considered to have the most sites, then classifying much of this area as medium sensitivity in the zonal management model could be a conservative and reasonable approach.

Also due mostly to the predictions of the subsurface model, the vast majority of the Alluvial Flood Plains physiographic zone (0.86) is identified as medium sensitivity in the zonal management model. This outcome seems reasonable given the elevated potential for discovering buried sites in an alluvial floodplain.

The highest proportion of low-sensitivity zone in the zonal management model occurs in the Lake Plains physiographic zone (0.70). This outcome is a result of the combined predictions of the subsurface and surface models, both of which define most of the Lake Plains as low sensitivity, with the exception of land parcels located close to streams and landforms highlighted as important by the baseline Glacial Lake model. These predictions are also generally consistent with the expectations of installation staff, who have considered the Lake Plains physiographic zone to be generally of low sensitivity with the exception of areas located adjacent to streams and along paleolake features (e.g., fossil islands).

The highest proportion of high-sensitivity zone in the zonal management model occurs in the Upland physiographic zone. This outcome is largely the result of the surface model predictions for the Upland physiographic zone which, as discussed above, are not particularly promising. As such, the sensitivity zones defined in the zonal management model for the Upland area will likely not be particularly useful until more geology and CRM inventory data are available for the Upland area and the Upland surface model can be further refined.

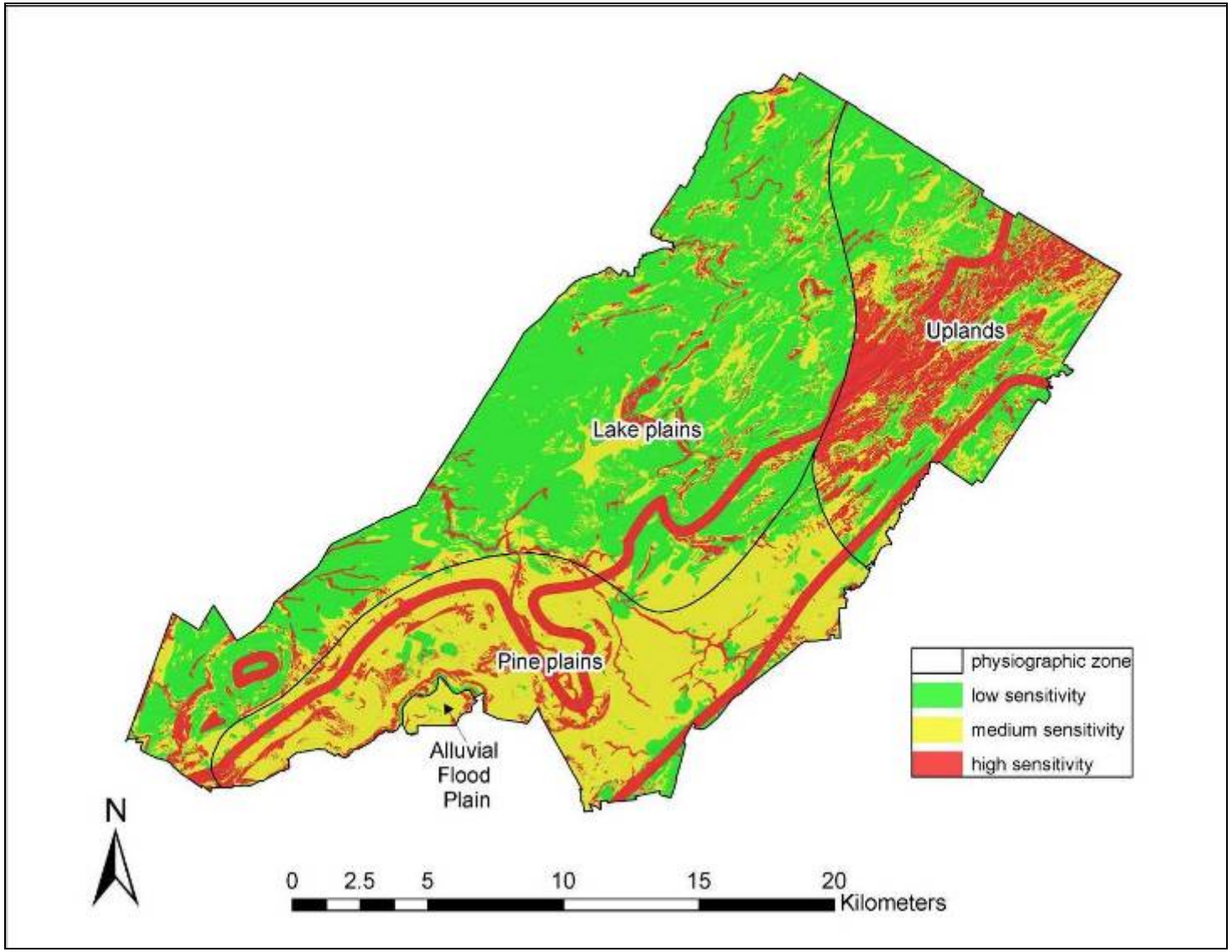

Figure 5-15. The zonal management model for Fort Drum.

5.5 SAMPLING PROTOCOL

Since the response variable in site location modeling is binary, consisting of site and non-site locations, samples used in model building and testing had to be drawn from within recorded site areas as well as from areas that have been surveyed, but where no site has been recorded. Random point samples were generated in ArcGIS from within site areas to develop site samples. To develop non-site samples, random point samples were generated from previously surveyed areas where no site had been discovered. In the case of Eglin, sample strata consisted of individual watersheds and site types. In the case of Fort Drum, sample strata consisted of physiographic regions and arbitrary site classes defined through k-means cluster analysis.

At Eglin AFB, site samples could be drawn from polygons representing prehistoric site boundaries, as sites are conventionally defined as bounded polygons in the Eglin AFB CRM program. Nonsite samples were drawn from surveyed areas and were restricted from being within 150 m of a site boundary. At Fort Drum, site boundaries rarely have been established and polygons representing site boundaries were uncommon. Many prehistoric sites at Fort Drum, rather than being represented by a polygon, are instead represented by a point representing the approximate location of the site. For CRM purposes, this approach to representing sites in a GIS can be reasonable, particularly since it is often difficult to reliably establish site boundaries using STPs (Heilen et al. 2008). For modeling purposes, however, this means of representing a site in a GIS can be problematic, since the point selected to represent the site location is not necessarily representative of the environmental context of the site. A large site, for instance, could cover a more environmentally diverse area than is represented by a single point. Moreover, samples selected to represent non-site locations could be drawn from within sites in this scenario since explicit site boundaries have not been defined.

To establish site samples for modeling at Fort Drum, prehistoric site locations were identified using the CRM database. Existing polygon boundaries were used for a few sites that had explicitly defined boundaries while boundaries for the remaining sites were derived in a GIS. To establish the site boundary for a site defined only as a point, positive STPs identified using the STP database located within 50 m of a prehistoric site point were also considered to be part of a site. These point data were then used to create convex hulls around a set of points identified as site to create a site polygon. These areas were then merged with prehistoric sites for which polygons had been defined. Nonsite samples were chosen from within survey areas in locations that were at least 50 m from an area defined as site.

For any given strata, site and non-site samples were randomly reduced in size to develop site and non-site samples that were roughly equivalent in size, in keeping with standard practice. Particularly due to limitations in processing power and available memory, samples used in Random Forest modeling were further reduced using a tool in ModelMap that automatically generates testing and training samples according to a specified proportion. Typically, training sample sets consisted of approximately 10 to 20 percent of the larger site and non-site sample from which they were drawn, a process that typically resulted in approximately 60 percent of sites in a given strata being sampled for model training. The remaining samples were used as a testing set.

A major component of this demonstration plan is statistical *validation* of the models. Validation is a family of statistical approaches used to test predictive models. Sampling methods for assessing the validity of predictive models include *split-sample*, *resampling*, and *"double validation"* methods (Rose and Altschul 1988:243). The first two validations methods are dependent on using subsamples drawn from the same sampling population. The third is based on testing with independent data. Due to the dependency between the predicted and actual site locations, the first two approaches can generate an overly optimistic assessment of model performance. The third requires validation data that were not drawn from the sampling population used to build the model. Statistical validation measures designed to deal with precisely these kinds of contexts have been developed and were implemented as a part of this project (e.g., Kvamme 1988a, 1990:263–264; Rose and Altschul 1988:242–247).

5.5.1 Split-Sample Validation

In the split-sample validation approach, the existing regional sample of sites is divided into two separate datasets, often of approximately equal size (Mosteller and Tukey 1977:133). One sample is used to construct the model; the other sample is used to test the model. These two samples are sometimes referred to as the training set and testing set, respectively. The key to the split-sample approach is achieving a representative sample of site types and environmental strata (Kvamme 1988a:395–396). Hence, a relatively robust regional site inventory is needed to ensure ample representation of sites to construct both the training and testing datasets (Rose and Altschul 1988:243). The sampling strategy used to define the training and testing sets depends on previous knowledge of the archaeological record and independent variables that condition site locations, such as landform types, soil types, and distance to water and other critical resources. When little is known about the effects of independent variables on site location, the training set and the testing sets are selected on the basis of a simple random sample. A stratified random sample is used when the influence of key variables on site distributions are known or expected. Random number generators often are used to select samples for modeling and validation.

5.5.2 Resampling Approaches

A disadvantage of split-sampling is that the model and validation procedures only make use of half the available data (Kvamme 1988a:396). One way to rectify this problem is to split the sample into more than two samples and use one sample to test a model based on the remaining groups (McCarthy 1976). This procedure can then be repeated so that each possible combination of subsets is used to develop and validate the model. Iterations can be compared for consistency or merged into a single model using a weighted average or some other means of combining the results.

Resampling methods rely on a similar logic to select a sample for model validation. For instance, a jackknife approach uses all cases, save one, to create the model, and the remaining case to test the model. The process is repeated for each case, until all possible iterations have been tested. In archaeological contexts, the cases (*n*) are often defined not as individual sites but as spatial clusters of sites (or land parcels containing site clusters), since results from the clustered sites are likely to be spatially correlated (Kvamme 1988a:396). A bootstrap approach follows a similar process, but instead of sampling without replacement as in the case of the jackknife method,

individual cases can be used more than once. In other words, a bootstrap approach allows sampling with replacement whereas a jackknife approach employs sampling without replacement. These kinds of sampling approaches can be considered a combination of all possible regression, residual analysis, and validation techniques. Such approaches can generate very robust results for model-building, as the results from multiple trials are combined to generate a more powerful model than could be provided using a split-sample approach (Mosteller and Tukey 1977:152).

As discussed in a previous section, Random Forest analysis uses a bootstrap sampling approach as part of the model-building exercise. In generating individual trees for Random Forest modeling, the algorithm randomly selects approximately 70 percent of cases as a training set and reserves the remaining 30 percent of cases as a testing set, in order to calculate error estimates and other model statistics. The method is considered robust enough that additional training and testing sets are thought to be unnecessary, but as mentioned above, training and testing sets were nonetheless still applied for model building. In addition, the Random Forest algorithm also randomly selects a set number of predictor variables to be tested against a response variable when building an individual tree. Combined, these bootstrap approaches to sampling both cases and variables are considered to result in very robust models that are substantially less susceptible than other approaches to overfitting the data and are considered to minimize the effects of intercorrelations between predictor variables.

5.5.3 Double Validation

Validating the model by generating a new and independent dataset through direct field testing is referred to as “double validation” (Rose and Altschul 1988:243). This approach avoids, to some degree, the problem of data dependency that is inherent in the other two validation approaches. A potential problem with this validation method, however, is that the location of survey is largely determined by factors other than sampling requirements. As a result, locations of subsequent survey may not comprise a representative sample of test cases.

Implementing double validation from the ground-up requires substantial time and cost. Only existing or archival data could be used in validation as part of this project. We were not able to develop new data through onsite investigation. As such, double validation could only be performed using existing data and was used to test baseline models as well as the Fort Drum subsurface model, where STP data could be used to identify previously discovered, buried cultural deposits. In the case of Eglin, double-validation data can include survey data that post-dates the development of the baseline model. In the case of Fort Drum, STPs and site data were not used in building the baseline models and thus could be used to perform double-validation for the baseline models.

5.5.4 Validation of Subsurface Models

An important component of our predictive modeling effort involves delineating where buried archaeological sites may exist within the four demonstration installations based on available information. This information was used to create a preliminary subsurface model. Comprehensive validation of subsurface models would entail conducting field research to

document the ages of sediment-landform assemblages likely to be associated with buried sites, however, such an effort is clearly beyond the scope of the current study. However, we were able to use STP data at Fort Drum to identify buried cultural deposits discovered during previous survey in order to perform a preliminary test of the subsurface model. Information on buried deposits at Eglin has thus far been anecdotal and incomplete and has not been sufficient to validate the subsurface model for Eglin.

5.6 SAMPLING RESULTS

The major factor affecting sampling results is the reliability and representativeness of survey. For any archaeological predictive model, the performance of the model is ultimately constrained by the extent and representativeness of survey and site discovery and recording methods. For instance, both Eglin AFB and Fort Drum use STPs to discover sites during inventory, but apply different methods in doing so. At Fort Drum, STPs are placed systematically at standard intervals throughout a survey area. Standard survey intervals at Fort Drum are generally between 5 and 20 m and are commonly 15 m. At Eglin AFB, STPs are generally placed at a wider interval, 50 m or more, and although spaced relatively evenly apart, are placed in a more judgmental fashion. This is largely because Eglin AFB is an exceptionally wet environment where the practical placement of a STP in a location likely to contain a site has to be adjusted in the field frequently due to ground conditions encountered during fieldwork. The result is that STPs at Eglin cover survey areas less evenly and at a lower density of effort than at Fort Drum.

Due in part to the practical constraints on the placement of test pits at Eglin AFB, STPs excavated at Eglin AFB are larger than those excavated at Fort Drum. STPs at Eglin are 50 x 50 cm in plan view while those at Fort Drum are 30 x 30 cm in plan view. The larger STP size at Eglin helps to elevate site discovery rates, but overall, the wider survey interval translates into the greater probability at Eglin AFB that sites will be missed. In addition, the greater variability in STP placement at Eglin AFB results in greater variability between inventoried areas in survey reliability (Heilen et al. 2008).

At both Eglin AFB and Fort Drum, survey reliability varies spatially and temporally, resulting in samples that are less than ideal, but are generally adequate for modeling purposes.

5.6.1 Fort Drum Sampling Results

At Fort Drum, areas defined as surveyed in a GIS date from 1995 to 2007 and cover approximately 35 percent of the installation. Another 19 percent of the installation is classified as off-limits, much of it being located in the Lake Plains or Upland physiographic zones. Although 35 percent of installation area from which to derive site and non-site samples is a substantial percentage, survey areas are distributed unevenly across the installation and different survey areas were subjected to different levels of effort, depending in part on when they were surveyed (Figure 5-16). Figure 5-16 shows where survey has been conducted on Fort Drum (red areas) as well as areas that are off limits and surveyed areas where shovel test pits are recorded in a GIS (yellow areas).

Most of the recent survey work (2001–2007) occurred in the Pine Plains area whereas most of the earlier survey (1995–2000) work occurred in the Lake Plains, Upland, and Alluvial Flood Plain zones. As a result of the Glacial Lake model work, Fort Drum determined that survey work in some areas of the installation, particularly in the Lake Plains area, was unproductive as thousands of negative STPs were excavated and positive finds were extremely rare. Fort Drum subsequently shifted most survey work to areas of the Pine Plains where survey was considered to be more productive, using the unsystematized Glacial Lake Model to guide survey effort. At the same time, the number of STPs per acre surveyed has increased steadily through the years at Fort Drum, meaning that the density of effort was substantially higher in the later survey areas as opposed to the earlier survey areas. One would expect that site discovery would be elevated in the areas surveyed later as a result of this change in methods, independent of the "true" density of archaeological sites.

A previous evaluation of archaeological data quality showed that STP density (excluding shovel test locations that were planned but had to be avoided due to disturbance, vegetation, health hazards, or other factors) increased through time at Fort Drum from being around one STP per acre in 1995 to over eight STPs per acre by 2001 and afterwards (Heilen et al. 2008:2.31, Figure 2.18). Part of the difference appears to have resulted from STPs being dug only within sample plots located within the earlier survey areas, whereas STPs were excavated across the entirety of later survey areas. However, test pit spacing appears to have generally decreased over time as well at Fort Drum, resulting in a higher number of test pits per acre through time.

To ensure that areas recorded in a GIS as surveyed had actually be subjected to STP excavation, non-site samples were selected only from survey areas within which STPs have been recorded in a GIS. The result is a substantial reduction in the amount of area from earlier survey that could be sampled, reducing the sampling area from 38,644 ac to 11,665 ac. Most of the area removed from the sampling area was from surveys conducted prior to 2001, and much of this was located either on the Lake Plains or the Upland physiographic regions.

One possible result of these conditions is that refined surface model for Fort Drum is likely to identify areas of medium and high sensitivity for prehistoric sites as those that are most similar to the environmental conditions in which sites have been found in the Pine Plains area. The development of arbitrary site classes with different environmental signatures may have helped to reduce this problem somewhat, but it seems likely that the model is influenced by the fact that the most reliable and abundant data are located within a fairly restricted area of the installation.

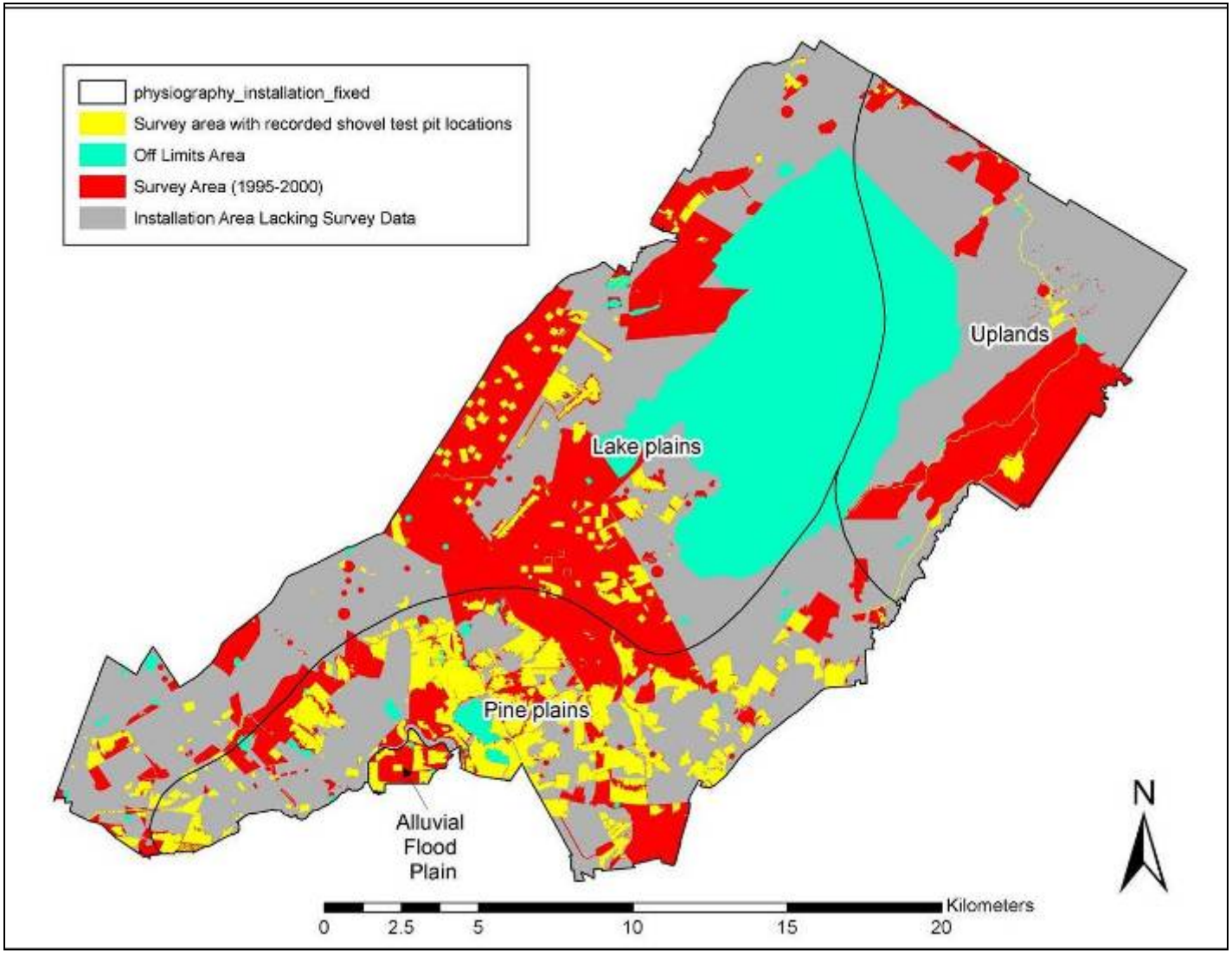

Figure 5-16. Fort Drum survey areas from which samples (Shovel Test Pits) could be selected for modeling purposes.

Table 5-1 shows the distribution of a sample of positive and negative surveyed locations with respect to the predictions of the Fort Drum refined surface model, which consists of low-, medium-, and high-sensitivity zones. The sample consists of roughly 27,000 samples derived from surveyed areas, half of which contain a site; the remaining half of the sample consists of STP locations where a site has not been discovered. As would be expected, the majority of site-positive samples occurred within the medium- and high-sensitivity zones. Overall, three quarters of site-positive samples occurred within the high-sensitivity zone and a fifth of site-positive samples occurred within the medium-sensitivity zone. The remaining 5 percent of site-positive samples occurred within the low-sensitivity zone.

Site-negative samples were predominantly located within the low-sensitivity zone. More than two-thirds of site-negative samples were located in the low-sensitivity zone and a fifth of site-negative samples occurred within the medium-sensitivity zone. Eleven percent of site-negative samples occurred within the high-sensitivity zone.

Variation occurs among physiographic zones in the distribution of positive and negative samples, according to sensitivity zone. In the Pine Plains and Upland physiographic zones, roughly three quarters of site-positive samples occurred within the high-sensitivity zone and a fifth of site-positive samples occurred within the medium-sensitivity zone. Approximately 5 percent of site-positive samples occurred within the low-sensitivity zone. These results are consistent with the overall distribution of site-positive samples with respect sensitivity zones, in large part because most samples for the lowland portion of the model come from the Pine Plains and the upland portion of the model was developed using samples for the Upland physiographic zone.

In the Lake Plains physiographic zone, a similarly high percentage of site-positive samples occurred in the high-sensitivity zone. Only around 7 percent of site-positive samples occurred within the medium-sensitivity zone and around 9 percent of site-positive samples occurred within the low-sensitivity zone, however. This suggests that in the Lake Plains physiographic zone, the vast majority of site-positive samples occurred within the high-sensitivity zone, but similar and low percentages of site-positive samples occurred in the low- and medium-sensitivity zones.

The lowest percentage of site-positive samples in the high-sensitivity zone occurred in the Alluvial Flood Plain physiographic zone, where less than half of site-positive samples occurred in the high-sensitivity zone. In the Alluvial Flood Plain physiographic zone, over one-third of site-positive samples occurred within the medium-sensitivity zone and roughly 16 percent of site-positive samples occurred within the low-sensitivity zone. In other words, an elevated percentage of site-positive samples in the Alluvial Flood Plain physiographic zone occur in the low- and medium-sensitivity zones. This suggests that the model is less successful in identifying the high-sensitivity zone within surveyed areas of the Alluvial Flood Plain physiographic zone, placing a comparatively large percentage of site-positive samples in the low- and medium-sensitivity zones.

Table 5-1. Distribution of Positive and Negative Sample Locations at Fort Drum and their Correspondence to Predictions of the Refined Surface Model

	Low-Sensitivity Zone				Medium-Sensitivity Zone				High-Sensitivity Zone			
Physiographic Zone	**Positive Samples**	**Negative Samples**	**% Total Positive Samples**	**% Total Negative Samples**	**Positive Samples**	**Negative Samples**	**% Total Positive Samples**	**% Total Negative Samples**	**Positive Samples**	**Negative Samples**	**% Total Positive Samples**	**% Total Negative Samples**
Alluvial Flood Plain	22	94	16.3%	69.6%	50	18	37.0%	13.3%	63	23	46.7%	17.0%
Lake Plains	139	1,256	9.2%	80.3%	114	215	7.5%	13.7%	1,260	93	83.3%	5.9%
Pine Plains	529	7,793	4.6%	67.4%	2,446	2,433	21.1%	21.1%	8,642	1,331	74.4%	11.5%
Upland	13	166	5.4%	65.4%	48	45	19.8%	17.7%	181	43	74.8%	16.9%
Total	703	9,309	5.2%	68.9%	2,658	2,711	19.7%	20.1%	10,146	1,490	75.1%	11.0%

	All Sensitivity Zones			
Physiographic Zone	**Positive Samples**	**Negative Samples**	**% Total Positive Samples**	**% Total Negative Samples**
Alluvial Flood Plain	135	135	50.0%	50.0%
Lake Plains	1,513	1,564	49.2%	50.8%
Pine Plains	11,617	11,557	50.1%	49.9%
Upland	242	254	48.8%	51.2%
Total	13,507	13,510	50.0%	50.0%

The distribution of site-negative samples according to sensitivity zone is broadly similar among the Alluvial Flood Plain, Pine Plains, and Upland physiographic zones where on the order of two-thirds of site-negative samples occurred within the low-sensitivity zone. The remaining third of site-negative samples in these physiographic zones occurred in varying percentages within the medium- and high-sensitivity zones. In the Lake Plains physiographic zone, an elevated percentage of site-negative samples occurred within the low-sensitivity zone while a relatively small percentage of site-negative samples occurred within the high sensitivity zone. This suggests that, in contrast to the other physiographic zones, site-positive samples in surveyed areas of the Lake Plains physiographic zone are concentrated to a greater degree than other physiographic zones in the high-sensitivity zone while site-negative samples are concentrated to a greater degree in the low-sensitivity zone.

5.6.2 Eglin AFB

At Eglin AFB, one consequence of implementing the baseline model early in the installation's CRM history is that survey areas have generally been confined to areas relatively close to potable water sources (Figure 5-17). Figure 5-17 shows where survey has been conducted on Eglin AFB as well as the location of streams and wetlands. Areas outside the baseline model have also been surveyed, such as areas surveyed during the sample survey efforts used to develop the baseline predictive model as well as investigations in areas in the vicinity of surveyed historical-period homesteads and areas surrounding the location of large and obtrusive habitation sites. A consequence of the focus of most survey activities in proximity to potable water, however, is that much survey for prehistoric sites since the baseline model was implemented has occurred in fairly restricted environmental settings. Moreover, the precise footprint of shovel test survey is often adjusted in the field due to ground conditions, with potential STP locations being moved or abandoned depending on feasibility. As a result, determining in a GIS which areas have actually been physically tested is not always a straightforward process.

Since the precise location of intensive survey is not readily apparent in the available GIS data for Eglin, we allowed site and non-site samples to be drawn from any location indicated in the GIS data as surveyed since baseline model development and implementation. Necessarily, this includes some areas that have been recorded as surveyed, but have likely been subjected only to judgmental survey or pedestrian survey with limited subsurface testing. The result is that nonsite locations are drawn from a somewhat broader environmental context than many site samples since most prehistoric sites have been discovered as a result of intensive survey in locations close to potable water, with small numbers discovered during survey in other parts of the installation. There is a possibility that a very small proportion of nonsite samples selected at Eglin AFB correspond to locations where a site actually exits, but the risk is small.

However, since the highest density of inventory effort has been conducted in areas close to potable water for much of the installation's CRM history, our knowledge of the potential for sites in other areas of the installation is more limited. In particular, the wetland areas seem to have been subjected only to limited inventory, although there is at least the theoretical possibility that significant sites will be found within wetland areas. Intensive use of wetlands prehistorically and

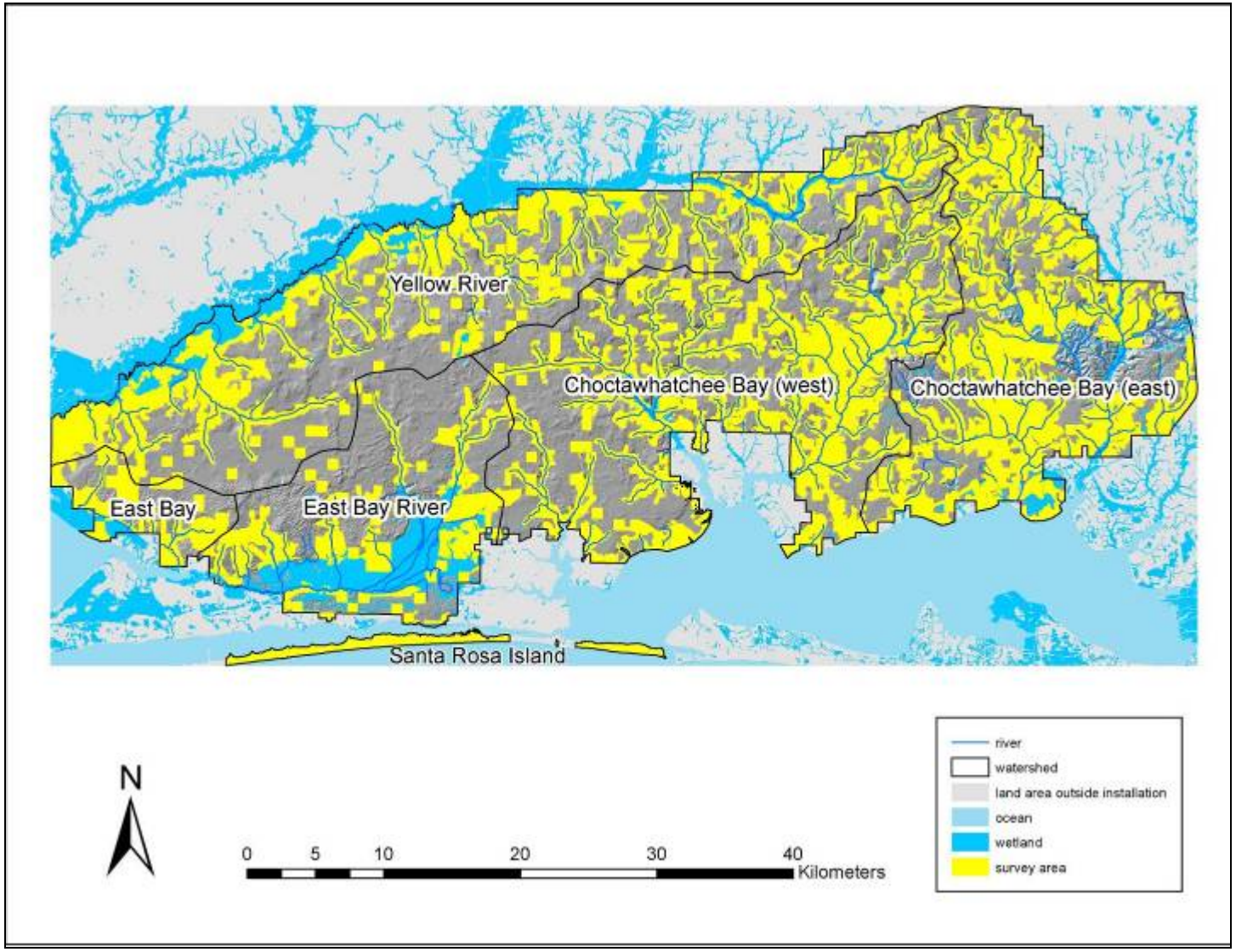

Figure 5-17. Eglin AFB survey areas.

change through time during the Holocene in the extent and distribution of wetland areas suggests that wetland sites are likely present on some areas of the installation. As a result, there could be key areas within the installation where sites exist, but are not reliably predicted by either the baseline surface model or the refined surface model due to a lack of data on the location of sites within such areas. However, the red flag model and the subsurface model for Eglin AFB both identify areas of medium or high potential within wetlands areas and their combination in the zonal management model for Eglin helps to identify areas that are ignored in the baseline and refined surface models.

Much of the remainder of the installation where inventory activity has been limited is within the Sandhill ecological complex in the interior of the installation. Neither expert geoarchaeological opinion nor survey conducted within this zone has suggested a strong potential for surface or subsurface sites. Consequently, it seems unlikely that site densities within the Sandhill ecological complex are remotely comparable to site densities in other parts of the installation. Nonetheless, it would be worthwhile to conduct limited archaeological inventory in this low sensitivity zone during other inventory activities in order to test model predictions with independent field data and to address the sampling biases inherent in the history of inventory on Eglin AFB.

Table 5-2 shows the distribution of positive and negative sample locations with respect to the predictions of the Eglin refined surface model, which consists of low- and high- sensitivity zones. The sample consists of roughly 9,500 test locations, half of which are located within sites; the remaining half of the samples consists of surveyed locations where a site has not been discovered. Overall, more than 98 percent of site-positive samples occurred within the high-sensitivity zone, while the remainder of site-positive samples occurred within the low-sensitivity zone. Eighty percent of site-negative sample locations occurred in the low-sensitivity zone, while 20 percent of site-negative sample locations occurred in the high-sensitivity zone.

For each of the watersheds, similar percentages of site-positive samples occur in the low- and high-sensitivity zones. The distribution of site-negative samples among watersheds is somewhat more variable. In the Santa Rosa Island, East Bay, and East Bay River watersheds, on the order of 10 percent of site-negative samples occurred in the high-sensitivity zone. In the remaining watersheds, roughly 20 percent of site-negative samples occurred in the high-sensitivity zone. This suggests that the model, although of similar accuracy in each of the watersheds, is less precise in the Choctawhatchee Bay East, Choctawhatchee West, and Yellow River watersheds.

Table 5-2. Distribution of Positive and Negative Sample Locations at Eglin AFB and their Correspondence to Predictions of the Refined Surface Model

Watershed	Low-Sensitivity Zone				High-Sensitivity Zone				All Sensitivity Zones			
	Positive Samples	Negative Samples	% Total Positive Samples	% Total Negative Samples	Positive Samples	Negative Samples	% Total Positive Samples	% Total Negative Samples	Positive Samples	Negative Samples	% Total Positive Samples	% Total Negative Samples
Santa Rosa Island	6	185	3.0%	92.0%	192	16	97.0%	8.0%	198	201	49.6%	50.4%
Choctawhatchee Bay (east)	35	1,505	1.9%	79.6%	1,847	386	98.1%	20.4%	1,882	1,891	49.9%	50.1%
Choctawhatchee Bay (west)	17	920	1.5%	80.3%	1,124	226	98.5%	19.7%	1,141	1,146	49.9%	50.1%
East Bay	3	159	1.8%	91.9%	168	14	98.2%	8.1%	171	173	49.7%	50.3%
East Bay River	4	326	1.1%	88.8%	359	41	98.9%	11.2%	363	367	49.7%	50.3%
Yellow River	11	753	1.1%	76.6%	968	230	98.9%	23.4%	979	983	49.9%	50.1%
Total	76	3,848	1.6%	80.8%	4,658	913	98.4%	19.2%	4,734	4,761	49.9%	50.1%

6.0 PERFORMANCE ASSESSMENT

As discussed in Section 5.0, the baselines for this demonstration are (1) predictive models prior to systematization, (2) the performance of systematized predictive models prior to validation and refinement, and (3) CRM program performance prior to model integration. The performance of systematized, validated, and refined models in predicting site location will be assessed with reference to the baselines of (1) and (2) above, whereas the performance of CRM programs before and after model integration will be assessed with reference to (3). Below we discuss the analyses of data obtained during the demonstration for each of the performance objectives listed in Section 3.0. Additional details are provided in Table 6-1.

6.1 IMPROVE ARCHAEOLOGICAL SURFACE PREDICTIVE MODELS

6.1.1 Sampling Protocols for Independent Tests

The sampling protocols described in Section 5.0 to build and validate predictive models have been published and are generally accepted within the archaeological community (Westcott and Brandon 2000). Additional insight can be gained by exploring how models fail. Understanding model failures is often best achieved by examining whether a model works better for certain site types or environmental zones than other types or zones. For instance, does the model tend to situate habitation sites in high-sensitivity zones but place lithic procurement sites in medium- or low-sensitivity zones? Does the model tend to predict sites well in river valleys, but not well in upland zones? Identifying specific kinds of cultural resources or environmental contexts that are not correctly predicted by the model will help to clarify what is missing from a model and how it may be refined (Altschul 1988, 1990).

6.1.2 Validation Tests for Model Accuracy

Most predictive models generate probabilities of site detection for all land parcels in a study area. Typically, the probabilities are transformed into categorical variables summarized as high-, medium-, and low-sensitivity land parcels (Kvamme 1990:264, 276–277). Once sensitivity zones have been defined, the validation dataset (see below) can be used to evaluate the model results. This is done by evaluating the number of sites (or the total site area) found in each sensitivity zone according to the relative area of each sensitivity zone. Model validation is often performed using the Gain[9] and GOR[10] statistics (see Section 3.1.1 for descriptions).

[9] Gain = 1– (percentage of total area covered by model/percentage of total sites within model area). As the Gain statistic approaches one (1), the model's predictive accuracy increases. A Gain Score near zero (0) means the model has little or no predictive utility beyond what could be gained through random chance. A negative Gain Score means the model performs worse than random chance.

[10] GOR = *(percentage of sites within model area – percentage of area covered by model area).* GOR ranges from -100 to +100. Negative index values reflect a model that works worse than random chance; low positive values reflect a model that works little better than random chance. High positive values reflect a model that accurately predicts site parcels within a relatively small model area.

Table 6-1. DoD Installations Selected for the ESTCP Project

DoD Installation	Armed Service	GIS Data Requirements for Validation of Surface and Subsurface Predictive Model(s)	Statistical Validation Tests	Performance Standards (Sensitivity [S] Score)
Fort Drum, NY	Army	**Environmental:** geomorphic data on paleo-shorelines, fossil drainages, and fossil islands; soils; climate data; elevation (DEM); slope; aspect; hydrological boundaries; wetland coverage; terrace coverage; watercraft portage locations; economic plant distributions; and primary lithic sources. **Cultural:** Survey areas; site polygons/centroids and site attributes; shovel test pit locational and attribute data. Data coverage requirements: (1) post-wide systematic sampling, (2) model testing, and (3) Section 106 actions. **Predictive models:** GIS sensitivity maps and all GIS layers used to generate sensitivity maps.	**Modeling Approaches:** Logistic Regression and/or Weighted Intersection for Surface models; Paleo-Landscape Reconstruction through geomorphic analysis for Subsurface/Buried sites models **Sampling Protocols for Independent Tests** (for Surface models only): Double Validation, Split-Sample and/or Jackknife **Validation Tests** (for Surface models only): Gain and Gain over Random (GOR) statistics	**All-Sites Surface and Buried models:** Overall: S ≤ 0.39 High: S ≈ 0.20 Medium: S ≈ 0.75 Low: S ≈ 14.0 **Red Flag model:** Overall: S ≤ 0.25 High: S ≈ 0.13 Medium: S ≈ 0.87 Low: S ≈ 15.4 Positive gain values approaching 1.0 Positive GOR values approaching 100
Eglin AFB, FL	Air Force	**Environmental:** potable water, DEM, physiographic zones (i.e., coastal and alluvial plains), LIDAR data, and geomorphology. **Cultural:** Survey areas; site polygons/centroids and site attributes; isolated find locations and attributes. Data coverage requirements: (1) base-wide random sampling and (2) Section 106 actions. **Predictive models:** GIS sensitivity maps and all GIS layers used to generate sensitivity maps.	**Modeling Approaches:** Logistic Regression and/or Weighted Intersection for Surface models; Paleo-Landscape Reconstruction through geomorphic analysis for Subsurface/Buried sites models **Sampling Protocols for Independent Tests** (for Surface models only): Double Validation, Split-Sample and/or Jackknife **Validation Tests** (for Surface models only): Gain GOR statistics	**All-Sites Surface and Buried models:** Overall: S ≤ 0.39 High: S ≈ 0.20 Medium: S ≈ 0.75 Low: S ≈ 14.0 **Red Flag model:** Overall: S ≤ 0.25 High: S ≈ 0.13 Medium: S ≈ 0.87 Low: S ≈ 15.4 Positive gain values approaching 1.0 Positive GOR values approaching 100

The Gain and GOR statistics provide measures of overall model performance. They are relatively easy to compute and thus serve as useful initial measures. However, for a performance standard, we want a statistic that mirrors stakeholders' perceptions of what is acceptable model performance. Altschul et al (2004:21) designed the Sensitivity Score (S)[11] to address this need (see Section 3.1.1 for description).

S is related to the Gain statistic, except that it calculates model performance for each sensitivity zone using all the available data, rather than using a random sample to calculate the performance of only the higher sensitivity zones. Because of this, we can use S to calculate the performance of high-, medium-, and low-sensitivity zones and evaluate performance according to standards agreed-upon by archaeologists and other stakeholders.

As described in Section 3.1.1, we adopted the MnModel standard for assessing performance of the all-surface sites and buried sites models (≥ 85% of sites within ≤ 33% of modeled area; S = 0.39). The MnModel standard is a very conservative standard arrived at in Minnesota by stakeholder consensus. Installation personnel participating in the current project agreed to use the same conservative standard, although it is certainly possible for other standards to be applied in other situations. An even more conservative performance standard was adopted for red flag models as red flag sites are typically rare and require special management considerations not typically afforded to sites of other types. The standards adopted for assessing model performance, as well as the target values for individual sensitivity zones, are summarized in Table 6-1 (see also Section 3.1.1).

6.1.2.1 Validation Tests for Eglin AFB Surface Models

To calculate the Gain and GOR statistics for the Eglin surface model, 100,000 random points were generated from within surveyed areas. The resulting points were then attributed in terms of whether they fell within a site area or a non-site area as well as according to the sensitivity zone within which they were located for both the baseline surface model and the refined surface model. The numbers of points falling inside and outside sites and in the different sensitivity zones were then used as a proxy for area, since the points were generated randomly at a uniform density throughout surveyed areas.

The baseline surface model for Eglin AFB has only low- and high-sensitivity zones, and no medium-sensitivity zone, so the model area for the baseline model consists simply of the high-sensitivity zone, rather than medium- and high-sensitivity zones. For the baseline model, the Gain statistic was computed as 0.29 and the GOR statistic as 18.2, indicating that the model has predictive utility and performs better than random. For the refined surface model, the Gain statistic was computed as 0.70 and the GOR statistic was computed 69.3, indicating a substantial improvement over the baseline model in performance.

Sensitivity scores were calculated, as indicated above, using all the available data, rather than a random sample. Overall, the baseline model appears to work quite well, achieving an S Score of

[11] $S_i = (a_i)/(b_i)$ where a_i is the proportion of sensitivity zone (i) surveyed to the total area surveyed, and b_i is the proportion of the total number of sites that are found in sensitivity zone (i). Assuming at least one site is recorded in each sensitivity zone, S varies between zero and infinity. The closer S is to zero, the greater the sensitivity.

0.46 (Table 6-2). Sixty-two percent of site acres are found within just 29 percent of installation area, resulting in an S Score which is relatively close to the MnModel standard of ≤ 0.39. It should be kept in mind, however, that most survey for prehistoric sites since model development has been conducted in areas of high sensitivity, so the sample of sites used to test the model could be biased towards those that occur mostly in high sensitivity zones of the baseline model. When tested according to watershed, it can be shown that model performance varies considerably among watersheds. At face value, the model meets the MnModel standard (S = 0.39) for four of six watersheds—the western half of Choctawhatchee Bay, East Bay, East Bay River, and Yellow River—but is far from meeting the standard in the remaining two watersheds (see Table 6-2). However, examination of the underlying proportions that make up the S Score shows that for the watersheds where the baseline model achieves an S Score less than 0.39, the model does not place 85 percent or more of site area within the high-sensitivity zone. The high-sensitivity zone is in each case smaller than specified than by the standard, being less than 33 percent of modeled area, but less than 85 percent of site area falls within the high-sensitivity zone in each of the watersheds. A low S Score is calculated for some watersheds because a relatively large proportion of site area falls within a high-sensitivity zone smaller than that specified by the performance standard. For the watersheds with low S scores for the baseline model, the high-sensitivity zone comprises approximately 20 to 30 percent of installation area. Thus, the baseline model does not strictly meet the MnModel performance standard established for the project in any watershed (85 percent of sites within 33 percent of modeled area), although it is fairly close to meeting the standard in most cases.

Table 6-2. Sensitivity Scores for the Eglin AFB Baseline Surface Model, According to Watershed

	Low-Sensitivity Zone			High-Sensitivity Zone		
Watershed	a	b	S	a	b	S
Barrier Island	0.93	0.98	*0.95*	0.07	0.02	*3.96*
Choctawhatchee Bay (west)	0.72	0.28	*2.62*	0.28	0.72	*0.38*
Choctawhatchee Bay (east)	0.57	0.39	*1.45*	0.43	0.61	*0.71*
East Bay	0.80	0.35	*2.26*	0.20	0.65	*0.32*
East Bay River	0.77	0.33	*2.31*	0.23	0.67	*0.35*
Yellow River	0.77	0.35	*2.22*	0.23	0.65	*0.35*
Entire Installation	0.71	0.38	*1.90*	0.29	0.62	*0.46*

A similar situation obtains when the baseline model is tested according to site type. When tested according to site type, the S Score is below 0.39 for a burial site, a mound site, and raw material collection sites; the S Score is slightly above 0.39 for campsites and sites of undetermined function (Table 6-3). The S Score is substantially higher and well outside the standard for village/town sites. At face value, these data would suggest that the model meets the standard for a wide range of site types. However, as was the case when the baseline model was tested according to watershed, the model does not place at least 85 percent of site area within 33 percent or less of modeled area for any site type, except a burial site. For campsites, collection stations, a mound site, and sites of undetermined function, on the order of two-thirds to three quarters of site area falls within slightly less than two-thirds of modeled area. Thus, the baseline model does not meet the strict definition of the standard when tested according to site type, but it nevertheless performs fairly well in predicting most site types.

When tested according to temporal affiliation (Table 6-4), the model is closest to the MnModel standard for Paleoindian through Middle Archaic period sites and for sites of undermined temporal affiliation. The model performs less well for later periods (Late Archaic through Early Woodland, Middle and Late Woodland, Mississippian). The model achieves an S Score of 0.39 for Paleoindian through Middle Archaic period sites, but does so by placing approximately three quarters of site area within 29 percent of modeled area. To meet the standard, it would need to place 85 percent of site area within 33 percent or less of modeled area. Examination of the baseline model suggested that it performed worst in predicting prehistoric village/town sites (which tend to date to the Woodland and Missippian periods), sites in the eastern half of the Choctawhatchee Bay watershed, and sites on Santa Rosa Island.

Table 6-3. Sensitivity Scores for the Eglin AFB Baseline Surface Model, According to Site Function

	Low-Sensitivity Zone			High-Sensitivity Zone		
Function	a	b	S	a	b	S
burial site	0.71	0.00	—	0.29	1.00	*0.28*
campsite	0.71	0.33	*2.20*	0.29	0.67	*0.42*
collection station	0.71	0.24	*2.92*	0.29	0.76	*0.38*
mound site	0.71	0.22	*3.30*	0.29	0.78	*0.36*
undetermined	0.71	0.33	*2.15*	0.29	0.67	*0.43*
village/hamlet	0.71	0.50	*1.42*	0.29	0.50	*0.57*

Table 6-4. Sensitivity Scores for the Eglin AFB Baseline Surface Model, According to Temporal Affiliation

Function	Low-Sensitivity Zone			High-Sensitivity Zone		
	a	b	S	a	b	S
Paleoindian through Middle Archaic	0.71	0.26	*2.73*	0.29	0.74	*0.39*
Late Archaic through Early Woodland	0.71	0.39	*1.84*	0.29	0.61	*0.47*
Middle and Late Woodland	0.71	0.43	*1.67*	0.29	0.57	*0.50*
Mississippian	0.71	0.46	*1.55*	0.29	0.54	*0.53*
Undetermined	0.71	0.33	*2.16*	0.29	0.67	*0.43*

Like the baseline surface model, the refined surface model was tested according to watershed, site type, and temporal affiliation (Table 6-5, Table 6-6, and Table 6-7). The model correctly predicts over 98 percent of prehistoric site areas in just 17 percent of installation area. The refined model meets the MnModel standard for all watersheds according to the S Score as well as the underlying proportions that make up the S Score. The model works least well for the eastern half of the Choctawhatchee Bay watershed, as was the case with the baseline model. Unlike the baseline model, the refined model also meets the MnModel standard for all site types and temporal affiliations, suggesting that it is not biased against particular kinds of resources. One potential problem with the model is that, since Eglin AFB has focused nearly all intensive survey effort in areas predicted to be of high sensitivity in the baseline model, it could be missing less common sites located in the low-sensitivity zone of the baseline model and essentially predicting where sites are likely to be found using current detection methods within high-sensitivity zones of the baseline model, rather than correctly predicting site location for the entire

installation. However, high-sensitivity zones in the refined model do, in some cases, extend outside of high-sensitivity zones in the baseline model. This suggests that there are areas outside of high-sensitivity zones in the baseline model that are very similar environmentally to where sites have been found in previously surveyed areas. Further refinement of the model could be achieved by performing stratified sample survey in low-sensitivity zones to acquire additional independent data for model testing and refinement.

Table 6-5. Sensitivity Scores for the Eglin AFB Refined Surface Model, According to Watershed

	Low-Sensitivity Zone			High-Sensitivity Zone		
Watershed	a	b	S	a	b	S
Barrier Island	0.84	0.02	*50.81*	0.16	0.98	*0.16*
Choctawhatchee Bay (east)	0.74	0.02	*38.63*	0.26	0.98	*0.26*
Choctawhatchee Bay (west)	0.83	0.01	*59.77*	0.17	0.99	*0.17*
East Bay	0.90	0.01	*127.70*	0.10	0.99	*0.10*
East Bay River	0.92	0.01	*152.42*	0.08	0.99	*0.08*
Yellow River	0.83	0.01	*81.53*	0.17	0.99	*0.17*
Entire Installation	0.83	0.01	*55.76*	0.17	0.99	*0.17*

Table 6-6. Sensitivity Scores for the Eglin AFB Refined Surface Model, According to Site Function

	Low-Sensitivity Zone			High-Sensitivity Zone		
Function	a	b	S	a	b	S
burial site	0.83	0.00	—	0.17	1.00	*0.17*
campsite	0.83	0.02	*51.73*	0.17	0.98	*0.17*
collection station	0.83	0.01	*55.40*	0.17	0.99	*0.17*
mound site	0.83	0.00	—	0.17	1.00	*0.17*
undetermined	0.83	0.02	*39.97*	0.17	0.98	*0.18*
village/hamlet	0.83	0.00	*551.00*	0.17	1.00	*0.17*

Table 6-7. Sensitivity Scores for the Eglin AFB Refined Surface Model, According to Temporal Affiliation

	Low-Sensitivity Zone			High-Sensitivity Zone		
Period	a	b	S	a	b	S
Paleoindian through Middle Archaic	0.83	0.01	*92.34*	0.17	0.99	*0.17*
Late Archaic through Early Woodland	0.83	0.00	*283.06*	0.17	1.00	*0.17*
Middle and Late Woodland	0.83	0.01	*139.04*	0.17	0.99	*0.17*
Mississippian	0.83	0.01	*122.70*	0.17	0.99	*0.17*
Undetermined	0.83	0.02	*43.34*	0.17	0.98	*0.17*

6.1.2.2 Validation Tests for Fort Drum Surface Models

At Fort Drum, the Gain, GOR, and Sensitivity Score statistics were calculated for the baseline and refined surface models (Table 6-8 and Table 6-9) following the same methods as applied to the Eglin AFB surface models.

Table 6-8. Sensitivity Scores for the Fort Drum Glacial Lake and Upland Baseline Surface Models, According to Physiography

Physiographic Zone	Low-Sensitivity Zone			Medium-Sensitivity Zone			High-Sensitivity Zone			Medium/High-Sensitivity Zone		
	a	b	S	a	b	S	a	b	S	a	b	S
Alluvial Flood Plain	1.00	1.00	*1.00*	—	—	—	—	—	—	—	—	—
Lake Plains	0.67	0.60	*1.12*	0.25	0.22	*1.13*	0.08	0.18	*0.43*	0.33	0.40	*0.82*
Pine plains	—	—	—	0.78	0.72	*1.09*	0.22	0.28	*0.78*	1.00	1.00	*1.00*
Upland	0.54	0.64	*0.83*	0.39	0.31	*1.28*	0.07	0.05	*1.44*	0.46	0.36	*1.30*
Lowland combined	0.44	0.07	*6.25*	0.44	0.66	*0.66*	0.13	0.27	*0.47*	0.56	0.93	*0.61*
Entire installation	0.46	0.08	*5.81*	0.43	0.65	*0.65*	0.11	0.27	*0.43*	0.54	0.92	*0.59*

Table 6-9. Sensitivity Scores for the Refined Surface Model for Fort Drum, According to Physiography

Physiographic Zone	Low-Sensitivity Zone			Medium-Sensitivity Zone			High-Sensitivity Zone			Medium/High-Sensitivity Zone		
	a	b	S	a	b	S	a	b	S	a	b	S
Alluvial Flood Plain	0.76	0.32	*2.33*	0.15	0.41	*0.37*	0.09	0.27	*0.34*	0.24	0.68	*0.36*
Lake Plains	0.86	0.13	*6.75*	0.09	0.12	*0.77*	0.05	0.75	*0.06*	0.14	0.87	*0.16*
Pine plains	0.75	0.12	*6.07*	0.16	0.31	*0.50*	0.09	0.57	*0.16*	0.25	0.88	*0.28*
Upland	0.47	0.11	*4.36*	0.21	0.47	*0.45*	0.32	0.42	*0.76*	0.53	0.89	*0.60*
Lowland combined	0.82	0.13	*6.50*	0.12	0.29	*0.40*	0.06	0.58	*0.11*	0.18	0.87	*0.21*
Entire installation	0.74	0.13	*5.88*	0.14	0.30	*0.47*	0.12	0.58	*0.21*	0.26	0.87	*0.30*

Gain and GOR statistics show that the baseline Glacial Lake Model has some potential as a predictive model. The Gain statistic was calculated as 0.34, indicating the model has predictive utility. At 31.4, the GOR statistic is low-to-moderate, suggesting that the model works better than random chance.

Evaluation of Sensitivity Scores, however, indicates that the Glacial Lake Model does not work particularly well in identifying medium- and high-sensitivity zones. This is mostly because these zones are large with respect to the size of the installation. Although the model correctly places roughly 93 percent of sites area within medium- or high-sensitivity zones, these zones together comprise approximately 56 percent of installation area. In other words, the model is accurate in where sites are likely to be found but in a fairly coarse-grained fashion. The model is not very precise or specific in identifying medium- or high-sensitivity zones. Where the model does work moderately well is in identifying areas of low sensitivity, given that sites are especially rare within the low-sensitivity zone.

The Upland Model performed poorly when tested with validation statistics. The Gain statistic was computed as -0.33 and the GOR statistic was computed as -11.0, indicating that the model has no predictive utility and performs worse than random. Approximately 64 percent of site area falls within the low-sensitivity zone, which comprises a little more than half of the Upland physiographic zone. Sensitivity scores indicate that both medium- and high-sensitivity zones perform worse than a random model, while the low-sensitivity zone has a Sensitivity Score below 1, indicating that the proportion of site area within the low-sensitivity zone is higher than the proportion of installation area in that zone. This outcome suggests that the low-sensitivity zone is actually more likely to contain sites than the medium- and high-sensitivity zones.

As with the refined surface model for Eglin AFB, the refined surface model for Fort Drum performs substantially better than the baseline models. The Gain statistic was calculated as 0.75 for the refined surface model, indicating the model has high predictive utility. At 66.5, the GOR statistic is also relatively high, indicating the model works substantially better than random. In other words, the Gain and GOR statistics for the refined model increased by a wide margin in comparison to the baseline models.

When tested with the Sensitivity Score, the overall refined surface model meets the MnModel standard, with 87 percent of site area occurring in medium-or high-sensitivity zones, which together comprise approximately 26 percent of the installation. However, the model does not work particularly well in the Upland physiographic zone, which may be due to limited survey data from the area and a lack of fine-grained surface geology data. Although nearly 90 percent of site area falls within the medium- or high-sensitivity zone in the Upland physiographic zone, these sensitivity zones comprise approximately half of the installation area in the Upland physiographic zone. In addition, although the S Score for the Alluvial Flood Plain physiographic zone is below 0.39, only 68 percent of site area falls within medium- or high-sensitivity zone in this area of Fort Drum. To meet the standard in its strictest sense, 85 percent or more of site area would have to fall within the medium- and high-sensitivity zones in the Alluvial Flood Plain. Since many sites in the Alluvial Flood Plain are likely to be buried along with the paleolandforms that may have attracted land use in this area of Fort Drum in the ancient past, the somewhat weaker performance of the model in the Alluvial Flood Plain is not entirely unexpected.

The refined model meets the performance standard according to the S Score and the underlying proportions that make up the S Score for the Lake Plains and Pine Plains physiographic zones as well as for all lowland areas combined. As stated above, the model also meets the performance standard for Fort Drum overall, but this result is likely due to the strong performance of the model in the Lake Plains and Pine Plains physiographic zones. The model performs best in the Pine Plains physiographic zone, where the greatest survey effort has been placed.

Evaluation of the model suggests that additional inventory data from the other physiographic zones, particularly the Upland zone, would be useful to further refine the model. We recommend that, if the opportunity presents itself, additional sample survey in the Upland zone be conducted according to a stratified random sample in order to obtain additional and more widely distributed CRM data that can be used to model site location in the Upland zone. We also recommend that additional effort be made to acquire fine-grained geological data for the Upland zone and that

additional archaeological work be conducted in the Upland zone to determine what factors are likely to have affected site location in that area of the installation. In other words, we suggest that effort be placed in acquiring a larger and more representative sample of site and nonsite locations in the Upland zone and in refining independent variables to be used in modeling site location in the Upland zone. Efforts to identify paleo-landforms within the Alluvial Flood Plain, such as geoarchaeological mapping of buried paleo-stream channels, will help to improve model performance in the Alluvial Flood Plain.

6.2 IMPROVE ARCHAEOLOGICAL SUBSURFACE PREDICTIVE MODELS

As with surface archaeological models, there are no nation- or discipline-wide standard for evaluating the accuracy or precision of models that predict the location of buried archaeological sites. Expectations based on the environmental attributes are improved (i.e., adjusted, recalibrated) by (1) actual discoveries of buried sites revealed through deep shovel tests, augers holes, and trenches, and (2) additional data on past landforms, climate, water resources, vegetation, and geomorphic processes.

Given our current understanding concerning the arrival of human groups in North America, we expect that buried sites will be no older than about 13,000 years and that sites that resulted from human activities that leave physical evidence as artifacts, features, and various earth modifications will have taken place on late Pleistocene- and Holocene-age landforms. Therefore, to improve knowledge of the former landscapes on which ancient people lived, environmental data that help geomorphologists reconstruct landforms and economic resources at different points in the past, as well as the geological and climatic processes that influence landform morphology and evolution and resource distribution and abundance, must be gathered. Without initiating additional fieldwork, we suggest that buried sites models can be constructed and improved through the analysis and synthesis of extant data to reconstruct past landscapes. These data will likely include the following: analysis of black-and-white and color infra-red aerial photos of the demonstration project study areas, soil maps, geological maps, stratigraphic studies known from subsurface investigations on and near installations, paleoclimate reconstructions, archaeobotanical analyses, and absolute dates obtained from buried archaeological and geological deposits.

Validating a subsurface predictive model is time consuming and expensive. Unlike a surface model that can be tested with data obtained during routine compliance activities, buried sites can only be detected by deep subsurface probing or excavation of a type not normally conducted outside of development. Consequently, the number of “test” observations for a subsurface model is usually quite limited. In recognition of this problem, archaeologists often relax the “target” of these probes. Instead of only considering archaeological artifacts and deposits as “sites,” we often include buried surfaces on which sites are common. For example, archaeological sites are common on buried “A” horizons, but a single probe, even one placed in an archaeological site, can be “empty” (i.e., contain no evidence of archaeological material or deposits). Thus, we will consider the accurate prediction of buried “A” horizons and other similar depositional environments in the same category as correct prediction of archaeological resources. By relaxing the target, we can use data collected by a number activities, such as soil and hydrological studies as well as routine trenching for construction, for model testing and refinement.

In lieu of a widely acceptable standard, we suggest using the same Sensitivity Score (S) value of 0.39, which represents 85 percent of all buried archaeological sites located in no more than 33 percent of the model area, to be our measure of success for the buried sites model. We were not able to obtain information other than anecdotal information on the location of buried sites at Eglin AFB or Fort Drum; the little information that we do have is insufficient to validate the subsurface model for either installation. However, there are some data in the STP database for Fort Drum that could be used to perform a partial validation of the Fort Drum subsurface model. Using the database, we were able to identify STPs within which soil horizons with an upper depth of 40+ cm below ground surface and that contained prehistoric artifacts were discovered. This depth is, of course, shallower than the depth of 1 m or more that we have used to define buried sites for the project. Since STPs rarely extend beneath a meter in depth, however, and these were the only data available to assess the model, we felt it was worthwhile to determine how these more shallow buried deposits were distributed with respect to the model predictions. In other words, these horizons represent buried cultural deposits not at great depth; they could not be such given that these observations come from shovel test units of limited depth. Rather, these are cultural deposits that have the potential to have been buried as a result of landscape formation processes (e.g., alluvial or colluvial deposition) that occurred at some point after the prehistoric activities creating these deposits had taken place. In some cases, artifacts within these deposits could have migrated down the soil column through bioturbation or other disturbance processes and thus may not accurately represent a buried cultural deposit. Information in the database was insufficient to determine the integrity and depositional context of these deposits, but they nonetheless represent a proxy for buried deposits that could be used to partially validate the Fort Drum subsurface model.

Rather than randomly sampling the surveyed areas to calculate Gain and GOR statistics for the Fort Drum subsurface model, we used the sample of STPs (n = 137,839) to identify STPs with potential buried cultural deposits (n = 118). Using these data, the Gain statistic is calculated as 0.20, indicating that the model has low to moderate predictive utility, while the GOR statistic is calculated as 18.1, which suggests that the model predicts the location of buried cultural deposits better than random.

S Scores were calculated in the same manner as for the surface models, but using the STPs with potential buried cultural deposits in place of sites. Over 91 percent of STPs with potential buried cultural deposits were found within approximately 38 percent of the installation comprised of medium- and high-sensitivity zones. The vast majority of the test pits with a potential buried deposit (90 percent) occur in the Pine Plains zone—a result that conforms well to the predictions of the model in that the majority of the Pine Plains is considered to be of medium or high sensitivity for buried site potential. The small remainder of STPs with potential buried deposits (n = 12) fall in the Lake Plains zone. Interestingly, 5 of the 12 test pits with potential buried deposits in the Lake Plains zone fall in low-sensitivity areas but in each of these cases, the STP was placed within 20 m of a medium- or high-sensitivity zone. S Scores indicate that, overall, the subsurface model is close to meeting the performance objective, with an S Score of 0.42 for medium- and high-sensitivity zones. However, in examining the S Scores per sensitivity zone, it is clear that the model works well in predicting the low- and medium-sensitivity zones (S_{low} = 7.21; S_{medium} = 0.40), but not as well as we would expect for the high- sensitivity zone (S_{high} = 0.52). It is likely that there are areas within the medium-sensitivity zone that should actually be

characterized as high sensitivity. As discussed earlier in the document, aeolian deposits on the installation, for instance, are not particularly well captured by available mapping layers used to develop the Fort Drum subsurface model. Dr. Homburg observed during his field reconnaissance at Fort Drum that relatively confined areas or pockets of aeolian deposits were fairly prevalent in some areas of the installation but were not adequately represented by available mapping layers. The subsurface model could potentially be refined by developing and applying more detailed, finer-grained mapping information on the location of surface soils and geology.

Since systematically obtained data on the location of buried sites and deposits are not currently available, the subsurface models for Eglin AFB and Fort Drum will need to be validated with future field efforts aimed at discovering buried sites or in characterizing the subsurface depositional environment for different parts of the installation. Nonetheless, the subsurface models remain useful in their current state in that they formalize expert geoarchaeological knowledge about where buried deposits of an appropriate age are possible or likely and thus provide a useful model of where site discovery methods need to account for buried site potential. These models also indicate where installation staff should be looking to begin to determine where within the universe of potential buried contexts sites are actually discovered.

6.3 IMPROVE ARCHAEOLOGICAL RED FLAG PREDICTIVE MODELS

No red flag models had been developed for either Fort Drum or Eglin AFB prior to the current project. As discussed earlier, a red flag model was created only for Eglin AFB because site type data were lacking for Fort Drum. The red flag model was tested with Gain and GOR statistics in the same manner as for the surface models, as well as tested with sensitivity scores. The Gain statistic for the red flag model was calculated as 0.95, indicating very high predictive capacity, and the GOR statistic was calculated as 94.8, indicating the model works much better than random. The exceptionally high performance of the model is likely due to the relatively concentrated and discrete locations in which red flag sites have been found, resulting in nearly all red flag-site area falling within a very small model area.

When tested with the Sensitivity Score statistic, the red flag model performs very well identifying 99 percent of red flag sites in just 3 percent of installation area. According to the model, red flag sites tend to be located near the coast adjacent to estuaries and inlets, on Santa Rosa Island, near the Yellow River, and near the headwaters of some streams in the interior of the installation.

6.4 DEVELOP SECTION 106 PROGRAMATIC AGREEMENTS BASED ON MODELING

As noted in Section 3.0 and Table 3-1, the metric for this objective was to complete a draft(s) and final version of the PA, based on consultation with installation stakeholders and Section-106 consulting parties. This objective was partially met for the demonstration project and will ultimately be met for the installations when the PA is executed and filed with the ACHP. As previously explained, the PAs for Eglin AFB and Ft Drum were prepared as final first drafts to provide each installation with a solid foundation on which to complete the consultation processes.

Project team members met with the ACHP Federal Project Review staff members at their office in Washington D.C., in February, 2010 to discuss the ESTCP modeling project and the use of archaeological predictive models for Section-106 and Section-110 compliance. The ACHP staff was very supportive of this effort and explained that the ACHP encourages the development and use of predictive models for planning and compliance purposes. During the same trip, demonstration project team members attended the annual meeting of the National Conference of State Historic Preservation Officers (NCSHPO) to present a poster on the ESTCP project. The NCSHPO also endorsed the ESTCP project.

6.4.1 Eglin AFB

Demonstration project team members met with Eglin AFB staff on numerous occasions over the course of the demonstration project between 2008 and 2011. In 2009, archaeologists from URS Corporation assisted SRIF with data collection by reviewing Eglin AFB's electronic site and survey database. In June 2010, project team members traveled to Eglin AFB and reviewed a sample of its CRM report library and project files to collect data on the level of effort associated with archaeological survey and testing over time. In August 2011 project team members again traveled to Eglin AFB to provide the Eglin AFB CRM staff and its archaeological contractor, PTA, with a project status update, which included preliminary findings on the model testing and validation. In 2011, project team members completed a preliminary draft PA outline and then a final draft PA outline for Eglin AFB CRM staff to review; a complete first draft PA was prepared and submitted to Eglin AFB in October 2011. Although we had hoped to involve the SHPO and other consulting parties in the PA process during the course of the demonstration project, this has not yet taken place. These parties were not directly consulted about the PA draft for two reasons. First, it was necessary to wait until the preliminary models were developed and refined, which did not occur until 2011. Second, the first draft of any PA has to be reviewed approved by USAF management before it can be distributed to outside parties; this has not happened to date. The SHPO, however, is aware of the ESTCP demonstration project and wrote a letter as early as August 20, 2008 in support of the project's objectives. The SHPO has long approved of Eglin AFB's use of its Site Probability Model for resources management and compliance purposes. In this sense, the ESTCP demonstration project represents a refinement of the tools and processes already in place at Eglin AFB, which explains, in part, the SHPO's ready acceptance of the demonstration project's objectives.

In the course of preparing the draft PA, Eglin AFB CRM staff asked about the possibility of preparing a comprehensive PA that would address management of *all* cultural resources on the base. Demonstration project team members noted that a PA implemented in 2003 for historic buildings and structures was already in existence and suggested that instead of developing a separate PA, Eglin should amend the existing 2003 PA. Eglin AFB staff agreed. The draft PA, presented in Appendix B, is dedicated to the management of archaeological resources at Eglin AFB and specifically incorporates the models prepared for this demonstration project.

6.4.2 Fort Drum

Between 2008 and 2011, the demonstration project team repeatedly met with and discussed the ESTCP project with the Fort Drum CRM staff and the New York SHPO staff. A letter dated January 5, 2009 indicates that the New York SHPO was open to the possibility of using predictive models for resource management and compliance purposes and supported in principle the ESTCP project objectives. Project team members visited Fort Drum in October 2008 to provide an introduction to the ESTCP project and to initiate the discussion of how to meet the Fort's management needs. A second follow-up meeting brought the CRM staff and the New York SHPO staffs together to tour the base, visit its historic and archaeological sites, and to further discuss the ESTCP modeling project. In September 2009, archaeologists from URS Corporation collected summary information on Fort Drum's survey and testing program maintained in both electronic form and in its CRM report library. The Fort Drum CRM staff expended a significant amount of time reviewing project files and field notes for this 2009 effort. In August 2010, project team members met again with the Fort Drum and New York SHPO staffs, this time at the SHPO office, to present preliminary results of modeling testing and validation and to continue the discussion of the project and the PA. Subsequent conference calls in the fall of 2010 and the winter of 2011 laid the foundation for the draft PA presented in Appendix C. Although other consulting parties were not directly consulted during the drafting process, the Cultural Resources Manager at Fort Drum informed the federally recognized tribes with whom it consults about the project and its objectives.

Fort Drum also decided it wanted a comprehensive, installation-wide PA that would include archaeological resources as well as the historic built environment. Since one of the objectives of the ESTCP modeling effort was to demonstrate how modeling prehistoric site locations can assist DoD installations in the management of prehistoric archaeological resources, Fort Drum asked staff at Army Corps of Engineers (COE), Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) to prepare sections concerning the management of Fort Drum's historic buildings and structures. The draft PA for Fort Drum (see Appendix C) combines the efforts of this ESTCP demonstration project and CERL to meet Fort Drum's CRM needs.

6.5 STREAMLINE NATIONAL HISTORIC PRESERVATION ACT (SECTION 106) AND NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

As discussed in Section 3.3.4, the PAs for Eglin AFB and Fort Drum were not completed beyond first draft stage. As a consequence, it was not possible to conduct the before and after implementation interviews with the CRM staffs at Eglin AFB and Fort Drum concerning their perceptions of the Section 106 and NEPA compliance processes. We have, however, developed another approach to demonstrating the efficiency of developing and implementing predictive models of archaeological site location.

6.5.1 Reductions in Level of Effort, Cost, and Number of Sites Evaluated

In Section 3.3.1 and 3.3.2, we described an alternative means of demonstrating labor and cost savings through the use of archaeological predictive models. The method we used to illustrate

these savings compares the time and money expended during routine activities when a model is implemented with hypothetical levels of effort and cost incurred when predictive models were not used to make planning or compliance decisions. To conduct this analysis, we assume that survey for prehistoric archaeological sites without benefit of a predictive model would be conducted in the same manner and at the same level of intensity for all areas of the installation. This is how most DoD installations conduct archaeological survey if they do not have predictive models or do not employ some strategy for sample survey—all areas of an installation are treated as having equal potential for archaeological sites. Eglin AFB and Fort Drum, because they do have models in place and have been using them for planning and compliance purposes for many years, provide an opportunity for a "with and without" comparative analysis. Two scenarios for Eglin AFB are presented below, followed by Fort Drum. We also present a hypothetical scenario in which Eglin AFB could reduce the number of sites tested for National Register eligibility.

6.5.1.1 "With Model, Without Model" Comparison

To create the first scenario (Table 6-10), we looked at past performance at Eglin AFB, using cost and time (as a proxy for level of effort) for the period between 1994 and 2008.

For this first scenario, we used the annual average survey rate data from Table 4-4 to arrive at a figure of 12,932 ac per year (193,981[12] total survey ac/15 years). We also used cost information compiled by Eglin AFB to estimate the average cost of survey at approximately $62 per acre (see Table 4-5). Note that Table 4-4 reports that Eglin AFB has surveyed approximately 194,000 ac from 1994 through 2008, whereas Table 6-10 reports that as of 2008, slightly over 102,000 ac have been surveyed in the high-sensitivity zone (as measured in the GIS). Eglin AFB typically does not survey in the low-sensitivity zone but it does on occasion; high-sensitivity zones are not 100 percent shovel tested if field conditions suggest that survey is unwarranted. For this analysis, we used only those acres that are reported to have been physically shovel tested in high-sensitivity zones as defined by Eglin AFB's existing baseline model.

With the model, slightly more than 102,000 ac have been surveyed in Eglin's high-sensitivity zones. Without the model, we assumed random survey coverage. Since approximately 29 percent of the base is designated as highly sensitive for prehistoric archaeological sites, we assumed that if surveys were conducted at random, approximately 29,300 ac in high-sensitivity zones would have been investigated. We additionally assume that some 73,200 ac would have been surveyed at Eglin AFB in its low-sensitivity zones. This means that without the baseline model, Eglin AFB would have investigated approximately 73,200 ac that it did not have to survey. In both "with model" and "without model" scenarios, over a 15-year period, Eglin AFB expends $6,388,632, but it does so conducting archaeological survey in different parts of the installation. With the model, under the assumptions as given, Eglin AFB has saved $4,562,568 (73,200 ac x $63.33/ac) in survey expense and approximately 5.7 years (73,200 ac/12,932 ac/yr) in time using its baseline model by surveying only in the high-sensitivity zone. In projecting forward from 2008, Eglin would require an additional 2.4 years to complete survey of the 30,461 ac remaining in the high-sensitivity zone and another $1,898,665 if it continues to use its existing baseline model. Without the model, Eglin AFB would be required to survey the remaining 259,147 ac. At

[12] This number (193,981 ac) includes acres actually surveyed and acres in the low-sensitivity zone that were "cleared" but not surveyed due to environmental and safety conditions.

Table 6-10. Eglin AFB, Hypothetical Scenario One, Comparison of Past Performance With Model versus Without Model Using URS Annual Survey Estimate (see Table 4-4 and Table 4-8)

Cost and Level of Effort	With Baseline Model	Without Model
Past:		
Total reported surveyed and cleared acres (1994–2008)*	193,981	193,981
Total surveyed acres (1994–2008) calculated with GIS	102,496.9	102,496.9
Acres surveyed survey in low-sensitivity zone	0.00	73,200.2
Acres surveyed in the high-sensitivity zone	102,496.9	29,296.7
Cost per survey acre (1994-2008 15-yr average)	$62.33	$62.33
Total cost (1994–2008)	$6,388,632	$6,388,632
Cost for survey in low-sensitivity and cleared areas	$0.00	$4,562,568
Cost for survey in high-sensitivity zone	$6,388,632	$1,826,063
Survey acres per year	12,932.1	12,932.1
Time invested in survey (1994–2008)	15.0	15.0
Time savings with in-place model (yrs) [no low-sensitivity zone survey]	5.7	—
Cost savings with in-place model [no low-sensitivity zone survey]	$4,562,568	—
Future:		
Total acres remaining to be surveyed calculated with GIS for model	30,461.5	259,147
Acres surveyed in the low-sensitivity zone (or cleared)	0	183,994
Acres surveyed in the high-sensitivity zone	30,461.5	75,153
Cost per survey acre	$62.33	$62.33
Total survey cost (2009–?)	$1,898,665	$16,152,633
Cost for survey in low-sensitivity and cleared areas	$0.00	$11,468,369
Cost for survey in high-sensitivity zone	$1,898,665	$4,684,263
Survey acres per year (15-yr average)	12,932.1	12,932.1
Time required to complete survey (yrs)	2.4	20.0
Time savings with in-place model (yrs) [no low-sensitivity zone survey]	14.2	—
Cost savings with in-place model [no low-sensitivity zone survey]	$11,468,369	—
Full Cost (Past plus Future):		
Total cost with and without baseline predictive model:	$8,287,297	$22,541,264
Total time (yrs) with and without baseline predictive model	17.4	35.0
Time savings (percentage) using baseline model vs. using no model	50%	—
Cost savings (percentage) using the baseline model vs. using no model	63%	—

*Acreage includes surveys conducted for historic-period homesteads, limited survey in low-sensitivity zones, and areas precluded from survey due to environmental or safety conditions.

$62.33 an acre, and at a survey rate of 12,932 ac/yr, it would cost Eglin AFB $16,152,632 and take approximately 20 years to complete. The difference between the "with baseline model" and "without model" scenarios is a savings of 14.2 years and $11,468,369.

Another way to calculate how much Eglin AFB could benefit from using its baseline model is to add the actual time and money expended in the past to the estimated level of effort needed to complete survey in the future. By this calculation, Eglin AFB will expend a total of $8,287,297 over a 17.4-year period using the baseline model. Total costs to complete survey without the model would be the range of $22.5 million and require a total of 35 years. In other words, by continuing to use the baseline model Eglin AFB will ultimately achieve a time savings of 50 percent and a cost savings of 63 percent over what would have been required if no predicative archaeological model was employed.

To create Table 6-11, we ran the same scenario using a lower average survey rate per year based on GIS calculations of actual acres surveyed, but retained the other historic estimates. We did this because we believe that the data for average annual rate of survey estimated by URS archaeologists is too high, possibly reflecting inflated figures due to the effect of counting areas not intensively surveyed as surveyed. In this scenario, we calculated an average survey rate per year of 6,833.1 ac (rather than 12,932.1 ac) based on the number of acres surveyed in the high-sensitivity zone of the baseline model. This figure is derived by dividing the number of acres surveyed in the high-sensitivity zone (and thus, intensively surveyed) by the number of years of survey work since the model was implemented (102,496.9 ac/15 yrs).

The results differ from the first analysis because the rate of survey is slower in both the "with" and "without" model scenarios. In this case, Eglin AFB has saved the same amount of money using the baseline predictive model ($4,562,568), but it saved more time (10.7 yrs) due to the slower survey rate estimate. The amount of time needed to complete survey of the remaining 30,461 ac in the high-sensitivity zone using the baseline model would also be longer than the first scenario, at 4.5 years; however, the cost would be the same as in the first scenario at $1,898,665. Without the model, the figures are even more startling than those presented in Table 6-10 due to the slower survey rate estimate. In this second scenario, it would take Eglin AFB almost 38 years (259,147 ac/6,833 ac/yr) to complete archaeological survey of the installation at a cost of more than $16 million (258,147ac x $62.33/ac), not accounting for future inflation. At the slower and more realistic rate of 6,388 ac/yr, Eglin AFB can expect to save a total of $14,253,967 and 33.5 years using the baseline model versus no model.

Again, by adding the time and cost of archaeological survey already conducted to the projected level of effort needed to finish survey, a more complete picture emerges of the benefits of using the baseline model. With the model, the total cost of survey from beginning to end is estimated to be $8,287,297 and would take a total of 19.5 yr to complete. Without the model, the total expense of survey is projected to be approximately $22.5 million and would require almost 53 years to complete. Under this second scenario, with the baseline model Eglin AFB could achieve a savings of 63 percent in both time and funding.

Having shown that Eglin achieved substantial savings in time and money by implementing the baseline model, we now project into the future to estimate the difference in cost and time savings between Eglin AFB's current baseline model and the refined surface model prepared for this

Table 6-11. Eglin AFB, Hypothetical Scenario 2, Comparison of Past Performance With Model versus Without Model, Using GIS-Based Annual Survey Estimate (data derived from Table 4-4 and Table 4-8)

Cost and Level of Effort	With Baseline Model	Without Model
Past:		
Total reported surveyed and cleared acres (1994–2008)*	193,981	193,981
Total surveyed acres (1994–2008) calculated with GIS	102,496.9	102,496.9
Acres surveyed survey in low-sensitivity zone	0.0	73,200.2
Acres surveyed in the high-sensitivity zone	102,496.9	29,296.7
Cost per survey acre (1994–2008 15-yr average)	$62.33	$62.33
Total cost (1994–2008)	$6,388,632	$6,388,632
Cost for survey in low-sensitivity and cleared areas	$0.00	$4,562,568
Cost for survey in high-sensitivity zone	$6,388,632	$1,826,063
Survey acres per year (15-yr average calculated with GIS)	6,833.1	6,833.1
Time invested in survey (1994–2008)	15.0	15.0
Time savings with in-place model (yrs) [no low-sensitivity zone survey]	10.7	—
Cost savings with in-place model [no low-sensitivity zone survey]	$4,562,568	—
Future:		
Total acres remaining to be surveyed	30,461.5	259,147
Acres surveyed in the low-sensitivity zone (or cleared)	0.0	183,994
Acres surveyed in the high-sensitivity zone	30,462	75,153
Cost per survey acre	$62.33	$62.33
Total survey cost (2009–?)	$1,898,665	$16,152,633
Cost for survey in low-sensitivity and cleared areas	$0.00	$11,468,369
Cost for survey in high-sensitivity zone	$1,898,665	$4,684,263
Survey acres per year (15-yr average calculated with GIS)	6,833.1	6,833.1
Time required to complete survey (yrs)	4.5	37.9
Time savings with in-place model (yrs) [no low-sensitivity zone survey]	33.5	—
Cost savings with in-place model [no low-sensitivity zone survey]	$14,253,967	—
Full Cost (Past plus Future):		
Total inventory cost with and without baseline predictive model:	$8,287,297	$22,541,264
Total time (yrs) with and without baseline predictive model	19.5	52.9
Time savings (percentage) using baseline model vs. using no model	63%	—
Cost savings (percentage) using the baseline model vs. using no model	63%	—

*Acreage includes surveys conducted for historic-period homesteads, limited survey in low-sensitivity zones, and areas precluded from survey due to environmental or safety conditions.

demonstration (Table 6-12). In this comparison, we use same figures for average rate of survey per year and cost per acre as were used in Table 6-10 and Table 6-11. Both models assume that 100 percent of the high-sensitivity zone will be surveyed, although the number of acres differs because each model identifies the high-sensitivity zones in a different manner, with the refined surface model (12,227 ac) delineating a smaller area requiring survey than the baseline model (30,461 ac).

Using the baseline model and the annual survey rate of 12,932 ac, Eglin AFB can expect to conduct an additional 2.4 years of survey in the high-sensitivity zone at a cost of $1,898,665. Using the refined surface model, by contrast, Eglin can anticipate approximately one year of survey at a cost of $762,165 to complete survey. Thus, in this scenario, Eglin AFB would save approximately a year and a half of survey work and about $1,136,500 by implementing the refined model in place of the baseline model. This represents a 60 percent reduction in time and cost to complete shovel test survey.

As in scenario two above (see Table 6-11), we also used the lower figure for average annual survey rate to compare future performance expectations of the baseline versus the refined surface model (Table 6-13). With a lower annual rate of survey (6,833 ac/yr), the projected costs in millions of dollars are the same, but the amount of time it would take to complete survey would be longer. Using the baseline model and this slower estimated survey rate, approximately four-and-a-half years of survey work would be required to complete survey. Using the refined model and this slower estimated survey rate, only about two years of survey would be required to complete the shovel test survey, representing an approximately 60 percent reduction in time.

Turning to Fort Drum, Table 6-14 presents the percentages of survey area and STPs located in low-, medium-, and high-sensitivity zones of the baseline Glacial Lake Model, according to survey period.

Since Fort Drum has been using the Glacial Lake Model in some fashion to guide survey since 2001, the number of acres surveyed in the low-, medium-, and high-sensitivity zones of the systematized Glacial Lake Model were compared for periods before and after model implementation (1995–2000 and 2001–2007). The comparison was performed in two ways. First, we compared all survey areas represented in a GIS according to sensitivity zone and time period. Since some earlier survey appears to have sampled space within larger survey units, rather than have covered the entire survey unit represented in a GIS, we also performed the comparison using the recorded location of STPs for the two periods. This latter comparison was meant to account for possible shifts through time or across space in STP interval spacing, given that different test unit intervals were used by different projects and generally decreased over time as more intensive investigations have been conducted (see Heilen et al. 2008). Theoretically, the same amount of area could be surveyed but at a higher or lower level of effort, depending on variation in STP spacing.

For both of the above comparisons, we expected that for the period following model implementation (2001), relatively more survey area, more STPs, or both would be placed in the medium- or high-sensitivity zones of the systematized Glacial Lake Model. This was indeed the case, but it should be noted that evaluation of survey areas versus STPs showed smaller

Table 6-12. Eglin AFB, Hypothetical Scenario 1, Comparison of Future Performance Expectations using Refined versus Baseline Surface Model Using URS Annual Survey Estimate

Cost and Level of Effort	Refined Model	Baseline Model
Total acres remaining to be surveyed in high-sensitivity zone calculated with GIS	12,227.9	30,461.5
Cost per survey acre (1994–2008 15-yr average)	$62.33	$62.33
Survey acres per year (1994–2008 15-yr average)	12,932.1	12,932.1
Time Required to complete survey (yrs)	0.9	2.4
Cost to complete survey	$762,165	$1,898,665
Time savings using refined model (yrs)	1.4	—
Cost savings using refined model	$1,136,500	—
Time saving percentage using refined model	60%	—
Cost savings percent using the refined model	60%	—

Table 6-13. Eglin AFB, Hypothetical Scenario 2, Comparison of Future Performance Expectations using Refined versus Baseline Surface Model Using GIS-Based Annual Survey Estimate

Cost and Level of Effort	Refined Model	Baseline Model
Total acres remaining to be surveyed in high-sensitivity zone calculated with GIS	12,227.90	30,461.5
Cost per survey acre (1994–2008 15-yr average)	$62.33	$62.33
Survey acres per year (1994–2008 15-yr average)	6,833.1	6,833.1
Time required to complete survey (yrs)	1.8	4.5
Cost to complete survey	$762,165	$1,898,665
Time savings using refined model (yrs)	2.7	—
Cost savings using refined model	$1,136,500	—
Time savings (percentage) using refined model	60%	—
Cost savings (percentage) using the refined model	60%	—

Table 6-14. Percentages of Survey Area and Shovel Test Pits Located in Each Sensitivity Zone, per Survey Period, according to the Baseline Glacial Lake Model

Survey Data	Low-Sensitivity Zone	Medium-Sensitivity Zone	High-Sensitivity Zone	Medium/High-Sensitivity Zone
Survey areas (1995–2000)	40.8%	42.9%	16.3%	59.2%
Survey areas (2001–2007)	11.5%	69.7%	18.8%	88.5%
STP counts (1995–2000)	26.8%	51.6%	21.6%	73.2%
STP counts (1995–2006)	12.4%	69.3%	18.3%	87.6%

differences in survey effort for STPs in comparison to the same analysis using mapped survey areas. Both analyses showed that a majority of surveyed effort has taken place in medium- or high-sensitivity zones of the baseline Glacial Lake Model both prior to and after implementation of the model; this is because the majority of installation area is comprised of medium- and high-sensitivity zones in the baseline Glacial Lake Model. In and of themselves, these results do not indicate a deliberate emphasis on surveying in the medium- and high-sensitivity zone before and after model implementation.

To further evaluate potential differences in the placement of survey effort before and after baseline model implementation, chi-square tests comparing acres surveyed in each zone with the total number of installation acres in each sensitivity zone were performed. Analysis of residuals derived from these tests suggest that prior to model implementation, deviations from the amount of survey expected to occur in each sensitivity zone, based on the overall size of each zone, were only minor. The amount of survey area placed in medium- or high-sensitivity zones of the baseline model was approximately 4 percent higher than expected; the amount of survey area placed in the low-sensitivity zone was 5 percent lower than expected. By contrast, the focus of investigations after model implementation was substantially different, with the amount of survey area placed in the low-sensitivity zone being approximately 70 percent lower than expected and the amount of survey area placed in the medium- or high-sensitivity zones being over 50 percent higher than expected. The increased emphasis survey in the medium- and high-sensitivity zones of the baseline Glacial Lake Model is largely the result of shifting survey effort from the Lake Plains zone to the Pine Plains zone, where installation land is classified as either of medium or high sensitivity in the baseline model.

Examination of the number of STPs placed in each sensitivity zone using chi-square tests, as opposed to the number of mapped survey acres, suggests a somewhat less dramatic increase in survey effort in the medium- and high-sensitivity zones after model implementation. Prior to model implementation, the number of STPs placed in the low-sensitivity zone was approximately 26 percent lower than expected based on the number of installation acres in each zone while the number placed in medium- or high-sensitivity zone was approximately 14 percent higher than expected. These numbers suggest that, in terms of STPs, there was already an emphasis prior to model implementation on conducting survey in areas that came to be classified as medium- or high-sensitivity in baseline Glacial Lake Model. By contrast, after model implementation, STPs were placed in the low-sensitivity zone 60 percent less often than expected and were placed in the medium- or high-sensitivity zone 25 percent more often than expected. Thus, whether we examine mapped survey areas or the number of mapped STPs within

survey areas, it can be shown that survey effort has increased in the medium- and high-sensitivity zones and decreased in the low-sensitivity zone since implementation of the baseline Glacial Lake Model.

Table 6-15 presents data that allow us to estimate how much time and money have been saved thus far at Fort Drum by implementing the Glacial Lake Model in the lowland portions of the installation. Methods used to calculate these estimates are similar to those used for Eglin AFB (see Table 6-10 and 6-11). Using data collected by URS in Table 4-6 (also see Tables 4-7 and Table 4-8), we calculated that the average annual survey rate is 2,532.5 ac (37,988 total survey ac/15 yrs) and the average survey cost per acre is $141.35 ($2,951,500 total survey dollars/20,881 total survey ac). It is worth noting that the cost per acre is more than double that of Eglin AFB ($141.35 versus $62.33 per ac) and the annual survey rate is several times lower than Eglin AFB (2,532.5 ac versus 12,932 ac using the URS annual survey rate estimate or 2532.5 ac versus 6,833.1 ac using the GIS calculated survey rate). This difference results from the much smaller survey interval employed at Fort Drum, which has resulted in a substantially higher sampling density than that used at Eglin AFB and thus a more intensive survey effort per surveyed acre.

Table 6-15 also shows how much survey effort has been placed in low-, medium-, and high-sensitivity zones of the Glacial Lake Model during the period the model was implemented and for which we have survey data, 2001 through 2007. Shown at the top of the table are the number of acres surveyed between 2001 and 2007 based on a review of paper records reported in Table 4-3 (5,322) and below this, the number of surveyed acres derived from the GIS survey data layer (5,076) provided by Fort Drum. That these numbers are so close is a good indicator of the reliability of the data. For the purposes of comparing the baseline model to what might be expected if no model were used, the GIS-derived figure for total acres surveyed is used. Also shown in Table 6-15 is breakdown of acres surveyed by sensitivity zone and their corresponding percentages. Using the baseline model, approximately 12 percent of the low-sensitivity zone, 70 percent of the medium-sensitivity zone, and 19 percent of the high-sensitivity zone were tested for archaeological sites. Without the model, it is assumed that survey would more closely reflect the distribution of sensitivity zones across the installation where the low- and medium-sensitivity zones each cover approximately 44 percent of Fort Drum, whereas the high-sensitivity zone covers only 13 percent of the installation.

Assuming that Fort Drum would have surveyed randomly with respect to sensitivity zones without the model, we can estimate that over a seven-year period Fort Drum saved around eight months (0.6 years) worth of survey work and close to a quarter million dollars ($230,033) by implementing the model and limiting survey mostly to the medium- and high-sensitivity zones of the baseline Glacial Lake Model. To complete survey of the remaining 35,547 ac at a rate of 2,532.5 ac/yr will take 12.4 yrs and require an additional $4,446,718 (31,459 ac x $141.35). Without the model to guide where survey is conducted, completing the survey will require 14.0 yrs or over one-and-a-half years longer than estimated with the Glacial Lake Model; and, a total of $5,024,540 or over a half million dollars more in funding.

Combining the actual survey costs of the 2001–2007-interval with the expected costs to complete the survey at Fort Drum produces additional insight into the effect of the baseline model versus.

Table 6-15. Fort Drum, Hypothetical Scenario, Comparison of Past Performance With Model versus Without Model Using GIS-Based Annual Survey Estimate

Cost and Level of Effort	Baseline Model	Without Model
Past:		
Total reported survey acres (2001–2007)	5,322	5,322
Total surveyed acres (2001–2007) calculated with GIS	5,076.2	5,076.2
Acres surveyed in low-sensitivity zone (2001–2007)	585.8 (11.5%)	2,213.2 (43.6%)
Acres surveyed in medium-sensitivity zone (2001–2007)	3,536.6 (69.7%)	2,218.3 (43.7%)
Acres surveyed in high-sensitivity zone (2001–2007)	953.8 (18.8%)	644.7 (12.7%)
Cost per survey acre (1994–2008 15-yr average)	$141.35	$141.35
Total cost (2001–2007)	$717,521	$717,521
Cost for survey in low-sensitivity zone (2001–2007)	$82,803	$312,836
Cost for survey in medium-sensitivity zone (2001–2007)	$499,898	$313,557
Cost for survey in high-sensitivity zone (2001–2007)	$134,820	$91,128
Survey acres per year (1994–2008 15-yr average)	2,532.5	2,532.5
Time invested in survey (2001–2007)	7.0	7.0
Time savings with in-place model (yrs) [no low-sensitivity zone survey]	0.6	—
Cost savings with in-place model [no low-sensitivity zone survey]	$230,033	—
Future:		
Total acres remaining to be surveyed (2008–?) calculated with GIS	35,546.8	35,546.8
Total acres in low-sensitivity zone	4,087.9 (11.5%)	15,462.9 (43.6%)
Total acres in medium-sensitivity zone	24,776.1 (69.7%)	15,534.0 (43.7%)
Total acres in high-sensitivity zone	6,682.8 (18.8%)	4,514.4 (12.7%)
Cost per survey acre (1994–2008 15-yr average)	$141.35	$141.35
Total survey cost (2008-?)	$4,446,718	$5,024,540
Survey acres per year (1994–2008 15-yr average)	2,532.5	2,532.5
Time required to complete survey (yrs)	12.4	14.0
Time savings with in-place model (yrs) [no low-sensitivity zone survey]	4.5	—
Cost savings with in-place model [no low-sensitivity zone survey]	$1,607,853	—
Full Cost (Past plus Future):		
Total survey cost with and without baseline predictive model	$5,164,239	$5,742,061
Total time (yrs) with and without baseline predictive model	19.4	21.0
Time savings (percentage) using baseline model v. using no model [no low sensitivity]	8%	—
Cost savings (percentage) using the baseline model vs. using no model	10%	—

no model. With the model, total survey expenses are projected to be $5,164,239 ($717,521 + $4,446,718) and without $5,742,061 ($717,521 + $5,024,540) for a cost savings of 10 percent. With the model, total survey time will take 19.4 years; however, without the model survey will require 21.0 years. This represents a modest time savings of 8 percent.

Looking forward, we examined costs and time expenditures that can be expected in the future if Fort Drum were to perform survey in the lowland portions of the installation using the refined model versus using the baseline Glacial Lake Model according to current methods (Table 6-16). In this case, Fort Drum has already surveyed tens of thousands of acres in areas that the refined and baseline models recognize as low, medium, or high sensitivity. Table 6-16 shows the acres of each zone that are not off-limits to survey and remain to be surveyed, plus their corresponding percentages, based on whether the refined or baseline models are used to determine survey effort in the lowland zones of the installation. Based on conversations with Fort Drum staff, we assumed that going forward, 10 percent of low-sensitivity zone, 50 percent of medium-sensitivity zone, and 100 percent of high-sensitivity zone would be surveyed. With the baseline Glacial Lake Model, it is projected that Fort Drum will require 5.6 yrs to complete surveying the lowland portions of the installation at a cost of $2,016,597. With the refined surface model, by contrast, just 2.8 yrs and $1,012,599 would be required to complete survey in the lowland portions of the installation. In other words, implementing the refined surface model according to the strategy outlined above would save approximately $1,003,998 and 2.8 years of survey effort—a savings of approximately 50 percent in time and expense.

6.5.1.2 National Register Testing for Eglin AFB

In section 3.3.3.1 we recognized that one of the problems faced by DoD Cultural Resource Managers is testing archaeological sites for their eligibility for listing in the National Register. Testing often requires labor-intensive unit excavation and or use of mechanical equipment supplemented by hand excavation, analysis and reporting of testing results, and a period of review by SHPOs and other stakeholders. To date, only a small fraction of sites on DoD lands have been evaluated. Arguably, evaluating the hundreds of thousands of sites on DoD lands for significance represents one of the largest future expenditures on cultural resources faced by the DoD, in both time and money. If archaeological sites are evaluated individually on a case-by-case basis, as they have been historically by DoD, it will take billions of dollars and on the order of centuries to complete evaluation. Modeling, however, can be used to justify alternative approaches to evaluation that would reduce the time and money needed for evaluation. Such approaches potentially also could derive information on evaluated sites more cost-effectively, by evaluating groups of similar sites at the same time, and allowing a sample of sites to be held in reserve for future research. The proposed approach involves selecting samples of sites according to site type and sensitivity zone as well as other factors that often contribute to the outcome of a site evaluation, such as the presence or absence of temporal information. To ensure that highly significant sites are not overlooked in the process of sampling, the sites that could be sampled, rather than evaluated on a case-by-case basis, would include only those sites that are most frequently encountered on an installation, such as lithic scatters.

Table 6-16. Fort Drum, Hypothetical Scenario, Comparison of Future Performance Expectations with Refined Surface Model versus Baseline Glacial Lake Model

Cost and Level of Effort	Refined Model	Baseline Glacial Lake Model
Total acres remaining unsurveyed (2008?–?)	35,546.9	35,546.9
Total acres in low-sensitivity zone	29,278.2 (82.4%)	13,622.9 (38.3%)
Total acres in medium-sensitivity zone	4,065.5 (11.4%)	18,039.0 (50.7%)
Total acres in high-sensitivity zone	2,203.2 (6.2%)	3,884.9 (10.9%)
Total acres planned for survey (using a sampling plan)	7,163.77	14,266.7
Total acres planned for survey in low-sensitivity zone (10% of total)	2,927.8	1,362.3
Total acres planned for survey in medium-sensitivity zone (50% of total)	2,032.8	9,019.5
Total acres planned for survey in high-sensitivity zone (100% of total)	2,203.2	3,884.9
Cost per survey acre (1994–2008 15-yr average)	$141.35	$141.35
Survey acres per year (1994–2008 15-yr average)	2,532.5	2,532.5
Time required to complete Survey (yrs)	2.8	5.6
Cost to complete survey	$1,012,599	$2,016,597
Time savings using refined model (yrs)	2.8	—
Cost savings using refined model	$1,003,998	—
Time savings (percentage) using refined model	50%	—
Cost savings (percentage) using the refined model	50%	—

To estimate the kinds of savings that could be achieved by applying this kind of approach to evaluation, we applied a hypothetical scenario to evaluating common site types at Eglin AFB and calculated the expenditures in time and money if (1) all sites were evaluated individually, following current practice and (2) a sampling approach was applied, as described above. Fort Drum was not an appropriate candidate for this analysis because the installation has never clearly defined archaeological sites types; however, Eglin AFB does distinguish between site types based on site morphology and inferred function.

Prehistoric site types at Eglin AFB include village/hamlet sites, burial sites, mound sites, campsites, collection sites, and sites of undetermined function. Village sites, burial sites, and mound sites are excluded from the analysis under the assumption that all such sites will or have been evaluated. Only the more common and redundant site types are considered here (i.e., campsites, collection sites, and sites of undetermined function). To conduct this analysis, the archaeological site data at Eglin AFB were grouped by sensitivity zone of the subsurface model and according to whether or not they possessed diagnostic information on temporal affiliation, since temporal affiliation is often needed to assess the significance of a site. Sites that previously have been determined ineligible as a result of field investigations are not considered. The subsurface model was used as a means of stratifying the sample because subsurface potential as predicted by the model likely has a bearing on the data potential, and thus, the significance of a site. Other variables that could be included in such an approach, when the data are available, are integrity, assemblage size and diversity, and depositional context. The data requirements for the current analysis included only three variables: site function, subsurface sensitivity, and the presence or absence of temporal data. Again, the current hypothetical scenario is intended to demonstrate the kinds of cost savings that potentially could be achieved through a sampling approach to evaluations. A more refined approach that considers additional data important to determining significance, such as the potential presence of buried late Paleoindian or Middle Archaic components or Gulf Formational components, likely will need to be developed for such an approach to be successfully implemented.

Table 6-17 shows the number of sites under consideration according to function, sensitivity zone, and the presence or absence of temporal data. Sites that have already been determined ineligible are not considered, leaving only those prehistoric sites that are considered potentially eligible or eligible. Most sites, 60 percent, have no temporal information and 48 percent of the sites in total have no identified function.

Table 6-17. Numbers of Sites according to Function,* Majority Sensitivity Zone, and the Presence or Absence of Temporal Data at Eglin AFB

	Low-Sensitivity Zone		Medium-Sensitivity Zone		High-Sensitivity Zone		
Function	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Total Sites**
Campsite or Collection Station	44	34	10	9	20	14	131
Undetermined	12	67	0	19	15	10	123
Total	56	101	10	28	35	24	254

* Burial sites, Mound sites, and Village/Town sites are excluded.

To run the scenario, we decided on arbitrary percentages of sites that would be evaluated, left in reserve, or left unevaluated and not placed in reserve. For this exercise, 50 percent of sites with temporal data are tested for evaluation but only 25 percent of sites lacking temporal data are evaluated, with samples stratified according to sensitivity zone and site function (sample numbers are rounded up to be conservative in evaluating sites). Table 6-18 shows how many of the sites in Table 6-17 would be evaluated using the above scheme. In other words, site count data presented in Table 6-17 are reduced in Table 6-18 by 50 percent for sites with temporal data and by 75 percent for sites lacking temporal data. This scheme results in around 36 percent of the original sample of 254 sites being evaluated.

The remaining sites from Table 6-17 that are not to be evaluated (n = 162) would need to be either placed in reserve or left unprotected and unevaluated. Table 6-19 represents those sites that are not slated to be evaluated or left unprotected, but will instead be placed in reserve for future study. In Table 6-19, we specify the numbers of sites that would be placed in reserve by taking a sample of sites from those not to be evaluated according to the following scheme: half of the remaining sites with temporal data and a third of the remaining sites without temporal data are left in reserve. Again, the numbers are rounded up to be conservative in reserving sites, but the net effect is that 26 percent of sites total are placed in reserve. This number, of course, does not include mound sites, burial sites, and village sites that would presumably also be protected.

Table 6-18. Hypothetical Site Sample to be Evaluated at Eglin AFB

	Low-Sensitivity Zone		Medium-Sensitivity Zone		High–Sensitivity Zone			
Function	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Total Sites**	**Percent Sample**
Campsite or Collection Station	22	9	5	3	10	4	53	40.5%
Undetermined	6	17	0	5	8	3	39	31.7%
Total Sites	28	26	5	8	18	7	92	36.2%
Percent Sample	50.0%	25.7%	50.0%	28.6%	51.4%	29.2%	36.2%	

Table 6-19. Hypothetical Site Sample to be Left in Reserve at Eglin AFB

	Low-Sensitivity Zone		Medium-Sensitivity Zone		High-Sensitivity Zone			
Function	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Total Sites**	**Percent Sample**
Campsite or Collection Station	11	9	3	2	5	4	34	26.0%
Undetermined	3	17	0	5	4	3	32	26.0%
Total Sites	14	26	3	7	9	7	66	26.0%
Percent Sample	25.0%	25.7%	30.0%	25.0%	25.7%	29.2%	26.0%	

After samples of sites have been evaluated (36 percent) or placed in reserve (26 percent), the remaining 38 percent of sites are left unevaluated (Table 6-20). Table 6-20 shows the number of sites from the overall sample of 254 sites that would not be evaluated or placed in reserve. The vast majority of these sites lack temporal information (80 percent) and more than half are of undetermined type (54 percent).

Table 6-20. Hypothetical Site Sample to be Left Unevaluated and Not Placed in Reserve at Eglin AFB

	Low-Sensitivity Zone		Medium-Sensitivity Zone		High-Sensitivity Zone			
Function	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Temporal Data**	**No Temporal Data**	**Total Sites**	**Percent Sample**
Campsite or Collection Station	11	16	2	4	5	6	44	33.6%
Undetermined	3	33	0	9	3	4	52	42.3%
Total Sites	14	49	2	13	8	10	96	37.8%
Percent Sample	25.0%	48.5%	20.0%	46.4%	22.9%	41.7%	37.8%	

The percents for the different samples can be revised, of course, but a relatively conservative scheme such as this could be used to estimate the number of sites by site class that will not require archaeological testing for National Register eligibility. It costs Eglin AFB on average $9,658 to test each archaeological site (see Table 4-8). If we assume Eglin AFB tests 25 sites per year, then theoretically it would cost $2.5 million to evaluate all 254 sites and would take 10 years to complete the testing. If the schema presented here were followed instead, by removing 162 sites from the pool of sites that would normally be tested, Eglin AFB would save approximately $1.6 million and 6.5 years, a 64 percent reduction in the number of sites evaluated, resulting in a 64 percent savings in time and money. In reality, Eglin AFB does not test all sites for National Register eligibility; if the site can be avoided, it often will either not test the site or will test it at a later time. The practical returns in time and cost savings are therefore likely to be less than presented here; however, even if these estimates are off by half, the savings could still be significant.

6.5.1.3 Summary of Reductions in Level of Effort, Cost, and Sites Evaluated

The three metrics used in this demonstration—level of effort, cost, and number of sites evaluated—are based on data routinely collected by installations, including Eglin AFB and Fort Drum, regarding the time requirements of compliance and to a lesser degree the monetary cost. Since one of the goals of this demonstration is to move from project-by-project to programmatic compliance, it is important to measure whether overall installation performance could be enhanced by modeling. Installation-wide metrics and data requirements defined in Table 3-1 capture factors of time and money involved in conducting archaeological inventories and evaluating the National Register eligibility of identified sites. Inventory measures include per-acre costs and level of effort (time) for archaeological inventories. The third measure involves the number of sites requiring National Register-eligibility evaluations.

Table 6-10 and Table 6-11 presented two scenarios for Eglin AFB in which the time and costs of archaeological survey is compared using the baseline model and without the baseline model. Using Table 6-11, which likely is more realistic than Table 6-10, our scenario suggested that use of the baseline model will have saved Eglin AFB 63 percent in cost and time. The savings in cost and time achieved by Eglin AFB from using their archaeological predictive model far exceeds our 15 percent threshold for success. Looking to the future (Table 6-12 and Table 6-13), we illustrated how additional savings could be achieved by implementing the refined surface model in place of the baseline model. Future use of the refined model instead of the baseline model to complete survey could result in a savings of 60 percent in overall cost and time.

Using Table 6-15, our scenario suggests that use of the Glacial Lake baseline model has saved Fort Drum approximately 10 percent savings in cost and 8 percent savings in time, but neither exceed our 15 percent threshold for success. As with Eglin AFB, additional savings could be achieved by implementing the refined surface model in place of the baseline model. Using the refined model instead of the baseline model to complete future survey in the lowland portions of Fort Drum (see Table 6-16), we showed how a savings of 50 percent in both cost and time could be achieved.

Tables 6-17 through 6-20 presented a hypothetical scenario in which Eglin AFB samples three classes of archaeological sites with low information potential relative to larger, more complex sites such as village sites, burial sites, and mounds sites. In this scenario, Eglin AFB could achieve a savings of 64 percent in time and cost, far exceeding the 15 percent-threshold for success. This assumes that Eglin AFB will choose to adopt this or a similar approach and that the consulting parties to the Section 106-compliance process would agree. Nonetheless, as a comparative exercise we have demonstrated the potential for cost and time savings.

7.0 COST ASSESSMENT

7.1 COST MODEL

This section examines the expected operational costs for deploying the predictive models. The cost data presented in this section reflect our experiences with Eglin AFB and Fort Drum and the projected costs presented in Tables 6-10 through 6-16. Table 7-1 lists the cost elements that were relevant to creating, validating and refining the archaeological predictive models, and in developing the PAs that will be needed to streamline installation environmental compliance activities.

Table 7-1. Cost Model

Cost Element	Data Tracked During the Demonstration
Create, Validate, and Refine Surface Model	Labor and material required
Create and Validate Red Flag Model	Labor and material required
Develop Subsurface Model	Labor and material required
Develop and Implement PA	Labor and travel expenses

Most of the costs associated with developing a predictive model are labor costs, with some additional costs for computers and software, purchases of digital data, and travel costs associated with field visits to installations. No digital data were purchased for this project, but it is possible that obtaining CRM data from state agencies for large areas can run into the thousands or even tens of thousands of dollars. For instance, to obtain existing archaeological data from state agencies for large areas can cost from thousands to tens of thousands of dollars. It should generally be the case, however, that DoD installations and ranges can obtain these data at little or no cost through cooperative agreements. Software licenses for GIS software will generally be available to installation staff, but if needed can be purchased costing thousands of dollars, depending on what capabilities are needed. If using ESRI Arc/GIS software for modeling, licenses for ArcView and Statistical Analyst will be minimum software requirements. The current prices for ArcGIS Version 10 software are $1,500 for an individual ArcView license and $2,500 for an individual Statistical Analyst license.

The exact costs for developing a predictive model will likely vary among installations and circumstances, depending on the size of an installation, an installation's modeling needs, the complexity of an installation's environment or culture history, data quality, and the variety of issues faced in obtaining and understanding CRM and environmental data. The effort to obtain and organize CRM and environmental data for modeling purposes as well as to develop model variables and samples for model construction represents a considerable investment that feeds into other modeling activities. Because of this, advantages are gained in later stages of the modeling process by initial investments in developing and organizing the underlying data. In addition, it should be acknowledged that creating, validating, and refining a model is part of an ongoing and iterative process and deciding where to begin and end that process is based on an installation's modeling needs.

Our experience with the ESTCP project and other modeling projects suggests that it costs approximately $100,000 to $120,000 to create, validate, and refine a surface model, with approximately 70 percent of effort applied to creating a model, 10 percent of effort applied to validating the model, and 20 percent of effort applied to refining the model. The bulk of the investment stems from obtaining, organizing, and transforming data for model development and then analyzing those data to better understand the relationships among predictor variables and site location. Once these data have been developed and prepared for modeling purposes, other kinds of models, such as red flag models and subsurface models, can be more readily developed with less investment, since many of the underlying data have been already prepared and digested.

When many of the basic data are already prepared and modelers are familiar with the data, such as in the case where a surface model has been developed, the minimum cost of developing a red flag model is approximately $25,000. This is the cost of developing a red flag model in addition to a surface model when the data for the surface model have already been prepared and digested. The costs of developing a subsurface model for a project also involving the development of a surface model are somewhat larger than the costs for a red flag model due to the need for field visits and potentially greater investment of time and skilled labor. If the data have been prepared and digested for a surface model, the cost of creating a subsurface model is approximately $40,000.

However, if the development of a red flag model or a subsurface model was to be performed independently of developing a surface model, then the effort could be considerably more costly, due to the need to acquire digital data, CRM reports, and other information, and to organize and process the data so that they may be used for modeling. If a red flag model or a subsurface model was developed from scratch, with no prior investment, we might expect that the costs would increase substantially. The cost for developing a red flag model would be approximately $65,000, and the cost for developing a subsurface model would be approximately $80,000. In other words, we anticipate that it would cost an additional $40,000 to develop a red flag model or a subsurface model if the ground work for modeling had not already been established through the development of a surface model.

As discussed above, validation of surface models could be performed with existing CRM data obtained through routine installation activities. Validating a subsurface model, however, can require data that are obtained only through targeted field investigations involving the mechanical excavation of trenches or cores at depths exceeding those of typical STPs. Performing these kinds of field validation activities was outside the scope of this project. However, it is likely that such field validation efforts would minimally cost in the tens of thousands of dollars, depending on the nature of the effort. In all likelihood, it would be advisable to perform subsurface validation in conjunction with other installation efforts and as part of an effort to refine a subsurface model so that costs could be minimized and synergies achieved. Another way to validate subsurface models would be to maintain a database of all buried deposits discovered during the course of installation activities. Ideally, such a database would include the location, type, depth, integrity, and artifact or feature content of observed buried deposits, along with information on the project and excavation method from which the observation derives. Presumably, the development of such a database would allow subsurface models to be validated

at a lower cost and without the need to implement larger projects specifically tailored towards subsurface model validation.

The costs associated with developing a PA are generally $25,000 to $30,000, depending on the nature of the compliance problems that must be solved and the time required to consult with all appropriate parties. Costs typically involve labor time required to consult with installation staff and consulting parties via meetings and conference calls, labor time needed to prepare review drafts, and travel expenses.

Assuming that the goal of developing an archaeological model includes a package of modeling tools consisting of a surface model, a red flag model, a subsurface model, as well as a PA to operationalize the use of these models for compliance purposes, it is estimated that the total cost will be in the range of $215,000 plus-or-minus $10,000. Development of the individual models in this package will increase the costs by at least $30,000 not including the cost of developing the PA.

7.2 COST DRIVERS

Labor, materials, and travel expenses can all be expected to rise in the future by at least 3 percent per year. As discussed above, these are the principle costs associated with developing and implementing predictive models at DoD installations.

7.3 COST ANALYSIS AND COMPARISON

The only alternative methodology to CRM compliance that we can compare to a programmatic, predictive modeling approach is the current project-by-project method employed by DoD installations to fulfill their respective environmental compliance responsibilities. As noted above, the two demonstration installations (Eglin AFB and Fort Drum) do not track the labor or material costs expended in their compliance activities. It is not possible, therefore, to compare the use of archaeological predictive modeling directly with a project-by-project approach or with any other potential alternative methodology. However, as presented in Section 6, it is possible to provide summary statistics comparing the use of archaeological predictive models against survey conducted following standard operating procedures without such models at Eglin AFB and Fort Drum.

Current methods of recording archaeological sites require on-the-ground pedestrian survey by a team of archaeologists who are spaced apart at a standard interval (e.g., 15 m). The survey team traverses the landscape recording all cultural resources 50 yrs old or older within the survey transects. Typically excluded are areas heavily disturbed by past development, slopes not conducive to human habitation (e.g., 15 percent or greater), and any area that is not safely accessible, such as firing ranges with unexploded ordnance (UXO). In the absence of a sampling strategy or predictive model, 100 percent of the installation is investigated in this manner, which can involve intensive labor and high associated costs. The following tables compare level of effort for archaeological survey using archaeological predictive models versus standard survey methods without models at Eglin AFB and Fort Drum.

Table 7-2 compares cost and time (level of effort) invested in archaeological survey at Eglin AFB using the baseline model versus not using the model, both employing standard survey methods (see Table 6-11). Summary figures are presented for past survey costs and time invested, projected costs and years needed to complete survey, as well as total costs and time combining past and future levels of effort. In sum, Eglin AFB has invested $6,388,632 over 15 yrs to identify and manage its archaeological resources. Using the baseline model, Eglin AFB will require an additional $1,898,665 and 4.5 yrs to complete survey of the remaining acres in the high-sensitivity zone. The total estimated costs for archaeological survey from beginning to end are $8,287,297 over a 19.5-yr period. In contrast, without the model the level of effort needed to complete the work is considerably higher. Unless future survey is limited to the high-sensitivity zone, all remaining acreage at Eglin AFB will need to be surveyed to meet federal regulations and USAF requirements. Estimated cost to complete inventory of the installation following standard survey methods is $16,152,633 requiring an additional 37.9 yrs. Total projected cost of archaeological survey at Eglin AFB without using the baseline model is $22,541,264 requiring 52.9 yrs. The savings in time and money achieved by using the baseline model over not using a model is 63 percent.

Table 7-3 compares level of effort estimates for the baseline model and the refined model (see Table 6-13). With the baseline model, Eglin AFB will still need to expend an additional $1,898,655 to complete survey of the high-sensitivity zone requiring 4.5 more yrs of archaeological survey. If Eglin were to use the refined model instead of the baseline model (without figuring in the cost of developing and implementing the model), these same expenditures could be reduced to $762,165 and 1.8 yrs respectively. The approximate cost of developing and implementing a predictive model is $215,000. The total cost of developing and using the refined model then would be approximately $977,165. In short, using the refined model would save Eglin about $921,500 ($1,898,665 - $977,165) and 2.7 yrs of work, representing a 49 percent savings in cost and a 60 percent savings in time.

Table 7-4 presents estimated cost and time investments for using the baseline model to the end of the demonstration period (2008) together with the refined model for all future survey and compares these figures to the total level of effort without either model (see Table 7-2 and Table 7-3). As can be seen, the cost and time differences are significant. Using the baseline and refined models together, the level of effort can be limited to $7,365,797 and 16.8 yrs, compared to $22,541,264 and 52.9 yrs, representing a total cost savings of 67 percent and time savings of 68 percent over using the existing baseline model.

Table 7-5 summarizes information on cost and time invested in archaeological survey at Fort Drum, using the baseline model versus not using the model (see Table 6-15). This comparison looks at past expenditures in time and money, projects future levels of effort needed to finish survey at Fort Drum, and then adds both calculations to provide a total figure for survey level of effort. Fort Drum has invested $717,521 in archaeological survey over a seven-yr period. It is estimated that to complete the survey an additional $4,446,718 will be needed using the model and $5,024,540 without the model. With the baseline model the survey can be finished in 12.4 yrs and without the model in 14.0 yrs. The full cost of survey from beginning to end indicates that using the baseline model Fort Drum can save $577,822 or 1.6 yrs representing a cost savings of 10 percent and a time savings of 8 percent.

Table 7-6 provides summary information on level of effort for future survey using the refined model compared to the baseline Glacial Lake Model (see Table 6-16). Using the existing baseline model, Fort Drum can expect to pay an additional $2,016,597 to complete the archaeological survey in about 5.6 years. If Fort Drum were to use the refined surface model instead of the baseline Glacial Lake model, these expenses could be reduced to $1,012,599 and 2.8 yrs respectively. The approximate cost of developing and implementing a predictive model is $215,000. The total cost of developing and using the refined model then would be $1,227,599, representing a savings of $788,998 or about 39 percent in overall costs and about half the total time over using the baseline Glacial Lake Model.

Lastly, Table 7-7 compares the projected level of effort invested in archaeological survey from beginning to end using the baseline and the refined model versus not using models to present a comprehensive picture of total expected savings (see Table 7-5 and Table 7-6). Without the models, Fort Drum can expect to have paid $5,742,061 to complete archaeological survey over a 21.0-yr period. By investing in the development of refined model, and using the baseline model up until the end of the demonstration period (2008) and then switching to the refined model, Fort Drum could complete its remaining archaeological survey requirements for $1,227,599 over a total of 2.8 yrs. This would result in a total installation inventory cost of $1,945,120 ($717,521 + 1,012,599 + $215,000) over 9.8 yrs, representing a saving of 66 percent in cost and 58 percent in time.

In sum, the project has demonstrated that Eglin AFB has developed an effective baseline archaeological predictive model that has worked well over many years. With the refinements made to the baseline model, performance is expected to increase, resulting in additional savings in time and money. Without the use of either the baseline model in the past or the refined model in the future, Eglin AFB would have been faced with more than five decades of survey work costing more than $22 million. The savings at Fort Drum are not as extreme. Nonetheless, our estimates indicate, however, that by applying the refined model rather than the Glacial Lake baseline model to guide where future archaeological survey is conducted, Fort Drum will achieve savings of about $789,000 and approximately 3 yrs in survey time. Without the use of either baseline model or refined model, Fort Drum would have spent more than $5.7 million and taken more than two decades to address its site inventory requirements.

Table 7-2. Summary of Level of Effort at Eglin AFB With and Without Baseline Model (see Table 6-11)

Cost and Level of Effort	With Baseline Model	Without Model
Past:		
Total survey cost (1994–2008)	$6,388,632	$6,388,632
Time (yrs) invested in survey (1994–2008)	15.0	15.0
Future:		
Total survey cost (2009–?)	$1,898,665	$16,152,633
Time required to complete survey (yrs)	4.5	37.9
Full Cost (Past plus Future):		
Projected total survey cost with/without baseline model	$8,287,297	$22,541,264
Projected total time (yrs) with/without baseline model	19.5	52.9
Projected cost savings (percentage) using baseline model	63%	—
Projected time savings (percentage) using baseline model	63%	—

Table 7-3. Summary of Level of Effort for Future Survey at Eglin AFB Using Refined Surface Model versus Baseline Model (see Table 6-13)

Cost and Level of Effort	Refined Surface Model	Baseline Model
Cost required to complete survey	$762,165	$1,898,665
Time required to complete survey (yrs)	1.8	4.5
Cost of model development and implementation	~$215,000	—
Projected cost savings using refined surface model	~$921,500	—
Projected time savings using refined surface model (yrs)	2.7	—
Projected cost savings (percentage) using refined surface model	49%	—
Projected time savings (percentage) using refined surface model	60%	—

Table 7-4. Comparison of Projected Total Level of Effort at Eglin AFB Using Past Baseline and Future Refined Surface Models versus Using No Models

Cost and Level of Effort	With Models	Without Models
Projected cost using past baseline + future refined surface models vs. using no model	$7,365,797	$22,541,264
Projected time (yrs) using past baseline+future refined surface models vs. using no model	16.8	52.9
Projected cost savings (percentage) using the baseline model +refined model	67%	—
Projected time savings (percentage) using baseline model + refined surface model	68%	—

Table 7-5. Summary of Level of Effort at Fort Drum With and Without Baseline Model (see Table 6-15)

Cost and Level of Effort	With Baseline Model	Without Model
Past:		
Total survey cost (2001–2007)	$717,521	$717,521
Time (yrs) invested in survey (2001–2007)	7.0	7.0
Future:		
Total survey cost (2008–?)	$4,446,718	$5,024,540
Time required to complete survey (yrs)	12.4	14.0
Full Cost (Past plus Future):		
Projected total survey cost with/without baseline model	$5,164,239	$5,742,061
Projected total time (yrs) with/without baseline model	19.4	21.0
Projected cost savings (percentage) using baseline model	10%	—
Projected time savings (percentage) using baseline model	8%	—

Table 7-6. Summary of Level of Effort for Future Survey at Fort Drum using Refined Surface Model versus Baseline Glacial Lake Model (see Table 6-16)

Cost and Level of Effort	Refined Surface Model	Glacial Lake Baseline Model
Cost required to complete survey	$1,012,599	$2,016,597
Time required to complete survey (yrs)	2.8	5.6
Cost of model development and implementation	$215,000	
Projected cost savings using refined surface model	$788,998	—
Projected time savings using refined surface model (yrs)	2.8	—
Projected cost savings (percentage) using refined surface model	39%	—
Projected time savings (percentage) using refined surface model	50%	—

Table 7-7. Comparison of Projected Total Level of Effort at Fort Drum Using Past Baseline and Future Refined Surface Models versus Using No Model

Cost and Level of Effort	With Models	Without Models
Projected total cost using past baseline + future refined surface models vs. using no model	$1,945,120	$5,742,061
Projected total time (yrs) using past baseline+future refined surface models vs. using no model	9.8	21.0
Projected cost savings (percentage) using the baseline model +refined model	66%	—
Projected time savings (percentage) using baseline model + refined surface model	58%	—

8.0 IMPLEMENTATION ISSUES

DoD installations and ranges are responsible for the archaeological inventory of 21.9 million ac of land under their management (DoD 2011:Figure 3-2) As many as a 300,000 archaeological resources are estimated to lie on or under these lands, with only a third of them having been discovered. In pursuing their military missions, DoD installations and ranges comply with a host of laws and regulations protecting those archaeological resources judged important to preserving the historic and cultural values held dear by the citizens of the United States. As with other federal agencies whose primary mission is directed elsewhere, DoD's approach to complying with these mandates is to perform the needed studies and treatments as the need arises. In this sense, installation archaeologists and managers are largely reacting to planned land disturbing activities required by the military just prior to or as these activities occur. This project-by-project approach to CRM generally results in inventories of all Areas of Direct Impact (ADI), evaluation of all or most of the archaeological resources that are discovered, and the excavation of all National Register-eligible sites that cannot be avoided. By starting the process anew each time, DoD's approach to CRM is the most expensive, most comprehensive, and least efficient approach possible. As importantly, by reacting to military needs in a just-in-time manner, archaeological inventory, evaluation, and data recovery often become critical items leading to delay and increased costs of military activities.

It does not have to be this way. There is nothing in the laws or regulations that require a reactive approach. Indeed, the ACHP, SHPOs, and THPOs have long endorsed and encouraged programmatic approaches to CRM compliance. Furthermore, guidance developed by the National Park Service for implementation of Section 110 of the NHPA encourages proactive planning and management. The hurried nature of many military undertakings, as well as the sheer number of land-disturbing projects routinely conducted on installations and ranges, makes it advantageous for all parties to reach agreement on the best preservation outcome with the least regulatory effort.

Programmatic approaches require a good understanding of the archaeology of an installation: Where will sites be located? What types of sites will be found and will they have integrity? What types of research questions can be addressed by sites of different types? One of the great attributes of predictive models is that they provide an objective assessment of our ability to answer these questions. Predictive models also should be a measure of knowledge gained. As we survey and excavate more, model predictions should improve. Areas of high archaeological sensitivity should decrease in size, whereas those areas where sites are less likely to be found should grow. Unanticipated discoveries of archaeological sites during construction—particularly discoveries of sites that would be expensive and time-consuming to excavate (red flag sites)—should decrease, and delays to military activities caused by CRM should likewise decline.

8.1 PROJECT DESIGN AND RESULTS

The objectives of ESCTP project, *Integrating Archaeological Modeling in DoD Cultural Resource Compliance (#200720)*, can be reduced to three questions:

1. Does the technology exist to create predictive models of archaeological site location that are sufficiently accurate to be useful in DoD CRM compliance?
2. Can predictive models serve as the framework for installation and range-based programmatic approaches to CRM?
3. Does the incorporation of predictive models in DoD installation and range CRM compliance programs lead to less cost, greater efficiency, and better preservation outcomes?

We selected two installations and two ranges for demonstration projects—Fort Drum, Eglin AFB, SCR, and UTTR. The facilities represented different parts of the country, different branches of military service, different archaeological records, and different compliance issues. Given the variety of challenges presented by the various DoD facilities, we anticipated that the final outcome would be a good test of predictive modeling and its suitability to serve in a programmatic approach to CRM compliance.

The two installations—Eglin AFB and Fort Drum—followed our demonstration plan. We judge both demonstrations to be highly successful, not simply because the theoretical and methodological underpinnings of predictive modeling were borne out, but because modeling proved to be a catalyst for improved relationships among the stakeholders. Although PAs still have to be finalized, each installation is committed to completing the drafting process on its own and entering into a finished PA with its respective consulting parties. Even in draft form, however, the PAs have considerable value because they are capable of helping both installations make informed decisions about where to conduct archaeological survey and how to do this in a replicable and statistically valid manner. Once the PAs are executed, the NHPA Section 106 compliance and the NEPA compliance process at Eglin AFB and Fort Drum have the potential to be greatly streamlined. Determining whether cost savings and improvements in efficiency are achieved will have to await the implementation of these programmatic approaches, but our efforts to model the effects of the proposed PAs on past activities is certainly suggestive that the outcome will be positive.

Modeling has been successful at Eglin AFB and Fort Drum in large part because the revised and validated models are not perfect. Both models clearly point to areas of deficiency in our current knowledge of the region's archaeology. At Eglin AFB, we do not have a good understanding of where buried sites may be found. The models at Fort Drum identify aspects of upland settlement that are poorly understood. These deficiencies in the revised models provide installation managers with unambiguous directions for future studies, which can be monitored in objective ways by all stakeholders. Modeling, not models, is the key to the success of the CRM programs at Eglin AFB and Fort Drum.

The two western ranges chose to withdraw from formal participation in our demonstration project. The reasons were particular to each range. Mountain Home AFB agreed with the Idaho SHPO to inventory 100 percent of the SCR and to re-survey the entire range periodically. Hill

AFB chose to create a predictive model with a contractor familiar with the UTTR's particular paleoenvironmental history and to use the model solely as a planning tool (i.e., they chose not to incorporate the model into their PA with the Utah SHPO).

Although Mountain Home AFB and Hill AFB pulled out of the demonstration project, we continued to work with them on range-specific issues related to modeling. We did so because each of the four demonstration sites suffered from a related set of issues related to the quality of archaeological data collected in support of CRM compliance. We believed that more in-depth analysis of the situations at SCR and UTTR could highlight the problem of data quality in general and provide a set of best practices (see Appendix D, Appendix E, and Heilen et al. 2008).

The specific issues studied at SCR and UTTR were site detection and site-type modeling, respectively. The first issue, site detection, is well known in the archaeological literature, though it remains poorly studied. Most analyses have focused on site detection in regions with poor surface visibility. Indeed, in a separate project sponsored by Legacy (#07-353), we analyzed the issue for Eglin AFB and Fort Drum (Heilen et al. 2008), providing each installation with guidelines for assessing the error rate and rectifying the problem. Most archaeologists, however, assume that site detection is not a problem in areas with good surface visibility. The recent finding at SCR of numerous sites, some representing rare and scientifically important Paleoindian sites, in areas that had previously been surveyed was quite troubling. The primary difference between the early survey that missed the sites and the later survey that found them was surface visibility. In the interim between the two surveys, the area had burned and the second survey was conducted immediately after the fire when all ground cover had been removed. The long-held assumption, particularly strong in the Great Basin and desert regions of the American West, regarding site visibility was wrong.

Does that mean that all previous surveys need to be re-done? We do not think so. Instead, modeling can be used to predict those areas likely to contain surface sites that have previously not been detected. Instead of resurveying everything, we suggested that SCR focus on those areas likely to contain sites, but only perform those surveys after the ground cover has been removed by fire.

UTTR faces a very different problem. Native Americans have used the Great Salt Lake and its environs for millennia. Yet, modern tribes have little recollection of actual use on the UTTR. Archaeological surveys have thus far failed to find ethnographic villages. But do such villages exist? If so, where would they be likely to be found?

DoD facilities need to know where rare, but important resources, which we have termed "red flags," are located for a variety of reasons. Stakeholders will want such resources avoided and protected from military activities. It follows that if such resources are found during the planning or, worse still, as unanticipated discoveries during the implementation of an undertaking, they will likely cause delays, if not halt projects. Even if such resources can be treated through data recovery, the resulting excavations and analyses will probably be extremely expensive. No matter what the outcome, relations with stakeholders will likely be negatively affected.

UTTR encompasses almost a million acres. Searching for ethnographic villages is a little like trying to find a needle in the proverbial haystack. Range managers wanted a means of

demonstrating a “reasonable and good faith effort” to find ethnographic villages to short of full-scale coverage. Using ethnographic data as a guide, we developed a predictive model of village sites, which shows that for the most part such sites should not exist on the UTTR. There are some areas, however, where there is a modest chance that such sites may be found. As they become available, UTTR can allocate survey efforts to these areas.

8.2 IMPLEMENTATION ISSUES

Seven overarching issues related to predictive modeling for military installations emerged during the course of our ESTCP demonstration project. These issues concern: (1) the availability of data required to develop, test, and refine predictive models; (2) the need for standardization and explicit protocols related to archaeological survey and data recovery; (3) the recognition that modeling is an iterative process; (4) the usefulness of developing models for buried archaeological sites; (5) the necessity of developing a variety of predictive models to address CRM compliance responsibilities; (6) the effectiveness of programmatic agreements (PAs) to streamline compliance, and (7) the importance of early consultation in the development of a PA. Each issue is briefly described below**.**

1. Transmitting, organizing, and evaluating CRM data for modeling can require considerable effort for both installations and modelers.

Developing predictive models requires a large quantity of CRM and environmental data. Although many installations have compiled some of these data, they often are not readily available in a digital format. Reports describing the results of CRM investigations and providing information on methodology and culture history frequently will be needed to understand the data, and large volumes of data may need to be transmitted on external hard drives. Sometimes, in excess of a terabyte of data will need to be transmitted for use in modeling—a constraint which can sometimes pose logistical challenges for an installation.

When they are available, digital data may require extensive evaluation for data quality and representativeness. For instance, it is often the case that CRM site attribute data are scattered across multiple databases, tables, and fields, and that the data entered in a given field are recorded as unstandardized comments, making their interpretation difficult. Similarly, it is not uncommon for identical mapping features (e.g., a survey polygon feature or a STP point feature) to be duplicated multiple times within a GIS layer as a result identical polygon or point data being merged into a master shapefile for survey areas, site areas, or test locations, resulting in multiple copies of the same data. These erroneously duplicated features may need to be cleaned up in order to avoid over-counting features during analysis. There may also be problems with the topology of polygons; mismatches between the attributes of mapping features in a GIS and the same features recorded in an independent attribute database; inaccurate or unspecified datum and projection information; missing data; a lack of congruence between layers in the extent and shape of common features; and many other problems. These problems need to be resolved in order to use CRM data or environmental data appropriately for modeling.

Along with CRM data, environmental data need to be obtained and processed to develop predictor variables for modeling. Installations will often have some environmental data that have been developed in-house. These kinds of data can be very useful as they may be relatively fine-

grained and installation-specific, but understanding the source of the data and how the data were developed will be important in order to use them effectively. It may thus be necessary to have access to any reporting materials associated with the data as well as metadata in order to apply the data in modeling.

Publicly-available national mapping datasets—such as digital elevation data, vegetation data, hydrographic data, and soils data—will often comprise the primary data for deriving many predictor variables, but these, too, need to be examined closely for possible problems. For instance, National Elevation Dataset data are increasingly available at cell sizes of 10 m or less, but care will need to be taken in understanding the underlying sources of the contributing elevation data. Currently, many elevation datasets are derived from sources obtained at multiple resolutions, such as a combination of 10 m and 30 m cell size datasets, and then resampled to the smaller cell size. The process of bringing these elevation datasets together at a common resolution can introduce unwanted noise, or "digital artifacts," into the dataset. These artifacts of the process of combining datasets are not apparent when viewing the untransformed dataset, but can become more apparent when derivative layers, such as slope or flow accumulation, are derived from such layers. For instance, linear bands often show up in derivative layers and these can skew the results of a transformation enough to make the dataset unusable. In such cases, using a more coarse-grained dataset may be desirable in order to obtain usable results.

Once these kinds of problems have been resolved, environmental layers need to be projected into a common datum and projection system in order to be used in modeling. It is often the case that all layers used in modeling will need to cover the exact same extent and use the same units, datum, and projection system. Since most predictive modeling efforts are conducted within a raster environment, polygon and point layers used to create predictor variables need to be converted to raster cell grids. Grids need to be resampled as necessary to a common grid, such that each grid cell in each mapping layer overlaps precisely with the grid cells of the other mapping layers. Depending on the complexity of operations needed to develop a predictor variable layer, many steps can be required in order to derive the desired variable. The processing time for developing individual layers can sometimes take on the order of hours or days to complete, depending on the complexity of the algorithm used and the extent and resolution of the dataset.

Once CRM data and environmental layers are organized and processed, relationships among cultural resources and variables will need to be assessed to determine whether variables are intercorrelated and which variables have the strongest potential to predict site location. As a result of these assessments, it may be the case that variables will need to be refined and composite variables will need to be developed through methods such as principal components analysis to reduce intercorrelations among variables.

In short, before an actual model is developed a large amount of time and effort is needed to organize, transmit, process, and explore CRM and environmental data. These activities can require a considerable investment of time and effort for both modelers and installation staff. One can expect that it will generally take on the order of at least several months to acquire the core data from installations, and it may be necessary for project staff to visit an installation and work directly with installation staff in order to obtain the necessary data. Given the limited time and

resources that installation staff has available for such activities, obtaining the necessary data can be a strain on an installation. We recommend that time and resources be devoted to an installation to help them prepare data and work with modelers to transmit data and related information needed to understand the data. It would also be advisable for installations to organize and validate their CRM data according to an agency-wide set of data quality standards.

2. Installations should endeavor to develop a core set of validated attributes for survey areas, test units, and recorded sites in order to facilitate modeling.

There is a variety of common attributes that greatly facilitate modeling, but it is generally the case that relevant attributes are not readily available in a digital format. When such attributes are available, they may be available only in a spotty, incomplete, or unstandardized fashion. This situation is understandable, as many installations develop these data incrementally as time and resources permit. Moreover, an installation may not have had the time or resources to develop a comprehensive database structure or explicit protocols for data entry. Even in the best of circumstances, installations will not have developed digital attribute data with activities such as predictive modeling in mind.

In a report on archaeological data quality in the military, Heilen et al. (2008) found that many attribute data that could be used to assess CRM data quality on military installations were not commonly available. In that report, Heilen et al. (2008:5.6) recommended maintaining detailed digital data on survey and site recording methods as well as conditions during survey that could have affected results, such as archaeological visibility. These same kinds of data would be useful for predictive modeling in order to evaluate data quality. Other kinds of data that would be especially useful for predictive modeling would be standardized data that could be used to organize sites and isolates into types, including information on function and cultural and temporal affiliation, as well as information on artifact and feature counts and types. In addition, it would be useful to maintain data on the pedological horizons and artifact content of test units, as Fort Drum has done, and temporal data on when survey and site recording or rerecording were conducted. Many installations have some of these data in some form in their CRM database, but the data are often incomplete or entered in an unstandardized fashion across multiple fields.

Having these standardized data available so they can be clearly and unambiguously associated with site and survey polygons and other mapping features would not only greatly facilitate modeling efforts, but also would make greater use of data that the DoD has spent a great deal of time and money developing. Not using these data effectively or not maintaining them within a common and easily interpretable database environment erodes their potential usefulness. On the other hand, making these data available digitally in a standardized format would not only leverage their usefulness to multiple ends, but also would help installations identify data gaps and better understand the kinds of data they should be developing during current and future installation tasks.

3. Installations will need to plan funding for testing and refining models on a periodic basis. Include as commitment in PAs.

Modeling is a process, not an event. Models that are left as static maps lose their usefulness over time and become increasingly outdated as new data are developed. In order to be useful and to

maintain stakeholder buy-in, models should be tested on a periodic basis and refined with new data, refined variables, or alternate modeling approaches, as warranted. Ensuring that a model is a dynamic product that can be updated with new information and that responds to the changing needs of an installation helps to maintain the use-life of a model as well as shows that an installation is responsive to stakeholder concerns and current research directions. As a consequence, installations need to make sure that funds are planned on a periodic basis to revisit models, test how well they perform in light of new data, and refine models as appropriate. To ensure that periodic testing and refinement occurs and that funds are available to do so, it is advisable that these activities be included as a commitment in PAs.

4. Testing and refinement of subsurface models will require methods specifically tailored to the discovery of buried sites.

Buried sites are not commonly discovered through routine site discovery techniques, often because pedestrian survey or STPs do not adequately expose buried deposits to the extent that they can be recognized. The limited exposures resulting from routine discovery techniques are generally inadequate for feature manifestations or artifacts within buried deposits to be observed. Moreover, specific kinds of depositional environments (such as alluvial flood plains, aeolian dune formations, or wetland margins) may need to be specifically targeted for testing, even if they fall outside current impact areas. Most importantly, excavation strategies involving trenching or coring will likely be necessary to test for buried deposits in these environments. As a result, the full validation of a subsurface model, as well as its refinement, may require a geoarchaeological investigation to be conducted specifically for that purpose. As discussed earlier in this report, it may also be useful to compile information on buried deposits observed during routine investigations as well as during construction activities. In such cases, it is advisable to employ a geoarchaeologist to document exposures of potential buried deposits encountered during construction activities and to develop a comprehensive database to record these findings.

5. The needs of installations change, requiring a flexible approach to the kinds of models used now and in the future.

Not all installations need models of archaeological site location. There are many kinds of models that can be developed and these should be developed to address the current and anticipated needs of an installation's CRM program. For instance, an installation may have largely completed inventory, but may need a model to assess the adequacy of previous survey in order to decide which areas of the installation, if any, are in need of resurvey. Similarly, an installation may need a model to help decide which sites to test for National Register evaluations or to place sites into different significance categories. Alternatively, an installation may need a model to project where TCPs are likely to occur. Installations may also need models to assess what impacts to sites are likely in the future as a result of planned construction projects or the effects of climate change. In short, there is no one single kind of model that every installation needs; the right model(s) for an installation need to be developed through careful examination of the questions and concerns that need to be addressed and compilation of the data and methods relevant to answering those questions.

6. Modeling and Programmatic Agreement (PA) development should be conducted in close communication with consulting parties.

The overarching goal of this demonstration was to show that using archaeological predictive modeling can aide DoD installations in streamlining their CRM planning and compliance functions. To meet the requirements of NHPA Section 106, and by extension NEPA, DoD installations must be able to use predictive models on a daily basis. The regulations implementing Section 106 make provisions for tailoring the compliance process to meet the needs of federal agencies through PAs. These agreements are negotiated between federal agencies and consulting parties, such as Indian tribes, historical societies, and local museum organizations, that have a legal interest in or concern about the potential effects of federal undertakings on historic properties. The project team understood that PAs would have to be developed to harness the utility of predictive models in the Section 106 compliance process, and this would require working with the consulting parties to explain how models can be used to better manage archaeological resources. Developing and implementing predictive archaeological models to meet future Section 106 compliance needs at other DoD installations will require the same effort. Multiple meetings with an installation's CRM staff and consulting parties, supplemented by conference calls as needed, will be required from the beginning of the project to its end. It is advisable to hold a final meeting in which the model or models are presented and demonstrated using real-world examples specific to the installation.

7. Programmatic Agreement (PA) drafting should begin at the point models can be explained in operational detail.

As mentioned above, PAs are tools for achieving Section 106 compliance that meet the needs of federal agencies; this is done in consultation with other parties. Coordinating the developing of archaeological predictive models and the consultation process needed to prepare a PA is essential. Consultation should begin at the earliest stage in the project's development in order to explain to the consulting parties the purpose of the modeling and the project goals. The consulting parties need to be comfortable with the idea of modeling and have a basic understanding of what to expect from the modeling process. Although this early stage in the process is an opportunity to discuss a PA in general terms, drafting the PA should begin when the modeling is advanced to the stage where preliminary results can be presented. Up until that point, the modeling project will be an abstraction lacking in operational detail. After this point, however, the focus of discussion can shift to a real-world application. Consulting parties will want to know that the model or models are meeting the stated goals. Their ultimate concerns will be about the accuracy and reliability of the model or models when applied to real-world problems in CRM. As the modeling progresses, development of the PA can address operational detail on when and under what circumstances the model will be used. The PA should be completed after the modeling is concluded and a final project presentation is made to installation staff and the consulting parties.

8.3 LESSONS LEARNED

Four key lessons emerged from the ESTCP project. They range from technical issues surrounding data to human relations.

1. It's modeling, not models: Traditionally, predictive models have been created as stand-alone features. Installations and ranges expend substantial money and time to create the best model of archaeological site location at the time. These models are placed on the shelf or, in the case of a map, on the wall. They are rarely tested or kept up-to-date. The model may be referenced when projects are planned, providing planners with a sense of what may be expected and, occasionally, a rationale for altering the design of the project.

Our human ancestors did not use the landscape in random manner. They logically situated themselves in relation to resources and other social groups. It follows, therefore, that the more land we survey, the better our ability to discern those places favored in the past from those that were shunned. Predictive models will get better with additional data. Perhaps our best measure of knowledge about archaeological site location is the rate at which model predictions improve. A vastly improving model shows that we need to continue to survey, whereas a model whose predictive power remains the same as more data are incorporated suggests that the patterns in ancient settlement that can be discerned by our survey methods are well established.

It is our recommendation that DoD commit to modeling and not models. Part of the difficulty with predictive modeling in the past is that the commitment to maintain them requires specialized expertise and resources not generally available at the installation level. Currently, front-end software can be written that link site databases with predictive modeling algorithms so that models can be updated as archaeological are entered. With a modest investment, therefore, predictive modeling does not have to require specialized expertise, but can be easily incorporated into the flow of an installation's CRM program.

2. Garbage in, garbage out: quality in, quality out: At the four demonstration sites, the weakest link in the installation's CRM programs ability to model was the quality of the data in the installation's database. For most part, installations maintain data on archaeological sites relative to location, size, and gross time category (i.e., prehistoric versus historical period). Resulting models combined all sites from all periods (with the possible exception of historical-period sites). Given that many different cultures and adaptations are mixed in the data, the resulting models are often poor predictors of site location. These models generally predict the locations of site types encompassing the largest areas the best and are poor predictors of rare site types. Unfortunately, the latter tend to be the ones in which stakeholders have the most interest and greatest concerns.

Much of the data needed to refine models to site type and time period are routinely collected during archaeological surveys. These data, however, are commonly not entered in installation databases because of the effort needed to code and enter them combined with the fact that these data are not normally needed in routine day-to-day CRM decisions. DoD is sitting on a wealth of data, which the agency has collected at considerable cost and effort. It may surprise many that the best way to improve predictive modeling is not collecting more data, but using data that has already been collected. We note that progress in the development of enterprise-wide relational databases for use in CRM is uneven across the military services. One attempt was made in DoD in the 1990s, as part of the Defense Environmental Security Corporate Information Management (DESCIM) program. Cultural resources were to be treated in a late module, but the program was terminated in 2000 with no action in that regard. Most recently, DoD encouraged the revision of

the geospatial data standards for cultural resources in its update of the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) 3.0. Likewise, business data standards for cultural resources were revised as a follow-on effort and presented to the services for implementation. This remains a work in progress, and it will retard the corporate implantation of modeling at all echelons until established.

3. All together now: The biggest hurdles facing predictive modeling are not technological, they are sociological. Predictive models have been used in CRM for more than 30 years. Most agencies have tried to use models to lessen the amount of inventory by arguing that survey is not needed in low-sensitivity areas. The backlash led by tribes, SHPOs, and other archaeologists was swift. They argued that we do not know enough to have confidence in models and that sites will inevitably be lost. Many stakeholders remain both skeptical of models and skeptical of government agency motives in promoting models.

It would be a mistake for DoD as a federal agency or a military installation on its own to decide to incorporate predictive modeling in its CRM compliance. Such a move would feed into the skepticism that SHPOs, tribes, and others already have toward predictive modeling. The best way to move forward is to make predictive modeling a joint effort from the very beginning. Fort Drum is a case in point. Prior to this ESTCP demonstration project, the New York SHPO was strongly opposed to predictive modeling. Before initiating the demonstration project, the demonstration project team met with SHPO representatives and discussed the latter's concerns, how to meet them, and how to move forward. The project team provided the SHPO with a demonstration of the model and was in regular contact with them as the PA was drafted. The consultation required considerable effort. We are convinced, however, that without this effort, no model, regardless of how accurate and powerful, would have allayed SHPO concerns and that a programmatic approach could not be successfully implemented.

4. Modeling is not an option: The decision to develop a predictive model or to have no model is a false choice. Without a model, an installation archaeologist falls back on his or her accumulated knowledge of site location. Decisions to survey or not to survey, to probe for buried sites or not to probe, are based on what he or she believes is the most likely occurrence. Make no mistake, though the decision may be based on subjective inferences not subject to testing, it is based on an intuitive model of how the archaeological record was formed and its current condition.

The ultimate goal of predictive modeling is not, as some may claim, to lower costs. The ultimate goal is to make the best decision about archaeological resources in the most efficient manner. We strongly believe that good decisions will put the right dollars on the right resources. It will save money because the current situation is highly inefficient. Managers initiate the compliance process for each project as though they and their archaeological contractors know nothing about the installation's archaeology after expending millions of dollars and nearly 50 years of effort. The truth is we do know something; in fact, we know quite a lot. The problem is presenting that information in a way that others can readily understand and that allows all parties to come to a reasonable solution. That is the promise of predictive modeling.

8.4 FINAL COMMENT

ESTCP Demonstration Project 200720 has been successful. The technology needed to predict archaeological site location has been demonstrated. The sociology of predictive modeling—stakeholders agreeing to use predictive models as a framework for programmatic approaches to CRM—has also been demonstrated. Yet, we recognize that predictive modeling is not for everyone or for every installation. The failure to use predictive modeling in large part is a function of communication and experience. Many stakeholders in the CRM process, including many DoD archaeologists, still believe that predictive modeling is simply a tool to minimize inventory as opposed to a tool that provides decision makers with objective and scientifically-based information. They fail to see that they model, albeit subjectively, at the same time they decry the use of predictive models.

DoD has expended considerable effort and money collecting CRM information. Predictive modeling is the best venue for displaying that information, for synthesizing those data in ways that stakeholders can readily grasp, and the best framework for making management decisions that balance historic preservation with the needs of the military. It is no longer a question of whether predictive models work or whether they can be integrated in CRM compliance; they do and they can. We need to demystify predictive modeling by communicating through websites, trainings, and reports that installations not only can model, but in doing so they will improve their ability to proactively preserve the past and meet the military obligations. In sum, we believe that DoD should commit to the process of predictive modeling and invest in the staff and resources required to carry out this commitment.

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APPENDICES

Appendix A: Points of Contact

Appendix B: First Draft of Section 106 Programmatic Agreement for managing archaeological resources at Eglin AFB, Florida

Appendix C: First Draft of Section 106 Programmatic Agreement for managing cultural resources at Fort Drum, New York

Appendix D: Archaeological Site Visibility Model: Visibility and Archaeological Data Quality at Saylor Creek Range, Idaho

Appendix E: Archaeological Red Flag Model: Ethnographic Land Use Model at Utah Test and Training Range

Appendix F: Subsurface sensitivity determinations for National Resource Conservation Service soil types at Eglin AFB, Okaloosa County, Florida

Appendix G: Subsurface sensitivity determinations for National Resource Conservation Service soil types at Eglin AFB, Santa Rosa County, Florida

Appendix H: Subsurface sensitivity determinations for National Resource Conservation Service soil types at Eglin AFB, Walton County, Florida

Appendix I: Subsurface sensitivity determinations for National Resource Conservation Service soil types at Fort Drum, New York

Appendix J: Subsurface sensitivity determinations for National Resource Conservation Service soil types at Saylor Creek Range, Elmore County, Idaho

Appendix K: Subsurface sensitivity determinations for National Resource Conservation Service soil types at Saylor Creek Range, Owyhee County, Idaho

Appendix L: Subsurface sensitivity determinations for National Resource Conservation Service soil types at UTTR

APPENDIX A:
POINTS OF CONTACT

POINT OFCONTACT Name	ORGANIZATION Name Address	Phone Fax E-mail	Role in Project
Dr. Paul Green	AFCEE/TDI 129 Andrews Street, Suite 340 Joint Base Langley-Eustis VA 23665-2769	757-764-9335 (tele) 757-764-9305 (fax) paul.green@us.af.mil	Lead Principal Investigator
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Dr. Jay Newman	USACE, Fort Worth District CESWF-PER-EC P.O. Box 17300 819 Taylor Street, Room 3A14 Fort Worth, Texas 76102-0300	817-886-1721 jay.r.newman@usace.army.mil	Contract Administrator
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Dr. Laurie Rush	U.S. Army Fort Drum DPW, Environmental Division 85 1st Street Fort Drum, NY 13602-5097	315-772-4165 (tele) laurie.rush@us.army.mil	Cultural Resources Program Manager
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Ms. Jaynie Hirschi	Hill Air Force Base 75 CEG/CEVR 7274 Wardleigh Rd Hill AFB, UT 84056-5137	801-775-6920 (tele) Jaynie.Hirschi@HILL.af.mil	Cultural Resources Program Manager

APPENDIX B:
FIRST DRAFT OF SECTION 106 PROGRAMMATIC AGREEMENT FOR MANAGING ARCHAEOLOGICAL RESOURCES AT EGLIN AFB, FLORIDA

FIRST DRAFT

PROGRAMMATIC AGREEMENT
AMONG
EGLIN AIR FORCE BASE
FLORIDA STATE HISTORIC PRESERVATION OFFICER
AND
ADVISORY COUNCIL ON HISTORIC PRESERVATION
REGARDING
MANAGEMENT OF ARCHAEOLOGICAL SITES AT EGLIN AIR FORCE BASE, FLORIDA

WHEREAS, Eglin Air Force Base (Eglin AFB) has under its jurisdiction approximately 464,000 acres encompassing portions of in Okaloosa, Santa Rosa, and Walton Counties, Florida (Appendix A); and

WHEREAS, Eglin AFB plays a vital role in the development and testing of weapons and tactics, a mission it has met in the defense of the nation from 1940 until the present day, and is headquarters to the Air Armament Center (AAC), a component of the Air Force Material Command (AFMC); and

WHEREAS, over the years Eglin AFB has evolved into an extensive training complex including the Eglin Main cantonment, three air fields (Eglin Main Field, Choctaw Field, and Duke Field), multiple bombing and firing ranges, closed training areas, drop zones, and shoreline infiltration areas, (Appendix B); and

WHEREAS, Eglin AFB, in consultation with the Advisory Council on Historic Preservation (ACHP) and the Florida State Historic Preservation Officer (SHPO), has determined that future undertakings, including but not limited to, construction and development, weapons testing, troop training, explosive ordinance disposal (EOD) clearance, forestry and prescribed burns, road maintenance, and landscaping may adversely effect historic properties (prehistoric and historic archaeological sites) listed in or eligible for listing in the National Register of Historic Places (NRHP) (here after "archaeological sites"); and

WHEREAS, Eglin AFB has further consulted with ACHP and SHPO regarding its responsibility to manage its archaeological sites in accordance with Sections 106 of the National Historic Preservation Act (NHPA) (16 U.S.C. §470f) and its implementing regulations at 36 CFR Part 800; and

WHEREAS, Eglin AFB is also responsible for identifying, evaluating, and nominating archaeological sites properties to the NRHP in accordance with Section 110 of the NHPA and is actively engaged in Section 110 cultural resources inventory of the base; and

WHEREAS, Eglin AFB, wishes to comprehensively meet its management responsibilities in a manner that balances its regulatory obligations with its need for operational flexibility and seeks, therefore, to enter into a Programmatic Agreement (PA) with the ACHP, SHPO, Native American tribes, and other consulting parties as provided under 36 CFR Part 800.14; and

WHEREAS, Eglin AFB has consulted with the Miccosukee Tribe of Indians of Florida, the Seminole Tribe of Florida, the Poarch Band of Creek Indians of Alabama, the Muscogee (Creek) Nation of Oklahoma, and the Thlopthlocco Tribal Town of the Creek (Muscogee) Nation (of Oklahoma) (hereafter the Tribes) regarding management of, and effects to, archaeological sites of religious and cultural significance to the Tribes and has invited them to be concurring parties to this PA; and

WHEREAS, Eglin AFB, has built a nationally recognized cultural resources management program and is committed to meeting its responsibilities to be a good steward of the nation's heritage resources and to meet its regulatory obligations under federal law; and

NOW THEREFORE, Eglin AFB, SHPO, and ACHP agree that future management of Eglin AFB's archaeological sites shall be administered in accordance with the following stipulations.

Stipulations

I. Identification

A. Archaeological Predictive Models

1. Eglin AFB has developed two installation-wide archaeological predictive models, referred to collectively as the "Site Probability Model," which it uses for managing its archaeological sites in compliance with Sections 106 and 110 of the NHPA, as briefly described below.

   (a) The prehistoric site model, developed first in 1982 and adopted in 1993, correlates the location of prehistoric archaeological sites with key environmental variables (proximity to potable water, elevation above potable water sources, and proximity to the coast lines and alluvial planes). Eglin AFB uses these data to characterize the landscape within the base as either high or low probability for prehistoric archaeological sites.

   (b) The historic site model, added in 2001, identifies the expected location of historic homesteads and other settlements that are now archaeological sites by researching historic maps and archival records on homestead claims. Eglin AFB uses these data to characterize the landscape within the base as either high or low probability for historic archaeological sites.

2. In 2010–2011, Eglin AFB, in cooperation with the Department of Defense's Environmental Security Technology Certification Program (ESTCP), tested, refined, and validated the prehistoric site model. The ESTCP modeling project produced a refined surface model and a zonal management model. The zonal management model combines the surface model, a preliminary subsurface geo-archaeology model, and, a "red flag" model that predicts the location of certain classes of prehistoric archaeological sites (prehistoric villages, mounds). Both modeling products, the refined surface model and the zonal management model, will be part of the suite of modeling tools referred to here after as "the prehistoric site model."

3. Eglin AFB will continue to use the prehistoric site model and the historic site model to make planning and management decisions in compliance with Sections 106 and 110.

4. For a period of five years following the execution of this PA Eglin AFB will review, test, and upgrade, as needed, the prehistoric site model to ensure its continued accuracy and reliability. Once a year, during this five-year period, Eglin AFB will meet with SHPO and report on the review of the prehistoric site model.

5. To ensure that the prehistoric site model is reviewed, tested, and upgraded, as needed, in a manner that is acceptable to both Eglin AFB and SHPO, Eglin AFB, in consultation with SHPO, will hire an outside contractor to conduct the annual review and to make recommendations for any improvements to the prehistoric site model that may be needed. The contracting firm shall have demonstrated experience in building, testing/evaluating, and upgrading GIS statistically based archaeological predictive models.

6. Eglin AFB understands that modeling is an iterative process and that the prehistoric site model, as revised in 2011, will require continuous testing and refinement over time. For this reason Eglin AFB is committed to enhancing the accuracy and reliability of the prehistoric site model and will make any improvements it deems appropriate to achieve this end. These improvements may include, but are not limited to, conducting additional archaeological survey in low probability areas needed to statistically test and refine the prehistoric site model.

B. Identification Procedures

1. Eglin AFB will use the Site Probability Model to guide all archaeological surveys for Section 106 undertakings and Section 110 management projects in the following manner:

   (a) Areas identified as low probability areas for prehistoric and historic archaeological sites will not require archaeological survey, but may be surveyed to collect data needed to statistically test the prehistoric site model.

   (b) Areas identified as medium probability areas for prehistoric sites will require 50% survey, where surface conditions allow, unless otherwise exempted under Stipulation

VI.A. Survey standards will follow the standards used for archaeological survey in the High Probability Area (HPA).

(c) Areas identified as HPA for prehistoric, homestead/historic or wetlands will require 100% archaeological survey, where surface conditions allow, unless otherwise exempted under Stipulation VI.A. All archaeological survey conducted in the HPA will follow the survey standards for each HPA survey category set forth in the Eglin AFB Integrated Cultural Resources Management Plan (ICRMP) attached herein by reference.

2. All identification will be conducted by professional archaeologists who meet the qualification standards in Stipulation V.

II. National Register Eligibility

A. At Eglin AFB, archaeological sites require subsurface testing to determine their NRHP eligibility status for Section 106 undertakings or Section 110 management projects. Any archaeological site that requires NRHP evaluation that has not been previously evaluated will be tested for NRHP eligibility in the following manner.

1. Eglin AFB will not be required to consult with SHPO prior to eligibility testing.

2. All testing of archaeological sites will be conducted by a professional who meets the qualification standards in Stipulation V.

3. If an archaeological site can be avoided in accordance with Stipulation III.B, Eglin AFB may choose not to test the site for NRHP eligibility until a later time. Under these circumstances, the undertaking may take place provided that any measures necessary to ensure avoidance are put in place.

B. Eglin AFB, in consultation with SHPO, will make a determination of NRHP eligibility for any archaeological site not previously evaluated that will be adversely affected by the undertaking. The Tribes will not be consulted about NRHP eligibility; however, Eglin AFB will provide the Tribes with NRHP information on all prehistoric sites evaluated in the previous year to be presented in an annual report as provided for in Stipulation XIV.B.

C. In those cases where Eglin AFB must make a determination of NRHP eligibility because an archaeological site may be adversely affected, or it chooses to make an NRHP eligibility determination following avoidance, Eglin AFB will follow the procedures presented below.

1. Eglin AFB shall submit an archaeological testing report to SHPO for a 30-day review along with its eligibility recommendations.

2. If the SHPO does not respond within the prescribed 30-day comment period, Eglin AFB will assume that SHPO has no objection to its eligibility determination.

3. Where there is agreement on eligibility between Eglin AFB and the SHPO, the eligibility determination will be accepted by both parties. Any disagreement between Eglin AFB and the SHPO over the eligibility determination shall be submitted by Eglin AFB to the Keeper of the National Register for determination pursuant to 36 CFR Part 63. The Keeper's determination shall be final.

III. Effect and Avoidance of Effect

A. Eglin AFB will determine the effects of each undertaking on NRHP eligible archaeological sites in the following manner.

1. Eglin AFB will consult with the SHPO whenever an undertaking may have an adverse effect to archaeological sites, or Eglin AFB determines the undertaking may have an effect but the effect will not be adverse.

2. Eglin AFB will consult with the Tribes whenever an undertaking may have an adverse effect to prehistoric archaeological sites.

3. Eglin AFB will not be required to consult on effect with SHPO, the Tribes, or the other consulting parties in the following circumstances:

   (a) Where no cultural resources are found within the Area of Potential Effects (APE);

   (b) Where cultural resources are found but they have been determined not to be eligible through prior consultation with SHPO; or

   (c) Where NRHP eligible archaeological sites, previously determined to be eligible through consultation with SHPO, are found but will be avoided in accordance with Stipulation III.B.

4. Documentation supporting these "no effect" determinations will be provided to the SHPO and to the Tribes in an annual report as provided for in Stipulation XIV.A and XIV.B respectively.

B. Avoidance

1. All historic properties will be avoided whenever possible for the duration of this agreement. Where avoidance is not possible or desirable, Eglin AFB shall resolve the adverse effects of the undertaking in accordance with Stipulation IV.

2. Avoidance and preservation in place of archaeological sites will require use of highly visible avoidance measures installed on the ground around the recorded limits of the sites or buildings for the purpose of communicating "off limits" during the undertaking. The avoidance measures shall include one or more of the following as needed.

(a) Flagging: Installing temporary flagging around the limits of the site using colored flagging tape.

(b) Painting trees/vegetation: Applying highly visible paint to trees or other vegetation.

(c) Temporary fencing: Installing temporary fencing around the limits of the site using removable fencing, such as chain link fencing or wire and T posts.

(d) Other removable barriers: Installing removable barriers, such as earthen berms or portable concrete barriers.

(e) Signage: Installing permanent or semi-permanent signage at eye level in proximity to the site.

(f) Gating and other permanent barriers: Constructing permanent barriers, such as gates, around the limits of sites.

3. Eglin AFB will map the location of all archaeological sites to be avoided for the undertaking and describe in writing the avoidance measures used for each site.

4. Eglin AFB shall install all avoidance measures and ensure that for the undertaking all avoidance measures are in place on the ground before the undertaking commences. Eglin AFB will not be required to consult with the SHPO or other consulting parties when avoidance can be achieved, but may seek their advice, as needed.

5. If Eglin AFB determines, in consultation with SHPO, that avoidance is not possible, and there will be an adverse effect to an archaeological site, then Eglin AFB will mitigate the effects of the undertaking in accordance with a treatment plan.

C. Archaeological Monitoring

1. Eglin AFB may conduct archaeological monitoring as a means of ensuring avoidance, with or without the avoidance measures in Stipulation III.B; or, as a means of ensuring an undertaking will have no adverse effect to archaeological sites.

(a) All archaeological monitoring will be conducted by an archaeologist that meets the professional qualifications standards in Stipulation V.

(b) The archaeological monitor will be authorized to record features, collect artifacts and samples, take photographs, draw maps, and write notes, as needed. The monitor shall have the expressed authority to temporarily stop or redirect ground disturbing activities, as needed, at any time for the purposes of archaeological monitoring.

(c) A report of the monitoring activities will be prepared and submitted to the SHPO.

2. Should undisturbed archaeological deposits be observed during monitoring, the monitor will halt ground disturbing activities and immediately report a possible discovery to the Eglin AFB. If Eglin AFB determines these deposits represent either an unknown archaeological site or an unrecorded portion of a known site, it will declare the deposits to be an unanticipated archaeological discovery. Eglin AFB shall then follow the provisions for unanticipated archaeological discovery in Stipulation VII.

IV. Resolution of Adverse Effects

A. If avoidance of archaeological sites is not possible or desirable, Eglin AFB shall resolve the adverse effects of the undertaking through archaeological data recovery or by means of alternative mitigation. All archaeological data recovery or alternative mitigation shall be conducted by a professional meeting the qualification standards in Stipulation V.

B. Archaeological Data Recovery

Eglin AFB will ensure that archaeological data recovery is conducted in the following manner.

1. A data recovery plan shall be prepared. At a minimum, the plan shall include:

   (a) A description of the proposed undertaking that will adversely affect archaeological sites

   (b) A description of each archaeological site and how each may be affected by the proposed undertaking

   (c) A set of research questions and objectives

   (d) A description of methods to be used in collecting the data needed to address the research questions

   (e) A description of analytical techniques to be used in addressing the research questions

   (f) A description of the nature of materials and features expected to be revealed, materials expected to be collected, and all other materials to be generated including reports and associated media

2. Eglin AFB shall submit the data recovery plan to SHPO for 45-day review. If the archaeological site is prehistoric in age, Eglin AFB shall also submit the data recovery plan to the Tribes for 45-day review. The tribal review period will run concurrently with the SHPO review.

   (a) If the SHPO or one or more of the Tribes does not respond within the prescribed review period, Eglin AFB shall assume that party has no objection to the proposed treatment. Eglin AFB, in completing the data recovery plan, will take into account

any comments it does receive from the SHPO or the Tribes within the prescribed review periods.

(b) Once Eglin AFB has completed the data recovery plan, it shall ensure that the data recovery is conducted in accordance with the plan.

(c) All archaeological data recovery shall be reported within 12 months of the end of field work. Eglin AFB shall ensure that a draft of the report is prepared and will submit the draft to SHPO and the Tribes for a 45-day review. Any comments received by Eglin AFB from SHPO or any of the Tribes, within the prescribed review period shall be considered in completing the report. Eglin AFB shall provide the SHPO and the Tribes with one copy of any final report.

3. Eglin AFB may prepare historic context studies to guide archaeological data recovery and the preparation of archaeological data recovery plans. These historic contexts may be base-wide in scope, focus on a particular archaeological site type or time period, apply to a subarea of the Eglin AFB reservation, or be developed for a particular undertaking. Historic context studies shall be prepared in consultation with the consulting parties.

C. Alternative Mitigation

If Eglin AFB determines that resolution of adverse effects can best be achieved through means other than archaeological data recovery, it may adopt an alternative mitigation strategy on a case-by-case basis as presented below.

1. If the alternative mitigation will apply to historic archaeological sites, Eglin AFB will submit a mitigation plan to the SHPO for 45-day review. Eglin AFB shall take into consideration any comments it receives from the SHPO during the 45-day review period. If the SHPO does not respond within the 45-day review period, Eglin AFB shall assume the SHPO has no objection to the alternative mitigation.

2. If the alternative mitigation will apply to prehistoric archaeological sites, or historic archaeological sites with a prehistoric component, Eglin AFB will submit a mitigation plan to the SHPO and Tribes for a 45-day review. The tribal review period will run concurrently with SHPO review. Eglin AFB shall take into consideration any comments it receives from the SHPO or any one of the Tribes during the prescribed review period. If the SHPO, or one or more of the Tribes, do not respond within the prescribed review period, Eglin AFB shall assume that party has no objection to the alternative mitigation.

3. All alternative mitigation shall be reported within 12 months of the end of field work. Eglin AFB shall ensure that a draft of the report is prepared and will submit the draft to SHPO and to the Tribes, as applicable, for a 45-day review. Any comments received by Eglin AFB from SHPO or any of the Tribes, as applicable, within the prescribed review period shall be considered in completing the report. Eglin AFB shall provide the SHPO and the Tribes each with one copy of any final report.

D. Standards

Eglin AFB will ensure that resolution of adverse effects to all archaeological sites through data recovery or alternative mitigation is conducted in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation.

V. Qualifications

All investigation of archaeological sites conducted under the terms of this PA, including but not limited to, field work, archival research, artifact curation, and report preparation; and, all management of archaeological sites including, but not limited to, identification, evaluation of NRHP eligibility, assessment of effect, and treatment of effect, as the case may be, shall be conducted by, or under the supervision of, a person who meets the Secretary of the Interior's Standards and Guidelines for professional qualifications in archaeology described in the Federal Register: June 20, 1997 (Volume 62, Number 119, pages 33707-33723).

VI. Exemptions

A. The following areas shown on the map attached in Appendix C shall be exempted from the terms of this PA. These areas contain hazardous materials and are too dangerous to access for cultural resources investigations; or, they are off limits for reasons of national security. If, in the future, Eglin AFB determines that the exempted areas are accessible because the hazards preventing safe access have been removed or neutralized; or, the security restrictions have been lifted, then Eglin AFB will consult with the parties to this PA, in accordance with Stipulation XII, and amend the map in Appendix C. Thereafter, any area or areas removed from the map in Appendix C, will be subject to the terms of this PA.

B. The following undertakings, listed in Appendix D, shall be exempted from the terms of this PA. These undertakings are determined to have little or no potential to affect National Register-eligible historic properties. If, in the future, Eglin AFB determines that the list of exempted undertaking should be added to or subtracted from, then Eglin AFB will consult with the parties to this PA, in accordance with Stipulation XII, and amend the list in Appendix D. Thereafter, any undertaking not listed as exempt will be will be subject to the terms of this PA.

C. If during implementation or construction of any of these exempted undertakings, an unanticipated discovery is made, Eglin AFB shall follow the provisions for unanticipated discoveries in Stipulation VII below.

VII. Unanticipated Discoveries

A. If a previously unknown archaeological site is discovered during an undertaking, or an unanticipated effect to a known archaeological site is discovered during an undertaking, Eglin AFB shall immediately take the following steps.

1. All ground disturbances in the vicinity of the discovery shall cease and the discovery location will be secured from further harm until the discovery is resolved.

2. A professional, meeting the qualification standards of Stipulation V shall record the discovery evaluating its nature, extent, condition, and NRHP eligibility and prepare a field report.

3. The field report will be prepared within 48 hours and be submitted to the Eglin AFB Cultural Resources Manager.

B. Eglin AFB shall consult with SHPO on the NRHP eligibility of the discovery and the potential effect of continued development within two working days of the discovery. If the discovery is a prehistoric archaeological site, Eglin AFB will also consult with the Tribes concurrently with the SHPO.

C. If, in consultation with SHPO, and, when applicable, the Tribes, Eglin AFB determines that the discovery is NRHP eligible and that treatment is warranted, Eglin AFB shall conduct treatment following the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation.

VIII. Human Burials

A. If human remains and associated funerary objects are discovered during an undertaking, Eglin AFB shall immediately take the following steps.

1. All ground disturbing activity in the vicinity of the discovery shall cease and the discovery location will be secured from further harm until the discovery is resolved.

2. A professional, meeting the qualification standards of Stipulation V shall record the discovery evaluating its nature, extent, and condition and prepare a field report.

3. The field report will be prepared within 48 hours and submitted to the Eglin AFB Cultural Resources Manager.

4. Eglin AFB shall notify the Tribes within 48 hours of the discovery and provide a copy of the field report as soon as it is available. Eglin AFB may conduct analysis of the human remains, as needed, to determine their age and identity. Noninvasive techniques will be used whenever possible and if the remains need to be moved Eglin AFB will use natural fibers and materials (no plastic or synthetics) for this purpose.

B. If Eglin AFB determines the human remains are Native American; or, based on the preponderance of evidence, are likely to be Native American, it shall consult with the Tribes within 24 hours of its determination and comply with 43 CFR Part 10, the regulations implementing the Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001 et seq.).

C. If Eglin AFB determines the human remains are not Native American, or, based on the preponderance of evidence, are not likely to be Native American, Eglin AFB will consult with SHPO pursuant to 36 CFR Part 800 to resolve the discovery. Subsequently, should the remains be identified as Native American, Eglin AFB will consult with the Tribes pursuant to NAGPRA.

D. If Eglin AFB cannot determine the origin of the human remains as either Native American or non-Native American, it shall treat the remains as Native American and accordingly consult with the Tribes pursuant to NAGPRA.

IX. Declared Emergencies

A. Natural disasters such as hurricanes, tornados, tidal surges, etc. may occur requiring an immediate response by Eglin AFB in order to protect health, safety, and property. In the event of an emergency declared by the President of the United States or the Governor of the State of Florida, pursuant to 36 CFR Part 800.12, the following emergency actions, which could otherwise by undertakings, are exempted from further consideration under this PA.

   1. Protection of the human health and/or the environment from damage or harm by hydrocarbon or hazardous waste

   2. Prevention of imminent damage resulting from the threat of hurricane, tornado or other natural disasters

   3. Stabilization necessitated by the threat of imminent structural failure (e.g. repair of replacement of building footings)

   4. Actions waived from the usual procedures of Section 106 compliance, pursuant to 36 CFR 800.12 (d)

B. Once the President of the United States or the Governor of the State of Florida declares the emergency to be over, Eglin AFB will conduct an inspection of all archaeological sites located in the areas of the base where Eglin AFB has reason to believe the integrity of the sites may have been compromised during the emergency. Eglin AFB will record the condition of the archaeological sites, evaluate their NRHP eligibility status, and recommend any actions needed to protect, stabilize, and preserve the properties. This report will be sent to SHPO for review and comment.

C. Should Eglin AFB propose follow-up stabilization or other protective measures, including salvage excavation, to any archaeological site at the conclusion of the emergency, and those measures may result in additional effects, Eglin AFB shall consult with SHPO to develop a treatment strategy for those sites.

D. In all those cases in which Eglin AFB concludes that damage to archaeological sites resulting from the emergency is so severe that their integrity has been compromised, then, with SHPO concurrence, Eglin AFB may determine that these properties are no longer NRHP eligible.

X. Failure to Comply

A. If and when Eglin AFB is responsible for authorizing an action that would otherwise have been reviewed as an undertaking in accordance with this PA prior to such authorization, Eglin AFB shall, upon learning of the incident, immediately investigate the incident.

B. Eglin AFB will ensure that a professional meeting the qualification standards in Stipulation V inspects the location and prepares a damage assessment report within 30 days. The report will, at a minimum, include:

1. A description of the incident;

2. A description of any historic properties that may have been affected by the incident;

3. A description of the effects of the incident on archaeological sites, if any; and

4. A description of the steps that will be taken to protect, stabilize, and preserve any affected archaeological sites.

C. Eglin AFB will send the damage assessment report to the SHPO and to appropriate agencies, departments and clients within the base along with an explanation of what steps Eglin AFB will take to ensure that similar failures to comply will not happen again in the future.

XI. Dispute Resolution

A. Should any signatory or consulting party object to any actions proposed or the manner in which the terms of this PA are implemented, Eglin AFB shall consult with such party to resolve the objection. If Eglin AFB determines that the objection cannot be resolved, Eglin AFB will forward all documentation relevant to the objection, including a proposed response, to ACHP.

B. Within forty-five (45) days after receipt of all pertinent documentation, ACHP shall exercise one of the following options:

1. Advise Eglin AFB that ACHP concurs with Eglin AFB's proposed response to the objection, whereupon Eglin AFB will respond to the objection accordingly; or

2. Provide Eglin AFB with recommendations, which Eglin AFB shall take into account in reaching a final decision regarding its response to the objection; or

3. Notify Eglin AFB that the objection will be referred for comment pursuant to 36 CFR §800.7(a)(4), and proceed to refer the objection and comment; Eglin AFB shall take the resulting comment into account in accordance with 36 CFR §800.7(c)(4).

C. Should the ACHP not exercise one of the above options within forty-five (45) days after the receipt of all pertinent documentation, Eglin AFB may assume the ACHP's concurrence with its proposed response to the objection.

D. Eglin AFB shall take into account any ACHP comment or recommendation provided in accordance with this stipulation with reference only to the subject of the objection; its responsibility to carry out all actions under this agreement that are not the subject of the objection shall remain unchanged.

XII. Amendments

Any signatory to this PA may propose to the other signatory that it be amended, whereupon the signatories will consult in accordance with 36 CFR § 800.6(c)(7) to consider such an amendment. If the signatories cannot agree to appropriate terms to amend the PA, the PA may be terminated in accordance with Stipulation XIII below.

XIII. Termination

Any signatory to this agreement may revoke it upon written notification to the other parties by providing thirty (30) days notice to the other parties, provided that the parties will consult during the period prior to termination to seek agreement on amendments or other actions that would avoid termination. In the event of termination, Eglin AFB shall comply with 36 CFR §800 with regard to individual undertakings covered by this PA.

XIV. Annual Report

A. Every year, within 30 days of the anniversary of the signing of this agreement, Eglin AFB shall submit a report to the SHPO regarding determinations of effect made in the previous year in which prior SHPO consultation is not required under Stipulation III.A.4.

B. Every year, within 30 days of the anniversary of the signing of this agreement, Eglin AFB shall submit a report to the Tribes regarding determinations of NRHP eligibility and effect made in the previous year in which consultation with the Tribes is not required under Stipulations II.B and III.A.4.

C. These annual reports may be produced as a single report and sent to both the SHPO and the Tribes.

XV. Triennial Review

Every three years, Eglin AFB shall meet with the SHPO and the other consulting parties to review the performance of this agreement and determine if amendments are needed to improve its effectiveness.

XVI. Sunset Provisions

This PA shall become effective on the date it is signed by the ACHP and shall remain in effect for a period of 12 years, unless extended by unanimous approval of the signatories or terminated in accordance with Stipulation XIII.

Execution

Execution and implementation of this PA is evidence that Eglin AFB has satisfied its Section 106 responsibilities in managing its archaeological sites.

Signatories:

ADVISORY COUNCIL ON HISTORIC PRESERVATION

EGLIN AIR FORCE BASE

FLORIDA STATE HISTORIC PRESERVATION OFFICER

Concurring parties:

MICCOSUKEE TRIBE OF INDIANS OF FLORIDA

THE SEMINOLE TRIBE OF FLORIDA

POARCH BAND OF CREEK INDIANS

MUSCOGEE (CREEK) NATION

THE THLOPTHLOCCO TRIBAL TOWN OF THE CREEK (MUSCOGEE) TRIBE

Appendices:

Appendix A: Vicinity map of Eglin AFB [not included]

Appendix B: Map of Eglin AFB Reservation [not included]

Appendix C: Map of areas exempted from the identification requirements [not included]

Appendix D: List of undertakings exempted from the identification requirements [not included]

APPENDIX C:
FIRST DRAFT OF SECTION 106 PROGRAMATIC AGREEMENT FOR MANAGING CULTURAL RESORUCES AT FORT DRUM, NEW YORK

FIRST DRAFT

PROGRAMMATIC AGREEMENT
AMONG
UNITED STATES ARMY, FORT DUM
NEW YORK STATE HISTORIC PRESERVATION OFFICER
AND
ADVISORY COUNCIL ON HISTORIC PRESERVATION
REGARDING
MANAGEMENT OF HISTORIC PROPERTIES AT FORT DRUM, NEW YORK

WHEREAS, for over 100 years Fort Drum, and its predecessors, has been an important part of the United States Army (U.S. Army) training mission and currently is home to the 10th Mountain Division, Light Infantry, one of the most active military units in the U.S. Army; and

WHEREAS, Fort Drum has under its jurisdiction approximately 107,265 acres encompassing portions of Jefferson and Lewis Counties, New York (Appendix A); and

WHEREAS, to meet its training mission Fort Drum uses approximately 30,000 acres as firing ranges and impact areas, over 11,000 acres make up the Cantonment, including the Wheeler-Sack Army Airfield, and 66,000 acres are devoted to troop maneuvers and other training activities (Appendix B); and

WHEREAS, Fort Drum, in consultation with the Advisory Council on Historic Preservation (ACHP) and the New York State Historic Preservation Office (SHPO), has determined that future training may adversely effect historic properties that are listed in or eligible for listing in the National Register of Historic Places (NRHP); and

WHEREAS, these historic properties include multiple previously recorded prehistoric and historic archaeological sites, five archaeological NRHP listed historic districts, the LeRay Mansion Historic District, 13 historic cemeteries, and two properties of religious and cultural significance to federally recognized Indian tribes; and

WHEREAS, Fort Drum has further consulted with ACHP and SHPO regarding its responsibility to manage its historic properties in accordance with Sections 106 of the National Historic Preservation Act (NHPA) (16 U.S.C. §470f) and its implementing regulations at 36 CFR Part 800; and

WHEREAS, Fort Drum is also responsible for identifying, evaluating, and nominating historic properties to the NRHP in accordance with Section 110 of the NHPA and is actively engaged in Section 110 cultural resources inventory of the base; and

WHEREAS, Fort Drum, wishes to comprehensively meet its management responsibilities in a manner that balances its regulatory obligations with its need for operational flexibility and seeks, therefore, to enter into a Programmatic Agreement (PA) with the ACHP, SHPO, Native American tribes and other consulting parties as provided under 36 CFR Part 800.14; and

WHEREAS, Fort Drum has invited the ACHP to participate in consultations concerning management of historic properties at Fort Drum and the ACHP has agreed to participate in such consultations; and

WHEREAS, Fort Drum has consulted with the Oneida Indian Nation, the Onondaga Nation, and the St. Regis Mohawk Tribe (hereafter the tribes) regarding management of, and effects to, historic properties of religious and cultural significance to the tribes and has invited them to be concurring parties to this PA; and

WHEREAS, Fort Drum, since 1985 has built a nationally recognized cultural resources management program and is committed to meeting its responsibilities to be a good steward of the nation's heritage resources and to meet its regulatory obligations.

NOW THEREFORE, Fort Drum, SHPO, and ACHP agree that future management of Fort Drum's historic properties shall be administered in accordance with the following stipulations.

Stipulations

I. Background

A. Fort Drum encompasses 107,265 acres in upstate New York. It is utilized primarily for military training and is the permanent home of the 10th Mountain Infantry Division (Light). Within the Fort Drum reservation the Cultural Resources Manager (CRM), under the Environmental Division, Public Works, is responsible for managing historic archaeological sites, prehistoric archaeological sites and historic buildings and structures in compliance with Sections 106 and 110 of the NHPA and all applicable Department of Defense (DoD) directives and Department of the Army instructions.

B. Between 1984 and 1988, Louis Berger and Associates (LBA) conducted a cultural resources inventory of 11,189 acres, during which approximately 400 archaeological sites were identified, primarily from the historic period. Six historic contexts were drafted by LBA, as further described below. In 1989, the cultural resources program was established at Fort Drum and in that year its cultural resources inventory program was initiated to identify prehistoric sites on the Fort. Approximately 90% of Fort Drum has been inventoried or cleared for prehistoric archaeological sites since then. In 2008, the Army Corps of Engineers reviewed the building stock at Fort Drum to further identify historic properties related to World War II and the Cold War era.

C. Today, Fort Drum manages nearly one thousand archaeological sites from the historic and prehistoric time periods representing the last 10,000 years, and hundreds of historic buildings and structures dating from the 18th through the middle 20th centuries, including the Le Ray Mansion Historic District and 13 historic-period cemeteries. In the near future, additional

historic buildings and structures will become potentially eligible for listing to the NRHP and will require evaluation. This PA contains procedures that allow Fort Drum to meet its statutory obligations to be a good steward of the nation's historic properties while providing for the operational flexibility it needs to meet its mission in support of the nation's defense.

II. Procedures for Managing Historic Archaeological Sites

A. Inventory of historic archaeological sites has been completed at Fort Drum. Five historic contexts developed by LBA provide management guidance for historic archaeological sites. In 1987, Fort Drum entered into a Memorandum of Agreement (MOA) with the SHPO that accepts documentation as sufficient for mitigating future effects to certain types of historic archaeological sites as indicated below.

1. ***The Farmstead Historic Context, circa 1800–1920***. Involves foundations and archeological remains of Fort Drum farmsteads—the foci of family residence and farm production for a majority of the region's residents during this period. This context is considered as mitigated by the MOA between Fort Drum and the SHPO.

2. ***The Dispersed Agricultural Processing Industries Historic Context, circa 1800–1920***. Involves foundations and archeological components of sites related to industries intended to process agricultural and natural resource products, outside of nucleated village settlements on the Fort Drum lands. At present, this context is not considered as mitigated, or governed by the MOA between Fort Drum and the SHPO.

3. ***The Rural Village Historic Context, circa 1800–1920.*** Covers foundations and archeological components of small rural villages, often associated with an iron furnace or mill complex (especially a gristmill or gristmill complex), found within the boundaries of Fort Drum. This context is considered as mitigated by the MOA between Fort Drum and the SHPO.

4. ***Dispersed Social Centers Historic Context, circa 1800–1920.*** Consists of foundations and archeological remains from centers of non-farm and extra-family social activity located in completely rural areas (outside the recognized boundaries of villages) and created to facilitate and express the social lives of area residents. At present, this context is not considered as mitigated, or governed by the MOA between Fort Drum and the SHPO.

5. ***The Iron Industry Historic Context*** *(see LBA 1994:Technical Appendix 2, Task Order 15, Section 3),* ***circa 1830–1885***. This covers the archaeological remains of three blast furnaces (Lewisburg/Sterlingbush, Sterlingville, and Alpina) constructed in the region during the 1830s to exploit local deposits of iron ore and operated sporadically until the early 1880s. Also covered are ancillary structures and facilities, e.g., the lime kilns that supplied lime flux to Sterlingbush and possibly Alpina Furnaces. Iron furnace sites (with the exception of Alpina) are associated with rural villages. This context is considered as mitigated by the MOA between fort drum and the SHPO.

B. No additional archaeological investigation is required for historic archaeological resources that are covered by historic contexts 1, 3, and 5 as provided for in the MOA between Fort Drum and the SHPO. Additional investigation of historic archaeological properties covered by historic contexts 2 and 4 may be conducted in the future to achieve mitigation; this will require consultation between Fort Drum and SHPO. Until that time, Fort drum will follow the same procedures in Stipulations III.C through III.E whenever historic archaeological sites covered by historic contexts 2 and 4 may be effected by an undertaking.

C. Any undertaking that may affect the 13 historic cemeteries that Fort Drum manages will require consultation with the SHPO outside of the terms of this PA in compliance with 36 CFR §800.

D. Any previously unknown historic archaeological sites discovered during an undertaking anywhere on Fort Drum, will be an unanticipated discovery. Fort Drum shall resolve the unanticipated discovery following Stipulation VII.

III. Procedures for Managing Prehistoric Archaeological Sites

A. Archaeological Predictive Models

1. Fort Drum has developed four predictive models that it uses for managing prehistoric archaeological sites in compliance with Sections 106 and 110 of the NHPA, as briefly described below.

    a. Glacial Landscape model correlates the location of prehistoric archaeological sites with key environmental variables (proximity to ravines/fossil waterways, elevation and soils) in two post glacial physiographic zones that make up the majority of the base: The Ontario-St. Lawrence Lowlands and the Pine Plains Sands.

    b. Adirondack Uplands model deduces where prehistoric archaeological sites should be expected in the foothills of the Adirondack Mountains, which includes the upland areas of the base.

    c. Paleo-Maritime model extrapolates the ancient shore lines of glacial Lake Iroquois and predicts where shore line settlement ought to be located within the base.

    d. Prehistoric-Pathways model predicts where sites associate with prehistoric trail systems that pass through Fort Drum can be expected.

2. In 2010, Fort Drum, in cooperation with the DoD's Environmental Security Technology Certification Program, refined and validated the Glacial Landscape and Upland models creating a single base-wide archaeological predictive model (here after "revised predictive model).

3. Fort Drum will use the revised predictive model to meet its identification responsibilities under Sections 106 and 110 as further described in Stipulation III B. The SHPO accepts the use of the revised predictive model for this purpose.

4. For a period of five years following the execution of this PA, Fort Drum will review, test, and upgrade, as needed, the revised predictive model to ensure its accuracy and reliability. Once a year, during this five-year period, Fort Drum will meet with SHPO and report on the review of the revised predictive model. This requirement may be met during the annual review meeting between Fort Drum and the SHPO required under Stipulation XIII.

5. To ensure that the revised predictive model is reviewed, tested, and upgraded, as needed, in a manner that is acceptable to both Fort Drum and SHPO, Fort Drum, in consultation with SHPO, will hire an outside contractor to conduct the annual review and to make recommendations for any improvements to the revised predictive model that may be needed. The contracting firm shall have demonstrated experience in building, testing/evaluating, and upgrading GIS statistically based archaeological predictive models.

6. Fort Drum understands that modeling is an iterative process and that the revised predictive model will require continuous testing and refinement over time. For this reason, Fort Drum is committed to enhancing the accuracy and reliability of the revised predictive model and will make any improvements it deems appropriate to achieve this end. These improvements may include, but are not limited to, conducting additional archaeological survey, including re-survey of previously surveyed areas and random survey of the low sensitivity areas, that may be needed to further test and refine the revised predictive model.

7. Fort Drum has shared with SHPO its GIS data on archaeological sites and survey. Every two years, Fort Drum will provide an update of the archaeological database to SHPO.

B. Identification of Archaeological Sites

1. Ft Drum will apply the revised predictive model, and, as needed, the Paleo-Maritime and Prehistoric Pathways models, for all Section 106 undertakings and all Section 110 management projects, in the following manner:

    a. Areas identified as having low sensitivity for prehistoric archaeological sites will not require archaeological survey but may be surveyed to test the revised predictive model or for other purposes at the discretion of Fort Drum.

    b. Areas identified as medium sensitivity for prehistoric archaeological sites will require 50% survey, where surface conditions allow, unless otherwise exempted under Stipulation VI.A.

c. Areas identified as high sensitivity areas for prehistoric archaeological sites, including any area within 50 meters of a navigable stream or river, will require 100% survey, where surface conditions allow, unless otherwise exempted under Stipulation VI.A.

2. All archaeological survey will be conducted in accordance with survey standards and procedures contained in the most current version of Fort Drum's Integrated Cultural Resources Management Plan (ICRMP) attached herein by reference. All archaeological surveys will be conducted by, or under the supervision of, an archaeologist who meets the professional qualifications standard in Stipulation V.

3. Fort Drum, in consultation with SHPO, shall establish and use standardized archaeological site definitions for all archaeological investigations at Fort Drum conducted pursuant to the terms of this PA. The definitions will be prepared by Fort Drum, in consultation with SHPO, within six (6) months of the execution of this PA and once completed will be attached to this PA as Appendix C.

4. All areas within the base Cantonment shall be subject to archaeological survey whenever undertakings are proposed within these limits, unless specifically exempted under Stipulation VI.B; or, unless the CRM at Fort Drum determines that previous ground disturbance has significantly reduced the probability of intact archaeological deposits. Should intact archaeological deposits be encountered during construction anywhere within the Cantonment, Fort Drum will follow the provisions for unanticipated discoveries in Stipulation VII.

C. Evaluation of Archaeological Sites

1. Fort Drum will apply the criteria for listing to the NRHP contained in 36 CFR part 60.4 to all archaeological sites recorded through identification for each Section 106 undertaking or Section 110 inventory.

2. Fort Drum will not consult with SHPO on NRHP eligibility for archaeological sites, unless Fort Drum requests such consultation.

3. A summary of all NRHP eligibility determinations Fort Drum makes each year will be submitted to SHPO in an annual management summary prepared pursuant to Stipulation XIV. Fort Drum will also provide SHPO all records on NRHP eligibility determinations upon request at any time.

4. Any dispute regarding NRHP eligibility, if not resolved through consultation between Fort Drum and SHPO, will be resolved by the Keeper of the National Register in accordance with 36 CFR Part 800.4 (c) (2).

D. Assessment of Effects to Archaeological Sites

1. Fort Drum will assess the effects of all Section 106 undertakings by applying the criteria of adverse effect in accordance with 36 CFR Part 800. 5.

2. Fort Drum will not consult with SHPO when an undertaking will have no effect to NRHP-eligible archaeological sites ("no historic properties affected"), unless Fort Drum requests such consultations. Circumstances under which no historic properties will be affected are as follows:

    a. When archaeological surveys do not identify prehistoric or historic archaeological sites; or

    b. When prehistoric or historic archaeological sites are located but determined by Fort Drum not to be eligible for listing to the NRHP; or

    c. When NRHP-eligible prehistoric or historic archaeological sites are found but are avoided through project design and preserved in place.

3. Fort Drum will not consult with SHPO when an undertaking may affect NRHP-eligible archaeological sites but the effect will not alter the characteristics that make the sites NRHP eligible by diminishing their integrity ("no adverse effect"), unless Fort Drum requests such consultation.

4. A summary of all "no historic properties affected" and "no adverse effect" determinations Fort Drum makes each year will be submitted to SHPO in an annual management summary prepared pursuant to Stipulation XIV. Fort Drum will also provide SHPO all records on these determinations at any time upon request.

5. Fort Drum will consult with the SHPO, the tribes, and the other consulting parties, whenever an undertaking may adversely affect NRHP-eligible archaeological sites. Unless the tribes indicate otherwise, however, Fort Drum will not consult with the tribes regarding adverse effects to historic archaeological sites.

6. Any dispute about effect determinations will be resolved following the provisions for dispute resolution in Stipulations X.

E. Resolution of Adverse Effects to Archaeological Sites

1. Avoidance

    a. All NRHP-eligible archaeological sites will be avoided whenever possible. Avoidance and preservation in place of NRHP eligible archaeological sites will require use of highly visible avoidance measures installed on the ground around the recorded limits of the sites or buildings for the purpose of communicating "off limits" during the undertaking. The avoidance measures shall include one or more of the following as needed.

(i) Flagging: Installing temporary flagging around the limits of the site or building using colored flagging tape.

(ii) Temporary fencing: Installing temporary fencing around the limits of the site or building using removable fencing, such as chain link fencing or wire and T posts.

(iii) Other removable barriers: Installing removable barriers, such as earthen berms or portable concrete barriers.

(iv) Signage: Installing permanent or semi-permanent signage at eye level in proximity to the site. Fort Drum shall employ a universally recognizable symbol printed on metal or other durable material that is mounted on metal stakes or posts and set on the ground around the limits of the site.

(v) Gating and other permanent barriers: Constructing permanent barriers, such as gates, around the limits of sites.

b. Fort Drum will map the location of all archaeological sites to be avoided for the undertaking and describe in writing the avoidance measures used for each site.

c. Fort Drum shall install all avoidance measures and ensure that for the undertaking all avoidance measures are in place on the ground before the undertaking commences. Fort Drum will not consult with the SHPO or other consulting parties when avoidance can be achieved, but may seek their advice, as needed.

d. If Fort Drum determines that avoidance is not possible, and there may be an adverse effect to a historic property, then Fort Drum will resolve the adverse effects of the undertaking in accordance with a data recovery plan prepared in accordance with Stipulation III.E.3.

2. Archaeological Monitoring

a. Fort Drum may employ archaeological monitoring as a means of ensuring avoidance, with or without the avoidance measures in Stipulation III.E.1; or, as a means of ensuring an undertaking will have no adverse effect to a historic property.

(i) All archaeological monitoring will be conducted by an archaeologist that meets the professional qualifications standards in Stipulation V.

(ii) The archaeological monitor will be authorized to record features, collect artifacts and samples, take photographs, draw maps, and write notes, as needed. The monitor shall have the expressed authority to temporarily stop or redirect ground disturbing activities, as needed, at any time for the purposes of archaeological monitoring.

(iii) A summary of all archaeological monitoring activities carried out during the previous year will be included in the annual management summary submitted to SHPO pursuant to Stipulation XIV.

b. Should intact archaeological deposits be observed during archaeological monitoring, and should the monitor determine these deposits represent either an unknown archaeological site or an unrecorded portion of a known site, the monitor will halt the undertaking and report the discovery to the CRM. If the CRM determines the deposits are an unanticipated discovery, Fort Drum shall follow the provisions for unanticipated discoveries in Stipulation VII.

3. Archaeological Data Recovery

a. Whenever NRHP-eligible archaeological sites cannot be avoided and may be adversely affected, Fort Drum will prepare a draft archaeological testing and/or data recovery plan and submit the draft plan to the SHPO and the other consulting parties for 30-day review.

b. If SHPO, or one or more of the other consulting parties, does not respond within 30 days of submittal, Fort Drum shall assume that party has no objection to the proposed testing and/or data recovery. If the SHPO, or one or more of the other consulting parties, objects to the testing and/or data recovery plans, however, Fort Drum will resolve the objection pursuant to Stipulation X. Fort Drum will take into account any comments or recommendations received from SHPO, or any of the other consulting parties, within the review period in preparing the final testing and/or data recovery plans.

c. Following the completion of field work for archaeological testing and/or data recovery, upon approval of the CRM, Fort Drum may initiate the undertaking provided that any analysis, report preparation, curation, or other tasks required in the testing and/or data recovery plan is completed in full within 12 months of the end of field work. Fort Drum shall prepare a draft of the report and submit the draft to SHPO, the tribes and the other consulting parties for 30-day review. Any comments received from SHPO, the tribes or any of the other consulting parties within the review period shall be considered by Fort Drum in making any revisions needed to complete the report.

d. Fort Drum will provide a copy of all reports to the consulting parties upon completion of all archaeological testing and data recovery

e. All archaeological testing and/or data recovery will be conducted by, or under the supervision of, a professional archaeologist meeting the qualification standards in Stipulation V in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation, as amended and annotated.

f. Any dispute about resolution of adverse effect will be resolved following the provisions for dispute resolution in Stipulations X.

IV. Procedures for Managing Historic Buildings and Structures

A. Existing Historic Buildings and Historic Districts

1. The LeRay Mansion Historic District is listed on the National Register. It consists of the second mansion built by James LeRay de Chaumont on the site in 1826–1827, four additional outbuildings, and the associated landscaping. The interiors of the four outbuildings have lost their integrity and were determined ineligible during the National Register listing of the District in the mid-1980s. A map of the LeRay Mansion Historic District and list of contributing and noncontributing properties are found in Appendix D.

2. Assessment of Effect

   a. Fort Drum will assess the effects of all Section 106 undertakings by applying the criteria of adverse effect in accordance with 36 CFR Part 800. 5.

   b. Fort Drum will not be required to consult with SHPO when an undertaking will have no effect on a historic property (‘no historic property affected) or will affect a historic property but the effect will not alter the characteristics that make the property eligible by diminishing its integrity (“no adverse effect”), unless Fort Drum requests such consultation.

   c. A summary of all “no historic properties affected” and “no adverse effect” determinations Fort Drum makes each year will be submitted to SHPO in an annual management summary prepared pursuant to Stipulation XIV. Fort Drum will also provide SHPO all records on these determinations at any time upon request.

   d. Any dispute about effect determinations will be resolved following the provisions for dispute resolution in Stipulations X.

3. Resolution of Adverse Effects

   a. Fort Drum will consult with the SHPO and the other consulting parties whenever an undertaking will adversely affect the LeRay Mansion Historic District or any of its contributing properties.

   b. Fort Drum will submit a proposed treatment plan resolving the adverse effects to the SHPO and the other consulting parties for 30-day review.

   c. If SHPO, or one or more of the other consulting parties, does not respond within 30 days of submittal, Fort Drum shall assume that party has no objection to the proposed treatment plan. Fort Drum will take into account any comments or recommendations

received from SHPO, or any of the other consulting parties, within the review period in preparing the final treatment plan.

d. All resolution of adverse effects to NRHP eligible or listed historic buildings and structures will be conducted by, or under the supervision of, a professional architect or architectural historian meeting the qualification standards in Stipulation V in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings.

e. Any dispute about resolution of adverse effect will be resolved following the provisions for dispute resolution in Stipulations X.

B. Potential Historic Buildings

1. Identification and National Register Eligibility

a. There are 89 buildings listed in Appendix E that are 50 years of age or will turn 50 years of age by 2022.

b. Fort Drum will conduct an architectural survey within two years of the signing of this PA to document these 89 buildings and evaluate their NRHP eligibility.

c. Fort Drum, in consultation with the SHPO, will determine the NRHP eligibility of the 89 historic buildings.

d. Any dispute regarding NRHP eligibility, if not resolved through consultation between Fort Drum and SHPO, will be resolved by the Keeper of the National Register in accordance with 36 CFR Part 800.4 (c) (2).

2. Assessment of Effect

Fort Drum will follow the provisions of Stipulation IV.A.2 whenever a proposed undertaking may affect any historic building listed in Appendix E that is determined to be NRHP eligible.

3. Resolution of Adverse Effects

Fort Drum will follow Stipulation IV.A.3 whenever a proposed undertaking may adversely affect any historic building listed in Appendix E that is determined to be NRHP eligible.

C. Program Alternatives

1. World War II Temporary Building Programmatic Agreement

There are 305 buildings listed in Appendix F constructed from 1940 to 1945 that are covered under the nationwide Programmatic Agreement for World War II Temporary Buildings implemented June, 7 1986. Accordingly, the Department of the Army has met its Section 106 responsibilities for World War II Temporary Buildings. Fort Drum will not consult with SHPO or the consulting parties on management, maintenance, renovation, or demolition for any of these 305 buildings.

2. Unaccompanied Personnel Housing Program Comment

   There is one building listed in Appendix F that is covered under the ACHP Program Comments for Cold War Era Unaccompanied Personnel Housing (1946–1974), implemented August 18, 2006. Accordingly, the Department of the Army has met its Section 106 responsibilities for Unaccompanied Personal Housing. Fort Drum will not consult with SHPO or the consulting parties on management, maintenance, renovation, or demolition for this building.

3. Ammunition Storage Program Comment

   There are 12 buildings listed in Appendix F that are covered under the ACHP Program Comments for World War II and Cold War Era (1939–1974) Ammunition Storage Facilities, implemented August 18, 2006. Accordingly, the Department of the Army has met its Section 106 responsibilities for Ammunition Storage facilities. Fort Drum will not consult with SHPO or the consulting parties on management, maintenance, renovation, or demolition for any of these 12 buildings.

V. Qualifications

Fort Drum shall ensure that all investigations performed in compliance with the terms of this PA shall be conducted by, or under the supervision of, a person who meets the Secretary of the Interior's Standards and Guidelines for professional qualifications in history, architecture, architectural history, historic architecture, or archaeology, as applicable, described in the Federal Register: June 20, 1997 (Volume 62, Number 119, pages 33707–33723).

VI. Exemptions

A. The following areas at Fort Drum, depicted on the maps attached in Appendix G, shall be exempted from the identification requirements of this PA. These areas contain hazardous materials, including but not limited to unexploded ordinance, and are too dangerous to access for cultural resources investigations.

B. The following undertakings carried out at Fort Drum, listed in Appendix H, shall be exempted from the management requirements of this PA. These undertakings are determined to have little or no potential to affect NRHP-eligible archaeological sites or historic buildings and structures.

C. If during implementation or construction of any of these exempted undertakings, an unanticipated discovery is made, Fort Drum shall follow the provisions for unanticipated discoveries in Stipulation VII.

VII. Unanticipated Discoveries

A. If a previously unknown archaeological site is discovered during an undertaking, or an unanticipated effect to a known archaeological site, historic building or structure is discovered during an undertaking, then Fort Drum shall resolve the discovery in the following manner.

    1. All disturbance of buildings, structures, or ground surfaces, as applicable, in the vicinity of the discovery shall cease and the discovery location will be secured from further harm.

    2. A qualified professional archaeologist or architect, meeting the qualification standards of Stipulation V, shall record the discovery and evaluate its nature, extent, condition, and NRHP eligibility.

    3. Fort Drum shall consult with SHPO on the eligibility of the discovery and the potential effect of continuing with the undertaking within two working days of the discovery.

    4. If Fort Drum determines that the discovery is NHRP eligible and will be further affected by the undertaking, it will consult with SHPO, and, whenever prehistoric archaeological deposits are discovered, the tribes, regarding treatment. Following consultation, Fort Drum will conduct treatment in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties; or, the Secretary of the Interior's Standards for

the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings, as applicable.

5. Once any field work required as part of treatment has been concluded, upon approval of the CRM, the undertaking may continue provided that all analysis, report preparation and curation, as needed, will be completed within 12 months following field work. Fort Drum will provide a copy of the discovery treatment report to the consulting parties.

VIII. Human Remains

A. If human remains and associated grave goods are discovered anywhere on the base, either during treatment or as an unanticipated discovery, then Fort Drum will resolve the discovery in the following manner:

1. All work will cease at the discovery location, and the grave and its contents will be protected from further harm.

2. A professional, meeting the qualification standards of Stipulation V will record the discovery and evaluate its nature, extent, and condition.

3. If Fort Drum determines the grave is Native American, or may be Native American, it will follow the procedures outlined in the Inadvertent Discovery Agreement signed with the Oneida Indian Nation. Fort Drum will also consult with the appropriate tribe or tribes in accordance with 43 CFR Part 10, the regulations implementing the Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001 et seq.).

4. If Fort Drum determines the grave is not Native American, or the identity of the grave cannot be determined, Fort Drum will consult with SHPO pursuant to 36 CFR Part 800 to resolve the discovery. If subsequently, the remains are identified as Native American, Fort Drum will consult with the tribes pursuant to NAGPRA.

IX. Tribal Consultation

A. Fort Drum intends to enter into separate consultation protocols with each of the tribes establishing procedures for government to government consultation on all matters of mutual concern related to historic preservation at Fort Drum. These protocols may be added to this PA through amendment under Stipulation XI. Until or unless consultation protocols with the tribes are put in place, Fort Drum will abide by the terms of this PA in consulting with the tribes.

B. In accordance with Stipulation III.D.5, Fort Drum will consult with the Oneida Indian Nation, the Onondaga Nation, the St. Regis Mohawk Tribe, and any other federally recognized tribes with an ancestral connection to the land within the base, whenever proposed undertakings may adversely affect prehistoric archaeological sites.

C. The purpose of these consultations will be to consider the views of the tribes regarding the potential effects of proposed undertakings to historic properties of religious and cultural significance to the tribes. Whenever possible, Fort Drum will work with the tribes to avoid or minimize effect to historic properties of religious and cultural significance.

D. Fort Drum has identified two prehistoric archaeological sites of religious and cultural significance to the Oneida Indian Nation, the Onondaga Nation, and the St. Regis Mohawk Tribes. The sites are the Calendar site (Site number) and the Iroquois Village site (Site Number). Fort Drum will protect and preserve these sites from future disturbance by maintaining their status as off limits to unauthorized personnel.

X. Dispute Resolution

A. Should any signatory to this PA object to any action carried out or proposed with respect to the implementation of this PA, Fort Drum shall consult with that signatory party to resolve the objection. If Fort Drum, after initiating such consultation, determines that the objection cannot be resolved, Fort Drum shall forward documentation relevant to the objection to the ACHP, including a proposed response to the objection, in accordance with 36 CFR Part 800.7. Within forty-five (45) days after receipt of all pertinent documentation, the ACHP shall exercise one of the following options:

   1. Advise Fort Drum that the ACHP concurs in its proposed final decision, whereupon Fort Drum shall respond accordingly;

   2. Provide Fort Drum with recommendations, which it shall take into account in reaching a final decision regarding its response to the objection; or

   3. Notify Fort Drum that the objection will be referred to the ACHP membership for formal comment pursuant to 36 CFR §800.7(a)(4), and proceed to refer the objection and comment within forty-five (45) days. Fort Drum shall take into account the resulting comment in accordance with 36 CFR § 800.7(c)(4).

B. Should the ACHP not exercise one of the above options within forty-five (45) days after receipt of all pertinent documentation, Fort Drum may assume the ACHP's concurrence in its proposed response to its objections.

C. Fort Drum shall take into account any ACHP recommendation or comment provided in accordance with this stipulation with reference only to the subject of the objection; its responsibility to carry out all actions under this PA that are not the subject of the objection shall remain unchanged.

XI. Amendments

Any signatory to this PA may request that it be amended, whereupon the signatory will consult with the other parties to consider such an amendment. Where there is no consensus among the signatories, the agreement will remain unchanged.

XII. Termination

Any signatory to this agreement may revoke it upon written notification to the other parties by providing thirty (30) days notice, provided that the parties will consult during the period prior to termination to seek agreement on amendments or other actions that would avoid termination. In the event of termination, Fort Drum shall comply with 36 CFR Part 800 with regard to individual undertakings covered by this PA or with regard to all remaining actions under this PA.

XIII. Annual Review Meeting

A. Every year, for the first five years following execution of this PA, Fort Drum will meet with the SHPO and the other consulting parties to review the performance of the PA and determine whether or not amendments are needed to improve its effectiveness. After five years, Fort Drum will meet with the SHPO and the other consulting parties every two years for as long as the PA is in effect.

B. Fort Drum may use the occasion of the annual review to report to the SHPO on the revised predictive model as required under Stipulation III.A.4.

XIV. Management Summary

A. Every year, within 30 days of the anniversary of the signing of this agreement, Fort Drum will submit a management summary to the SHPO reporting on the activities carried out for which prior SHPO consultation was not required as provided for in Stipulations IIII.C.3, III.D.4, and IV.A.2.c. The annual report, at a minimum, will contain the following information:

    1. A description of the undertaking;

    2. A description of the site, building or structure;

    3. The determination of eligibility;

    4. The determination of effect; and

    5. Any measures used to avoid or minimize effect.

XV. Sunset Provisions

This PA shall become effective on the date it is signed and shall remain in effect for a period of 15 years whereupon it will expire unless extended by unanimous approval of the signatories or terminated.

Signatories:

FORT DRUM

ADVISORY COUNCIL ON HISTORIC PRESERVATION

NEW YOR STATE HISTORIC PRESERVATION OFFICER

Concurring Parties:

THE ONEIDA INDIAN NATION

THE ONDONDAGA NATION

ST. REGIS MOHAWK TRIBE

Appendices:

Appendix A: Map of New York showing vicinity of Fort Drum [not included]

Appendix B: Map of Fort Drum [not included]

Appendix C: Archaeological site definitions [not included]

Appendix D: Map of LeRay Mansion Historic District and list of contributing and noncontributing properties [not included]

Appendix E: List of historic buildings that may be National Register eligible in the future [not included]

Appendix F: List of buildings covered under ACHP Program Alternatives [not included]

Appendix G: Map of hazardous areas excluded from Section 106 requirements [not included]

Appendix H: List of undertakings exempted from Section 106 requirements [not included]

APPENDIX D:
ARCHAEOLOGICAL SITE VISIBILITY MODEL: VISIBILITY AND ARCHAEOLOGICAL DATA QUALITY AT SAYLOR CREEK RANGE, IDAHO[13]

D.1 INTRODUCTION

During the past two decades, Mountain Home Air Force Base (AFB) in Idaho has performed nearly 100 percent inventory of cultural resources on the Saylor Creek Range (SCR), also in Idaho (Figure D-1). With most of the range inventoried, the installation has focused efforts on determining the eligibility of recorded sites for listing in the National Register of Historic Places (National Register). In 2005, Mountain Home AFB performed a survey of previously inventoried land on SCR that had been affected by the 2005 Clover Fire—an exceptionally hot and intense fire that swept across thousands of acres of the range. Subsurface tests showed that soils were burned to a depth of 10 cm below ground surface and that sagebrush roots carried the fire deeper into the subsoil. The intensity of the fire not only removed vegetation, but it also compromised soil stability. Soil depths measured during the first four weeks following the fire showed a loss of 3 cm of soil during the monitoring period, equating to a loss of 12 tons of soil per ac in affected areas. Together, loss of vegetation and soil altered the archaeological landscape and substantially increased the visibility of archaeological resources previously obscured by vegetation or sediment (personal communication, Sheri Robertson 2011). Survey in the area impacted by the fire was thus conducted to assess the impacts of the fire on previously recorded sites and to evaluate the eligibility of sites within the project area. Any new sites observed during the course of survey were to be recorded and evaluated as well (Polk and Weymouth 2006).

An added benefit of the project was that it allowed for an objective assessment of the resources that could be identified during favorable ground conditions, when visibility was excellent, and their comparison to the resources discovered during less optimal ground conditions, when visibility was poor or moderate.[14] The Clover Fire had removed much vegetation that had previously obscured the ground surface in the project area, resulting in visibility estimated to be from 76 to 100 percent. Previous estimates of archaeological visibility in portions of the project area, although not comprehensive, had typically been poor (1–50 percent) or moderate (51–75 percent) (Polk and Weymouth 2006; Rudolph and Bennick 1999, 2001).

This document is divided into five parts. The first part places the SCR within its prehistoric and historical-period context and briefly presents two interpretive schemes that address this 11,500-year sequence. The second part analyzes the extent to which site attributes for previously

[13] Analysis and report by Michael P. Heilen, Director of Research, Statistical Research, Inc.

[14] The adjectives "poor," "moderate," and "excellent" are used in place of "low," "medium," and "high" to describe classes of archaeological visibility to avoid confusion. This is because common statistical terms, such as "sensitivity" or "probability," will be frequently modified by the adjectives "low," "medium," and "high" when discussing different levels of visibility. In these contexts, using the adjectives "low," "medium," and "high" to modify archaeological visibility immediately seems like a contradiction, when a contradiction is not intended, and makes their use difficult to interpret.

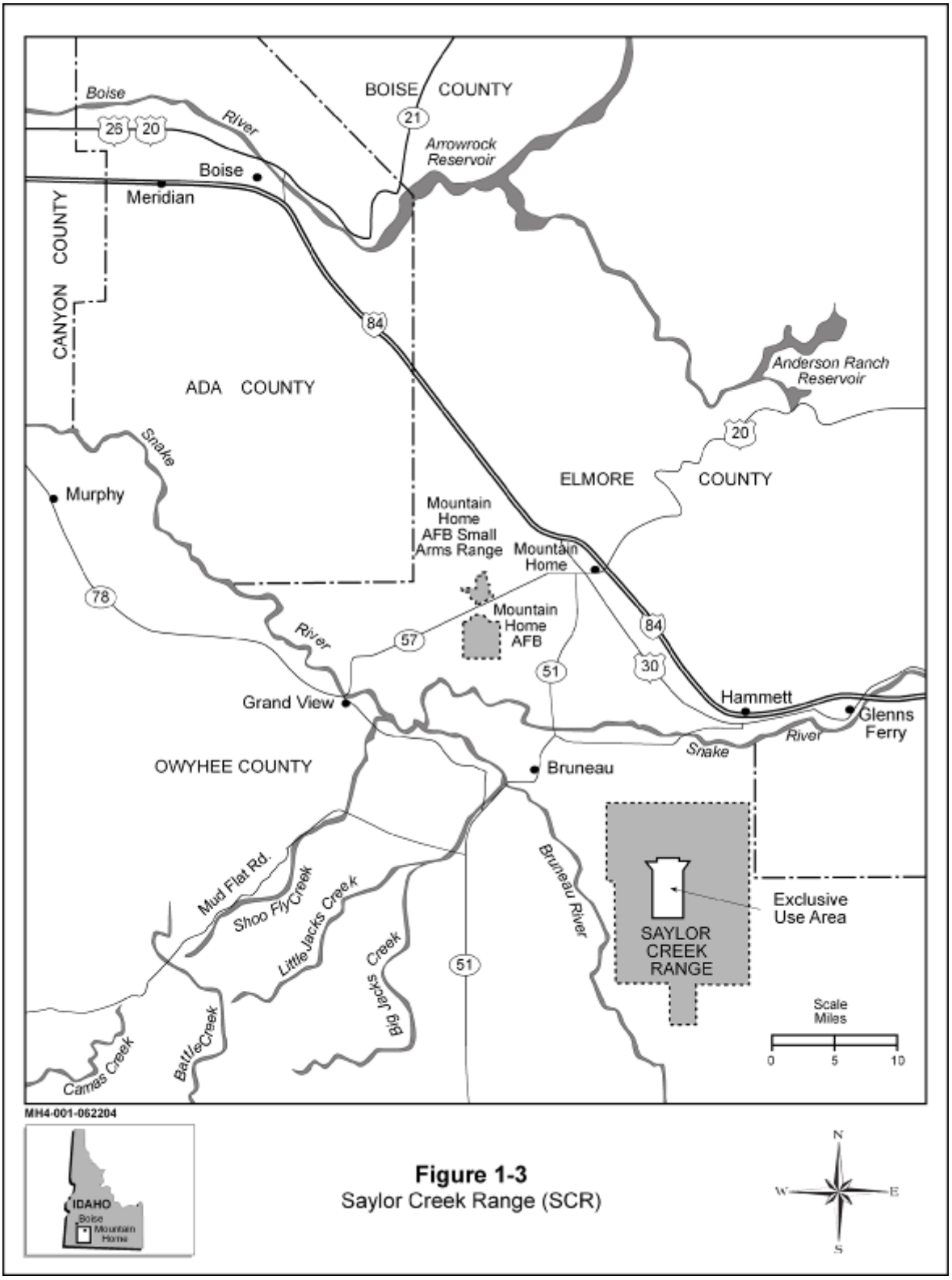

Figure 1-3
Saylor Creek Range (SCR)

Figure D-1. Saylor Creek Range, Idaho (Mountain Home AFB ICRMP (2006):Figure 1-3).

recorded sites changed as a result of resurvey. The third part consists of an analysis of the attributes of new sites discovered as a result of resurvey, in comparison to the attributes of previously recorded sites, and their implications for site discovery rates. The fourth part estimates the probability of discovery for new sites and previously recorded sites in the Clover Fire Project area. These estimates help to determine whether the size and artifact density of new sites could have contributed to their being missed during previous survey. The fifth part documents the development of an archaeological visibility model, which was constructed to allow managers to predict where conditions of poor visibility were likely to have occurred during previous surveys. The visibility model allows managers to identify areas of the range where archaeological data quality may have been most affected by poor visibility during previous survey.

D.1. Saylor Creek Range Cultural Overview[15]

SCR is located in Owyhee County in southwestern Idaho, approximately 20 mi southeast of Mountain Home AFB (see Figure D-1). SCR is located in the relatively flat upland of the Inside Desert at an average elevation of 3,700 ft above mean sea level (AMSL; Figure D-2). The range encompasses 109,466 ac withdrawn in 1942 for use by the DoD for weapons training. It includes a fenced area 12,200 ac in size near the center of the range that contains training targets used for inert (non-explosive) ordnance delivery training. Designated the Exclusive Use Area (EUA), this active portion of the range occupies a broad, relatively flat plain interrupted by a single butte (Pence Butte), one moderate intermittent drainage (a tributary of the West Fork of Brown's Creek), and several minor intermittent drainages. The remaining 97,266 ac (the public use area of SCR) surrounding the EUA exhibit more varied terrain with an array of buttes, canyon rims, deeply incised major intermittent drainages (Pot Hole Creek, West Fork of Brown's Creek, and East Fork of Brown's Creek) and abundant minor, ephemeral drainages. There are no perennial bodies of water within the range. This surrounding area is primarily used for livestock grazing and hunting. Although Mountain Home AFB manages all lands it operates on, the Bureau of Land Management (BLM) administers grazing permits and the Idaho Department of Fish and Game (IDFG) manages hunting on SCR outside the EUA. Additionally, there are approximately 6,080 ac of State land on SCR. Sections 16 and 36 are owned by the State of Idaho, but managed by the USAF. The USAF, specifically Mountain Home AFB, is responsible for the protection and management of any cultural resources on these lands.

SCR has been used since 1942 for training activities including artillery, air-to-air and air-to-ground gunnery, napalm delivery, precision bombing, and tactical air-to-ground reconnaissance. Within the EUA are target areas, towers, dumps, and strafe pits used for air-to-ground gunnery practice with inert ordnance. The EUA contains four scorable targets and two strafe pits used for conventional air-to-ground training. The targets include a small cluster of armored personnel vehicles, an airfield complex, and an air defense site with a Surface to Air Missile (SAM) and an Anti-Aircraft Artillery battery.

[15] This cultural overview is drawn from the 2006 Mountain Home AFB Integrated Cultural Resources Management Plan (ICRMP, 2006); figure and table citations are as in the original.

Figure D-2. View of Saylor Creek Range, Idaho (Mountain Home AFB ICRMP:Figure 1-4).

D.1.1.1Prehistory

Archaeological resources in southwestern Idaho provide evidence of American Indian occupation of the area for over 11,000 years. Based on archaeological evidence, the culture of these early peoples is generally recognized as a variant of the Clovis/Folsom culture in which large fluted projectile points were manufactured to hunt big game. However, far more common in the archaeological record of southern and central Idaho is the stemmed spear point which may have derived from the Clovis culture or may represent a separate contemporary cultural tradition (Murphey and Baxter 2002).

Southern Idaho partially lies in the northern Great Basin area and the cultural sequences follow the general trends of the Great Basin chronologies. Butler (1986), Meatte (1990), and Gehr et al. (1982) used data from southwestern Idaho to propose regionally specific cultural sequences, each developed from a different theoretical perspective. As Ames (1982) suggests, the lack of site excavation in the area requires that these chronologies be considered preliminary. Because none of these chronologies is more "correct," the following briefly presents all of them to provide a general framework for regional prehistory. Table D-1 depicts the four chronologies described below. Great Basin projectile point types and dates of use are presented in Table D-2. These general categories combined with measurements of point attributes (Fawcett 1998; Thomas 1981) were used to date sites with diagnostic artifacts.

Table D-1. Cultural Chronologies, Southwestern Idaho

Years B.P.	Owyhee Uplands (Plew 1980)	Snake River (Butler 1986/Plew 2000)	Developmental Model (Meatte 1990)	Paleoclimatic Model (Gehr et al. 1982)
0	**Historic**	**Protohistoric**	**Historic**	**Historic**
100			**Equestrian Foraging** wide ranging exploitation	
250	**Camas Creek IV**	Wickiup Structures **Late Archaic** Intensification of resource use		**Period 3** Large habitation sites on major rivers; campsites in uplands
	Camas Creek III Diversity of site types		**Semisedentary Foraging** Larger groups in riverine villages; greater reliance on salmon; collector strategy	
2000	**Camas Creek II** Base camps at Permanent streams	**Middle Archaic** Small foraging groups; more sedentary collectors later/housepits		**Period 2** Larger campsites near permanent water; field camps in uplands and broad plains
4000	**Camas Creek I** Hunting camps		**Broad Spectrum Foraging** Small, mobile groups; limited range of tools; exploitation of diverse resources	
6000		**Early Archaic** Developed new tools/ multiple resource use		Small mobile groups exploitation of diverse resources in different microenvironments
8000		**Plano** Bison, sheep, and elephant kills		
10,000		**Folsom**		**Period 1**
12,000		**Clovis**	**Early Man (?)**	Small, mobile groups hunting large game
14,000				

Table D-2. Great Basin Projectile Points

Point Types	Dates	Archaeological Periods (Plew 2000)
Desert Side-notched	Post-700 B.P.	Late Archaic to Protohistoric
Cottonwood Triangular Cottonwood Leaf-shaped	Post-700 B.P.	Late Archaic to Protohistoric
Bliss	1300 to 300 B.P. (Plew and Woods 1990)	Late Archaic
Rosegate Series	1300 to 700 B.P.	Late Archaic
Elko Corner-notched Elko Eared	3300 to 1300 B.P.	Middle to Late Archaic
Gatecliff Contracting Stem Gatecliff Split Stem	5000 to 3300 B.P.	Middle Archaic
Humboldt Concave Base	5000 to 1300 B.P.	Middle to Late Archaic
Large Side-notched	6800 to 6200 B.P.	Early Archaic
Large Stemmed	Pre-8000 B.P. (Homer 1986)	Early Archaic to Paleoindian
Clovis, Folsom	Pre-9000 B.P.	Paleoindian

Although these chronologies differ in the emphasis placed on changes between one period to the next, all agree that the cultural history of the region comprises a slow progression from small, highly mobile groups to larger, more complex villages. These villages are composed of collectors with foraging groups in some areas for portions of the year. The major differences in the chronologies occur because of disagreements in dates for the earliest occupation of the region, the importance of equestrian hunting, and the timing of the Shoshone migration into the area.

D.1.1.1.1 Owyhee Uplands Chronology

Based on an extensive survey and limited excavation in the Owyhee Uplands, Plew (1980) defined four phases (Camas Creek I–IV spanning the period from 4000 B.C. to historic contact at A.D. 1775 (6000 Before Present [B.P.] to 175 B.P.). The sites used to develop this chronology occur within the Camas and Pole Creeks National Register-listed Archaeological District.

Plew's chronological scheme was developed by correlating projectile point types recovered from the surface of sites along drainages in the Owyhee Uplands to types recovered from radiocarbon-dated strata in the Great Basin and from Nahas Cave, a site in the Owyhee Uplands. The defined

phases rely on changes in projectile point morphology and on the introduction of new tool types (e.g., ground stone artifacts).

None of the sites studied by Plew produced evidence of occupations predating 6000 years B.P. , but this may reflect the paucity of archaeological excavations in this part of the State rather than the earliest prehistoric use. Plew (1980) suggests that during the Camas Creek I phase (6000–2700 B.P.) activities in the Owyhee Uplands involved only low-intensity, short-duration hunting and trapping rather than long-term occupation. The evidence for this conclusion is the predominance of small lithic scatters and the absence of large campsites. Low-intensity use and an emphasis on hunting also characterize the Camas Creek II phase (2700–1400 B.P.). However, the presence of a few plant processing tools and evidence for tool manufacturing and maintenance suggest that there was a trend toward increased duration of site use and the development of temporary camps. A possible spatial correlation between temporary campsites and water sources may also indicate a need to support groups for longer periods than during the Camas Creek I phase.

Intensification and diversification of resource exploitation and settlement marks the Camas Creek III phase (1400–800 B.P.), a time of intensive seasonal use of small drainages for hunting and gathering. The broad range of site types and artifacts characteristic of this phase reflect a balance between hunting and plant food gathering. Winter campsites, located in major drainages, possibly indicate a semi-sedentary settlement system. The Camas Creek IV phase (800–175 B.P. is characterized by patterns similar to those noted for the previous phase, although there appears to have been a significant reduction in the number of sites and in overall use of the uplands. Winter campsites in major drainages again imply longer seasonal use of the area and possibly semi-sedentary settlement. Plew equates this last phase with the historic Shoshone occupation of southwestern Idaho.

D.1.1.1.2 Snake River Plain Chronology

Butler (1986) combined local cultural phases from a number of excavations of caves and rockshelters in the Upper Snake and Salmon River area to construct a regional chronology composed of three periods dating from 14,500 B.P. to historic contact. Butler argues that over time there was increasing complexity in settlement and subsistence—beginning with nomadic, big game hunting; continuing with small foraging groups during the Archaic period; and ending with semi-sedentary collectors affiliated with Fremont and Shoshone groups into the historic period. This basic chronology has been refined for the Lower Snake River by Plew (2000).

The earliest evidence of human occupation in the region consists of Clovis fluted points found in the eastern Snake River Plain area of Twin Falls. Elsewhere these points have been dated between 12,000 and 11,000 B.P. Folsom and Plano points, also part of Butler’s Early Big Game Hunting tradition or Plew's Paleoindian period, are abundant and widespread in the Upper Snake River region. Isolated finds of Clovis, Folsom, and Plano points have been recovered from the Snake River near Twin Falls (Titmus 1988); on the Bruneau River (Titmus and Woods 1988); and throughout the Snake River Plain (Titmus and Woods 1992).

The Archaic (7800–250 B.P.) has been divided into three periods: Early, Middle, and Late. It was characterized by small, foraging groups exploiting modern flora and fauna, and becoming increasingly sedentary through time. Large, semi-subterranean houses have been dated to 4300 B.P. at Givens Hot Springs (Green 1982). Where evidence of substantial houses exists, they are usually found in small groups of two or three. There is presently no evidence for large villages during the Archaic period in this area.

The Early Archaic (7800–5000 B.P.) occurred during a warmer and drier period when new tools appeared, resources were diverse, and people moved from resource area to resource area, leaving behind a variety of specialized sites. Projectile points are lanceolate and large corner- and side-notched points. Elsewhere in the Northwest and Great Basin these points were referred to as "large-stemmed" or "western-stemmed" points (Willig et al. 1988). Plew sees the Early Archaic as the beginning of "a seasonally-based transhumant settlement strategy" (Plew 2000:52).

The Middle Archaic period (5000–2000 B.P.) continues to have large corner- and side-notched points, but has noticeably more groundstone, and more diverse settlement and subsistence patterns. Specialized sites devoted to extracting one resource occur as do more sedentary sites with housepits.

The Late Archaic period (2000–250 B.P.) is characterized by more sedentary occupations and by the introduction of ceramics. Some controversy exists over the cultural affiliation of groups in the area. Butler (1986) infers evidence for a Fremont Culture occupation in the region perhaps beginning as early as 1450 B.P. According to Butler, clear evidence of Shoshone occupation dates to the early A.D. 1800s, but it is likely that movement into the area began as early as 500 B.P. The extent of Fremont occupation in the Snake River area is disputed by others (Plew 1980) and the reasons for shifting affiliations or migrations into the area are not well understood. Not disputed is the variety of tools, introduction of the bow and arrow, and the widespread occupation of the area. Rosegate and Desert Side-notched points are common.

D.1.1.1.3 Developmental Model

Meatte (1990), using a model first developed by Schalk and Cleveland (1983), offers a chronology for the region based on changes in settlement and subsistence. Meatte contends that the first evidence for use of the region dates to 11,500 B.P. From this time to approximately 4200 B.P., small, mobile groups defined as *broad spectrum foragers* occupied the region using a limited range of tools to exploit a variety of plants and animals. For the period spanning 4200 to 250 B.P., Meatte identifies a *semisedentary foraging* system. At this time, larger groups occupied riverine villages during the winter months, relying on stored foods they collected throughout the remainder of the year. Sites of this period are characterized by diverse tool assemblages, semi-subterranean pithouses, and an abundance of salmon bones. As its designation implies, the last period, *equestrian foraging*, involved intensive use of horses that permitted a dramatic increase in the efficiency and range of hunting and gathering.

D.1.1.1.4 Paleoclimatic Model

Gehr et al. (1982), in an overview of the cultural resources in an area encompassing most of southwestern Idaho, used changes in projectile point styles coupled with climatic patterns to define three broad chronological periods.

Cooler and moister conditions characterized most of Period 1 (15,000–7000 B.P.) which corresponds to the Anathermal climatic episode and Plew's Paleoindian and Early Archaic periods. At the outset of this period, a periglacial environment covered most of the region. Gehr et al. postulate that very small, mobile groups occupied the area to hunt large game. These groups left very little evidence of their presence and some doubts exist regarding human occupation in southwestern Idaho before 12,000 B.P. After 10,000 B.P. Gehr et al. argue that there was a gradual warming and drying that coincided with the extinction of many large game species. Although still organized into small, mobile groups, the local population had to exploit a wider range of resources and use different environmental settings.

Warmer and probably drier climatic conditions (Altithermal episode) characterized Period 2 (7000–3000 B.P.; Gehr et al. 1982), which corresponds to Plew's Middle Archaic period. Such conditions required the American Indians to focus settlement and subsistence activities around stable or predictable water sources, especially rivers. Large campsites dating to this period occur in these locations. In contrast, the uplands and broad plains received use primarily as resource exploitation locales. Site assemblages during this period reflect use of diverse resources, possibly as a result of the climatic conditions.

Period 3 (3000 B.P. to historic period), associated with a climate (Mesothermal episode) similar to the present, was characterized by development of a semi-sedentary settlement pattern with larger habitation sites along major rivers and specialized resource procurement sites in the uplands. It corresponds to Plew's Late Archaic period.

D.1.1.2 Historical Indian Tribal Use of the Area

Historical, linguistic, and ethnographic information suggests that Indian Tribes with historical ties to southern Idaho include the Shoshone, Paiute, and Bannock. These tribes included four distinct bands of Northern Shoshone: the Eastern or Horse Shoshone, the Western Shoshone or Salmon-Eaters (including the Boise and Bruneau bands), the Lemhi, several bands of Northwestern Shoshone, and the Northern Paiute, including a related but independent band—the Bannock. These peoples covered a wide subsistence area from Montana and Wyoming to eastern Oregon, northeastern Nevada, and northern Utah. Cultures varied by area with a strong Plains influence in the east and desert adaptations in southern and western portions of their territories. These tribes eventually settled on a number of reservations in Idaho, Nevada, and Oregon. Currently the Northwestern Shoshone have their own reservation in northern Utah near the Idaho border (Bureau of Indian Affairs 1992).

D.1.1.2.1 Shoshone and Bannock Tribes/Fort Hall Reservation

The people inhabiting southeastern Idaho eventually became known as the Shoshone-Bannock although they represented two linguistically distinct populations—the Northern Shoshone and the Bannock. Both language groups stemmed from the Numic family, but the Bannock spoke a dialect of the Paviotso language shared with the Northern Paiute and the Shoshone spoke their own dialect of the Shoshone language. This language difference makes sense in light of evidence supported by Murphey and Baxter (2002) that around A.D. 1700 some 600 Northern Paiute from western Idaho and eastern Oregon joined the horse Shoshone and came to be known as Bannocks. The Shoshone and Bannock were further linked by the fact that they shared a common horse culture and all of them exploited the same natural resources, shared a common environment, and developed similar social institutions. Shoshone and Bannock ranged from most of southern Idaho into western Wyoming and south into Nevada and Utah (Walker 1978).

These people were hunters and gatherers living in small bands of extended families that traveled seasonally to exploit various animal and plant resources. To supplement their diets in the spring and summer, they fished for salmon and other fish species in the Snake River. Occasionally, they formed encampments or temporary villages of families where resources were abundant near water holes or rivers. They closely resembled their neighbors the Northern Paiute in their reliance on small game, birds, insects, seeds, and nuts (Walker 1978). With the introduction of the horse between A.D. 1650 and 1700, the Shoshone bands based on the eastern edge of the Snake River Plain were able to expand their range and join with other Shoshone in buffalo hunts and raiding parties on the northern plains. However, the Shoshone fishermen of the Hagerman Valley maintained their lifestyle, without horses, until the mid-1840s (Murphey and Baxter 2002). The lifestyles of the Shoshone and Bannock began to change after this period as more white settlers moved into their territory. This was the era of westward emigration by Euroamericans and the beginning of the reservation period.

Fort Hall was established as an Indian Reservation in 1867 by Executive Order (EO) of President Andrew Johnson. A few years later, in 1869, the Fort Hall Reservation was reaffirmed by the ratification of the 1868 Treaty of Fort Bridger. The 1868 Treaty of Fort Bridger also set aside the Wind River Valley Reservation for Washakie's band of Eastern Shoshone (Clemmer and Stewart 1986). The Fort Hall Reservation was opened in April of 1869 by Federal Indian Agent J.W. Powell. The first Northern Shoshone Tribes (the Eastern or horse Shoshone) settled on the Fort Hall Indian Reservation that year and became known as the Fort Hall Shoshone. The Boise and Bruneau bands of Northern Shoshone moved to Fort Hall soon after. An EO on July 30, 1869 assigned the Bannock to the Fort Hall Reservation. It was not until the 1880s, when the Northwestern Shoshone experienced the pressures of white settlement, that they made the move to Fort Hall. The Lemhi Shoshone did not settle at the Fort Hall Indian Reservation until 1907 (Madsen 1980). Though the Shoshone and Bannock finally had a reservation, the tumultuous times in Idaho politics, the Federal government's neglect of Indian needs on the reservations, and the hostility of white settlers led to difficult transitional times for the Indians many of whom were forced to leave Fort Hall to seek sustenance on the buffalo plains to the east (Madsen 1980). In 1878, a series of skirmishes, known as the Bannock War, occurred in southern Idaho. The Bannock War represented the last major effort by Indian Tribes to resist settlement of the region.

D.1.1.2.2 Shoshone and Paiute Tribes/Carlin Farms and Duck Valley Reservations

In A.D. 1811, when the first Euroamericans traveled through southwestern Idaho, the Western Shoshone and Northern Paiute occupied the region. Horses, acquired from aboriginal peoples in contact with the Spanish in the southwestern United States, had been present in Idaho since A.D. 1700. Some researchers (Gehr et al. 1982; Young 1984) contend that the first explorers and trappers in the region described an aboriginal culture unaffected by the introduction of the horse. However, the early Euroamerican visitors to the area observed only a small segment of the cultural system, resulting in biased sketches of aboriginal life. In contrast, trained ethnographers such as Julian Steward (1938) conducted rigorous, systematic inquiries, but this was not until the late 1930s and 1940s when the aboriginal culture had been dramatically altered for more than 50 years. Therefore, the available ethnographic data provide a limited and biased understanding of aboriginal culture in the region.

As with the Bannock, the Western Shoshone and Northern Paiute represent two distinct linguistic populations (Gehr et al. 1982; Meatte 1990; Young 1984). Although each spoke a different language, both belong to the larger Numic language family. The data suggest that the territories of these two tribes overlapped in southwestern Idaho, with the territory of the Western Shoshone extending westward and that of the Northern Paiute extending eastward. These people were hunters and gatherers living in small bands of extended family members who survived by frequent travel over seasonal routes that provided them with game and plant food in the variable upland desert environment (Walker 1978).

Despite different languages, the Western Shoshone and Northern Paiute had similar tool assemblages, sociopolitical organization, religious practices, and subsistence systems. Gehr et al. (1982) provide a discussion of the ethnographic information on subsistence and settlement systems (Table D-3). Plant resources commonly used by the Shoshone include camas root, biscuitroot, wild onion, tobaccoroot, serviceberry, hawthorn, chokecherry, currant, and rose. Most of these resources occur along stream margins. Salmon fishing in the major rivers such as the Snake apparently formed a critical part of the annual subsistence cycle with major fishing efforts during early spring and early summer.

Ethnographic information by Steward (1938), derived from the memories of his informants, discusses the “Snake” Indians. The bands of “Snake” Indians on the Snake River had a less mobile lifestyle than the surrounding Shoshone bands, with a heavy reliance on fishing, and more complex political organization (Murphy and Murphy 1960). Campsites were located on both sides of the Snake River and on tributaries. The seasonal round of this Shoshone band fits a collector strategy; one in which several families settled in villages on the Snake River during the winter, spring, and fall and dispersed into the uplands to collect and process camas during the summer (Figure D-3). Dried camas roots were stored at camps along the river canyons to be used as food during the winter. People living in the Snake River/Little Camas Prairie region sometimes went into the Owyhee River area in late summer to obtain roots and berries as well as salmon and sucker fish. Families sometimes remained until the fall, when they would travel to the hills south of the Little Camas Prairie.

Table D-3. Summary of Ethnographic Subsistence and Settlement Systems

Season	Subsistence Activity/Location	Settlement Characteristics
Winter	Limited hunting/Snake River and main Tributaries	Villages with small populations along major rivers
	Use of stored foods/Snake River and main tributaries	Villages with small populations along major rivers
Spring	Plant food collecting/Snake River and main tributaries; low hills and upland valleys	Small family groups out of villages or small groups at temporary camps for more remote resources
	Salmon fishing/Snake River and main Tributaries	Multi-family groups out of villages or at temporary fishing camps
	Limited hunting/Snake River and main tributaries, nearby uplands	Small task groups out of villages or temporary camps
Summer	Plant food collecting/upland valleys and Plains	Small family groups out of temporary Camps
	Salmon fishing/Snake River and main Tributaries	Same as in spring
	Limited hunting/associated with location of family or task groups	Same as in spring
Fall	Hunting/upland valleys, plains and Drainages	Small task groups out of temporary Camps
	Salmon fishing/Snake River and main Tributaries	Same as in spring

Although the first American Indian contact with Euroamericans in the region had occurred in 1811, more extensive European contact started in the 1820s when trappers exploited game resources that American Indians needed for subsistence. By the 1840s, the beginning of the great westward emigration, much of the game in the region had been depleted and Indian Tribal economies crashed. As a result of these conditions, early historic accounts document extreme poverty among the Shoshone and Paiute.

Initially, the Shoshone and Paiute responded to the Euroamerican population influx by retreating to more remote portions of southwestern Idaho or clustering around the Euroamerican settlements and trading with the settlers (Gehr et al. 1982). Although isolated attacks on immigrants occurred in the late 1840s through the 1850s, hostilities were limited.

However, with increased mining activities in the area following gold discoveries in the Owyhees in 1859 and as Euroamericans moved westward along the Oregon Trail, Indian lands were heavily impacted. Many Shoshone and Paiute were forced to occupy marginal natural resource areas. This factor, as well as others, increased hostilities and culminated in the Snake Indian War (1866–1868). This war consisted of a series of raids and skirmishes, centered on the mining areas. A reported battle site is situated along Battle Creek in southwestern Owyhee County.

Beginning in 1870, Captain Sam, a Western Shoshone leader, repeatedly requested a reservation for his people (McKinney 1983). He suggested to a Federal Indian Agent that the traditional territory used by the Western Shoshone would be an ideal reservation because it had good potential for agriculture, fishing, hunting, and timber production and was located far from areas

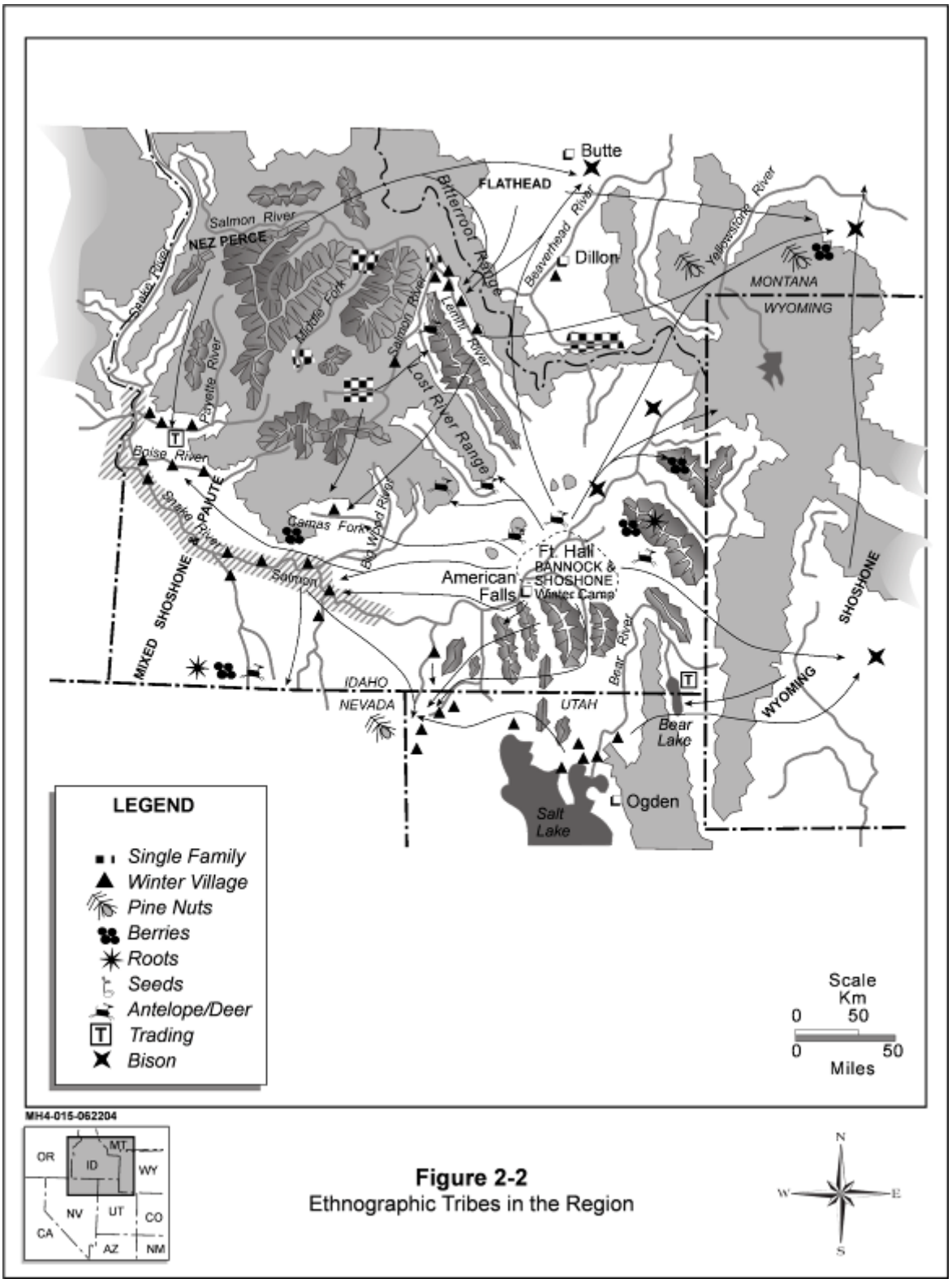

Figure D-3. Ethnographic Tribes in the Region near Saylor Creek Range (from Mountain Home AFB ICRMP 2006:Figure 2-2).

used by whites (Clemmer and Stewart 1986). Captain Sam's wish was not realized until April 16, 1877 when the President of the United States signed an EO establishing the Duck Valley Reservation.

In the interim between 1870 and the establishment of the Duck Valley Reservation in 1877, Captain Sam traveled to the Paiute Indian Agency in Wadsworth, Nevada where he met with Indian Agent C.E. Bateman and requested land for Indian farms. He explained to Bateman that his own Federal Indian Agent had been unresponsive. Bateman received permission from the Federal government to expend a small sum on establishing a farm for the Western Shoshone near Carlin, Nevada. Approximately 150 Indians signed petitions for deeds and farming supplies. They began farming in the spring of 1875 with only a small percentage of the $5,000 promised them by the Federal government. Bateman hired local farmer John A. Palmer to help set up and implement the Indian farms. When Indian Agent A. J. Barnes replaced Bateman in 1876 the Indians at Carlin Farms were still paying rent to farm the land. Barnes advocated securing legal Indian title to the land at Carlin Farms to end the payment of rent and to protect the Indians' livelihood (McKinney 1983).

It was not until the following year that Carlin Farms became a reservation. By EO on May 10, 1877, President Hayes established the 51.61 ac Carlin Farms Reservation for the Western Shoshone. However, Carlin Farms Reservation proved to be short-lived. In 1878 Indian Agent Barnes was told that most of Carlin Farms had already been claimed by white settlers prior to the EO. Palmer, who was still assisting the Indians at Carlin Farms, complained to the Commissioner of Indian Affairs that fraudulent documents had been used to claim the land by the settlers. Regardless, the EO establishing Carlin Farms Reservation was rescinded by President Hayes in another EO on January 16, 1879 (McKinney 1983).

Just a month before the Carlin Farms Reservation was officially established, the Duck Valley Reservation was finally established, also by EO, in the area Captain Sam had originally requested. Soon, a number of Western Shoshone and Northern Paiute bands moved to the reservation and began ranching and farming—without the aid of the Federal government. Euroamericans and Indians alike thought of the reservation as a place where the bands could attain self-sufficiency and historical documents indicate the Shoshone and Paiute spared no effort to do so. When Federal agents arrived to provide assistance, they found the Shoshone-Paiute had already constructed a diversion dam along the Owyhee River and built irrigation canals to provide water to farming plots throughout the Duck Valley Reservation (Clemmer and Stewart 1986). In the 1880s, the Shoshone and Paiute bands continued to develop their economic base through construction of a new flour mill and additional irrigation ditches.

Water was necessary for successful farming due to a short growing season, but as early as 1889 homesteaders upstream from the reservation were diverting water. In 1915, after numerous requests and years of struggle on the Duck Valley Reservation, the Federal government decided that the Shoshone-Paiute Tribes of Duck Valley Reservation had prior rights to water from the Owyhee River. However, construction of Wildhorse Reservoir was not undertaken for more than 20 years, and substantial areas of the reservation were abandoned due to lack of water.

In 1936, the Indian Reorganization Act significantly changed the political climate on the Duck Valley Reservation. The Act not only granted the right of self-government to the tribes, but also recognized the value of traditional tribal languages, religions, leadership, and subsistence practices. This right of self-government has continued importance on the Duck Valley Reservation; the self-governing Shoshone-Paiute Tribes of the Duck Valley Reservation control most activities on the reservation today.

D.1.2 Defining Archaeological Visibility

Following Schiffer et al. (1978), Banning (2002:46) defines visibility as "a characteristic of the environment in which archaeological materials may be found that can make it relatively easy, or more difficult, for archaeologists to detect them." Major characteristics of the environment that are often invoked as having an effect on visibility are vegetation types and soil types. It should be noted that although vegetation is often one of the major variables affecting visibility, the density of vegetation can vary throughout the year and between years depending on a number of factors, including the amount and timing of rainfall, the occurrence of wildfires, land use, or land treatments, such as controlled burns or disking. For instance, grasses and annual plants in a given survey parcel could be thinly distributed and low to the ground at some times and thickly distributed and waist high at other times. Moreover, vegetation growth and density is affected by spatial variation in surface runoff and ground water as well as factors such as soil quality, insolation, and exposure. Thus, it can be tenuous to associate different mapped vegetation or soil types conclusively with different levels of visibility, as there are multiple factors beyond the mapped distribution of vegetation or soil types that influence archaeological visibility.

Obviously, variation in visibility has an effect on the kinds and numbers of sites discovered in a project area as well as on parameter estimates. Consequently, modeling of the distribution of cultural resources on a military installation can be affected adversely by variation in visibility, as analytical techniques such as predictive modeling generally assume that sites do not exist in surveyed areas where no site has been recorded. Rather than indicating a lack of cultural resources, the absence of archaeological discoveries in a survey parcel can result from poor visibility, as is so evidently the case in portions of SCR, which will be discussed below.

D.1.3 Post-Fire Resurvey in the Clover Fire Survey Project Area

Most archaeologists are fully aware that visibility can have a strong effect on site discovery (Banning 2002; Schiffer et al. 1978); hence, the need to make observations on ground visibility during survey. However, archaeologists were shocked to learn of the extent of the problem on SCR. Resurvey of the project area following the Clover Fire resulted in the discovery of numerous cultural resources that had previously gone unnoticed (Polk and Weymouth 2006). Resurvey resulted in:

- discovery of substantially higher artifact densities at many previously recorded sites
- many more culturally, temporally, or technologically diagnostic artifacts than had previously been recorded in the project area
- additional site components at several sites
- expansion of site boundaries for some sites
- discovery of an additional 29 sites

Perhaps most surprising was the discovery of an additional 29 sites, a number that nearly doubled the number of known sites in the project area. The discovery of new components that had been missed by previous survey, particularly Paleoindian-aged components, was also surprising. The discovery of these components suddenly elevated relatively nondescript and common lithic scatters to comparatively rare and highly significant sites. Given the large disparity between previous survey and survey following the Clover Fire, the reliability of previous survey came into question. How reliable was previous survey in finding sites? What kinds of sites tended to be missed? What kinds of diagnostic information had been missed? What kinds of disparities in results could be expected if other previously surveyed areas were resurveyed under similar conditions as had been created by the Clover Fire?

D.1.4 Previous Survey Methods

With the exception of early surveys undertaken in the area of the installation prior to 1990 (e.g., Corbyn 1988; USAF 1990), all of the surveys on SCR have been conducted according to similar methods for site discovery and recordation. All the surveys in the past two decades have reported a standard survey interval of 30 m, with only slight deviations. Two surveys used smaller survey intervals, between 22 and 27 m, in areas where visibility was considered to be poor, and used intervals of 30 m in areas where visibility was better (Rudolph et al. 1997). Field crews were of similar sizes for most surveys as well, with surveys being conducted by one or two crews each consisting of three to five crew members.

In essence, reported survey methods remained nearly constant among surveys conducted in the project area. Of course, there certainly could have been unreported variation in survey methods or variation in the abilities of field crew, but the effects of such influences on survey results would be difficult, if not impossible, to isolate with the available data. The main factor that had changed substantially between previous surveys and the Clover Fire Project survey was the improved visibility of surface and near-surface artifacts resulting from the removal of vegetation by the fire and subsequent erosion of several centimeters of surface sediment.

D.2 THE CHANGE IN SITE ATTRIBUTES AS A RESULT OF RESURVEY

Prior to the Clover Fire survey, a total of 32 sites had been discovered in the project area. In order to evaluate the extent to which site attributes changed as a result of resurvey, we tabulated numbers of artifacts, site dimensions, and diagnostic artifact discoveries for previous survey and resurvey following the Clover Fire using data presented in Polk and Weymouth (2006) (Table D-5). These analyses show, as Polk and Weymouth (2006) emphasized, that there were dramatic changes in site size, artifact density, and diagnostic information when previously recorded sites were rerecorded under improved ground conditions. Changes were most dramatic for prehistoric lithic scatters, suggesting that there has been a strong bias against the discovery and attribution of these sites. Part of the difference could relate to differences in the expertise of contractors performing the work, with previous survey conducted by contractors with less-specialized expertise in lithic tool identification (personal communication, Sheri Robertson 2011), but

Table D-5. Attributes of Previous Sites in the Clover Fire Project Area

State Site No[a]	Year	Site Type	Site Dimensions			Prehistoric Artifacts, Previous Survey			Prehistoric Artifacts, Resurvey			Increase in Prehistoric			Notes
			As Originally Recorded	Revised	Change in Site Area (%)	Flake	Tool	Total	Flake	Tools	Total	Artifact Count (%)	Tool Count (%)	Artifact Density (%)	
3847	1990	prehistoric lithic scatter	37 × 21 m	37 × 21 m		20	2	22	32	5	37	68.2	150.0	68.2	New discovery of Humboldt Concave-Base type (5920–3100 B.P.) of the Black Rock-Humboldt-McKean-Pinto Basin Series
5474	1990	prehistoric lithic scatter	60 × 30 m	67 × 75 m	179.2	100	2	102	450	14	464	354.9	600.0	62.9	New discovery of Elko Eared type of the Elko Series (4,000–820 B.P.) as defined for the Intermountain/Plateau Culture Area
7982	2000	historical-period sheep camp	62 × 45 m	62 × 45 m											Consistent with original recordation
7986	2000	historical-period can scatter / newly discovered prehistoric lithic scatter	60 × 30 m	60 × 30 m					250	9	259	increased from 0	increased from 0	increased from 0	Elko Series (4,000–820 B.P.) (Drager and Ireland 1986:601); Rose Springs/Eastgate Series of the Desert Complex (4,000–250 B.P.) as defined for the Great Basin Culture Area (Drager and Ireland 1986:594–595).
7992	2000	historical-period trash scatter	27 × 24 m	27 × 24 m											Consistent with original recordation
7994	2000	historical-period trash scatter	130 × 50 m	130 × 50 m											Not relocated; could not be found during resurvey
8003	2000	historical-period sheep camp	40 × 45 m	40 × 45 m											Consistent with original recordation
8007	2000	historical-period trash scatter	53 × 27 m	53 × 27 m											Consistent with original recordation
8008	2000	historical-period trash scatter	96 × 65 m	96 × 65 m											Consistent with original recordation
8025	2000	prehistoric lithic scatter	47 × 35 m	47 × 35 m		13		13	45	3	48	269.2	increased from 0	269.2	New tool types
8027	2000	historical-period trash scatter	80 × 55 m	80 × 55 m											Not relocated; could not be found during resurvey
8042	2000	historical-period can scatter / newly discovered prehistoric lithic scatter	35 × 25 m	35 × 25 m					137		137	increased from 0		increased from 0	Historical-period component consistent with original recordation, but new prehistoric component identified
8043	2000	lithic scatter	20 × 25 m	59 × 66 m	678.8	15	2	17	415	18	433	2447.1	800.0	227.0	
8168	2000	historical-period can scatter / newly discovered prehistoric lithic scatter	60 × 50 m	60 × 50 m					80	4	84	increased from 0	increased from 0	increased from 0	New prehistoric component identified; Rose Springs/Eastgate Series of the Desert Complex (4000–250 B.P.) as defined for the Great Basin Culture Area
8174	2000	historical-period trash scatter/ prehistoric lithic scatter	80 × 100 m	107 × 125 m	67.2	36	6	42	89	6	95	126.2	0.0	35.3	Historical-period component consistent, but prehistoric component much larger than original recordation; Humboldt Concave-Base type (5920–3100 B.P.) of the Black Rock-Humboldt-McKean-Pinto Basin Series as defined for the Intermountain/Plateau Culture Area (Drager and Ireland 1986:599)
8175	2004	historical-period trash scatter/ prehistoric lithic scatter	75 × 65 m	200 × 170 m	597.4	774	37	811	2,500	70	2,570	216.9	89.2	-54.6	Site was revisited in 2004, with boundary expanded and more artifacts found; again expanded with many more artifacts found during Clover Fire survey (see Table 2); the previous data here are from 2004; newly discovered Elko Series (4000–820 B.P.), Haskett type (8500-7000 B.P.), Humboldt Concave-Base type (5920–3100 B.P.) of the Black Rock-Humboldt-McKean-Pinto Basin Series as defined for the Intermountain/Plateau Culture Area (Drager and Ireland 1986:598–601)
8380	2000	historical-period trash scatter	50 × 40 m	50 × 40 m											Consistent with original recordation
8548	2000	historical-period trash scatter	31 × 24 m	31 × 24 m											Consistent with original recordation
8549	2000	historical-period trash scatter	25 × 7 m	25 × 7 m											Consistent with original recordation

State Site No [a]	Year	Site Type	Site Dimensions			Prehistoric Artifacts, Previous Survey			Prehistoric Artifacts, Resurvey			Increase in Prehistoric			Notes
			As Originally Recorded	Revised	Change in Site Area (%)	Flake	Tool	Total	Flake	Tools	Total	Artifact Count (%)	Tool Count (%)	Artifact Density (%)	
8550	2000	historical-period trash scatter	55 × 56 m	55 × 56 m											Mostly consistent with original recordation, but found a larger number and greater diversity of artifacts
9499	2004	prehistoric lithic scatter	32 × 36 m	32 × 36 m		45		45	167	1	168	273.3	increased from 0	273.3	
9500	2004	historical-period trash scatter	56 × 39 m	56 × 39 m											Consistent with original recordation
9501	2004	historical-period trash scatter	65 × 54 m	65 × 54 m											Consistent with original recordation
9502	2004	prehistoric lithic scatter	51 × 53 m	51 × 53 m		70	1	71	70	1	71	0.0	0.0	0.0	Haskett point found during original recordation; no change in site size or content
9505	2004	prehistoric lithic scatter	58 × 24 m	61 × 75 m	228.7	5	2	7	26	5	31	342.9	150.0	34.7	Newly discovered Haskett point (8500–7000 B.P.) as defined for the Intermountain/Plateau Culture Area (Drager and Ireland 1986:598–599)
9506	2004	prehistoric lithic scatter	67 × 32 m	67 × 32 m		65	1	66	65	2	67	1.5	100.0	1.5	Newly discovered point of the Elko Series (4,000–820 B.P.) as defined for the Intermountain/Plateau Culture Area
9507	2004	historical-period trash scatter	16 × 32 m	16 × 32 m											Consistent with original recordation
9508	2004	historical-period trash scatter	33 × 121 m	33 × 121 m											Mostly consistent with original recordation, with a few additional artifacts discovered
9509	2004	prehistoric lithic scatter	93 × 49 m	93 × 49 m		300	7	307	300	10	310	1.0	42.9	1.0	Newly discovered Haskett type (8500–7000 B.P.)
9511	2004	prehistoric lithic scatter	32 × 25 m	32 × 25 m		15	2	17	15	3	18	5.9	50.0	5.9	Haskett point found during original recordation; one additional point fragment from a Haskett point found during resurvey; otherwise the same.
9512	2004	prehistoric lithic scatter	72 × 60 m	72 × 60 m		111	13	124	600	21	621	400.8	61.5	400.8	Haskett points found during original recordation; additional point fragments from Haskett points found during resurvey along with many flakes
9515	2004	prehistoric lithic scatter	76 × 35 m	76 × 35 m			10	10		17	17	70.0	70.0	70.0	Newly discovered Desert Side-notch type of the Desert Complex (1250 B.P. to historical period) (Drager and Ireland 1986:602) and Elko Corner-notch and Elko Series (4000–820 B.P.) as defined for the Intermountain/Plateau Culture Area

[a] Site numbers are preceded by 10-OE-.

differences in archaeological visibility appear to have played a strong role in the difference between pre- and post-fire survey as well.

D.2.1 Change in Site Size

In order to track change in site size, we calculated site area using the formula for an ellipse. We used the reported dimensions of each site as the semi-minor and semi-major axes of an ellipse. Because polygons were not always available in a GIS for earlier recordings of a site, we focused on calculations made using reported dimensions. Comparison of area calculations made using reported dimensions with measurements made using the polygon area in GIS suggest that polygon measurements are often similar. In the main, calculations using the reported site dimensions tend to be smaller by a few percent.

Site size did not commonly change for rerecorded sites.[16] Only 4 of the 32 sites that were rerecorded changed in size. An additional site, 10-OE-8175, changed in size from its initial recording in 2000 when it was revisited in 2004, but it remained the same size when rerecorded in 2005 during the Clover Fire survey. Importantly, all of the sites that changed in size were prehistoric lithic scatters or were multicomponent sites consisting of a historical-period trash scatter and a prehistoric lithic scatter. Thus, it appears that scatters of flakes that had gone unrecognized previously due to poor visibility occasionally had the effect, when recognized, of increasing site size.

Depending on whether 10-OE-8175 is included in the calculation, site size changed for 12.5 to 16 percent of sites. However, if only sites with prehistoric lithic-scatter components are considered in the calculation (n = 17), the percentage of sites affected nearly doubles, to between 23 and 29 percent. Thus, we might say that approximately 1 of every 4 prehistoric lithic scatters will increase in size as a result of resurvey when visibility is excellent. By contrast, historical-period sites can be expected to increase in size only rarely.[17]

Also significant is the fact that all sites that changed in size became larger, often by a substantial amount. Sites increased by 1.7–7.8 times in size. For all five sites that increased in size, this represents an increase in site area of nearly 35,000 sq m, which is approximately one third of the total site area of the 32 previously recorded sites in the project area and one-half of the total site area of the 17 previously recorded sites with prehistoric lithic scatters. Affected sites more than tripled in size on average. Thus, when resurveyed under improved visibility conditions, it appears that the total amount of site area represented by prehistoric lithic scatters could be expected to increase substantially, and some individual sites could be several times larger than originally recorded.

[16] Previous and revised site dimensions for previously recorded sites are provided in tabular form for a total of 5 sites in Table 4-3 in Polk and Weymouth (2006), but the text on page 4-28 mentions that 12 previously recorded sites had their boundaries expanded

[17] This result may need to be revised, if there were 12 rather than 4 sites that had their boundaries expanded (see Note 2).

D.2.2 Change in Artifact Counts

More dramatic than the increase in site area were changes in artifact counts and densities for prehistoric lithic scatters. Of the 14 prehistoric components that had been previously recorded in the project area (3 additional prehistoric components were discovered at sites previously identified only as historical-period in age), all but 1 were found to have a greater number of artifacts than had been originally recorded (see Table D-5). For a few sites, only 1 or a few additional prehistoric artifacts were discovered, but the number of additional artifacts increased by as many as 25 times for individual sites and increased by more than 300 percent, on average. For the 17 previously recorded sites with prehistoric components (14 previously recorded plus 3 newly recorded prehistoric components) this represents an increase of more than 3,700 prehistoric artifacts, or a total that is more than three times the original total of recorded prehistoric artifacts in the project area.

Unfortunately, the number of historical-period artifacts was not explicitly stated in many cases, so it was not possible to calculate the change in artifact count and density for historical-period components. We can say, however, that the reported artifact count increased for some historical-period sites as a result of resurvey but not nearly to the degree encountered for prehistoric lithic scatters. Of the 20 sites with historical-period components, 15 had historical-period components consistent or mostly consistent with their original recording, meaning that perhaps one or a few additional historical-period artifacts were discovered and site boundaries did not change. Another 2 sites with historical-period components could not be relocated. Thus, at least three-quarters of historical-period components could be expected to be largely the same when recorded under improved visibility conditions. Perhaps, the larger size and obtrusiveness of historical-period artifacts makes them more readily observable under a broad range of ground conditions, whereas prehistoric artifacts are much more likely to go unnoticed when visibility is poor.

D.2.3 Change in Artifact Density

As stated above, the number of artifacts for historical-period sites was provided only for some sites with historical-period components. As a result, artifact density could only be analyzed comprehensively for sites with prehistoric components. Artifact density was calculated by summing all the prehistoric artifacts recorded during initial recording and during resurvey and dividing that number, respectively, by the site size (in sq m) as recorded during initial recording and during resurvey. These data provide an indication of how artifact density changed between recordings for sites with prehistoric components.

Artifact density calculations reveal that, of the 14 previously recorded prehistoric components, 12 increased and 1 decreased in artifact density as a result of an increase in the site size. For 1 site, artifact density remained the same between recordings; for a few other sites, artifact density increased by only a minor amount. Prehistoric artifact density, however, increased by as much as four times. On average, artifact density doubled, with artifact density increasing on around two thirds of sites by more than 50 percent.

D.2.4 Change in Prehistoric Artifact Types

Formal stone tools generally produce the most information about site function and temporal and cultural affiliation at SCR. For four sites with prehistoric lithic-scatter components, tools were discovered for the first time. The sites had previously yielded only flakes or lacked a recognized prehistoric component. For sites where tools had been previously noted, an increase in the number of tools was the norm. Overall, more than double the number of tools was discovered when the sites were rerecorded. A broader variety of tool types was recognized at these sites as well. This represents a substantial increase in the amount and quality of information that could be used to evaluate these sites.

Many of the tools discovered were scrapers, utilized flakes, retouched flakes, and biface fragments. Remarkably, no core tools appear to have been recorded. Substantial numbers of tools were projectile point fragments, a number of which could be typed. For 10 of the 17 rerecorded sites with prehistoric components, projectile point artifacts that could be typed were newly discovered, substantially contributing to an understanding of the time periods during which these sites were used prehistorically. Many of these points were Haskett points (8500–7000 B.P.), as defined for the Intermountain/Plateau Culture Area. Other newly discovered projectile point artifacts included examples of the Desert Side-notch type of the Desert Complex (1250 B.P. to historical period); Elko Corner-notch and Elko Series types (4000–820 B.P.), as defined for the Intermountain/Plateau Culture Area; and Rose Springs/Eastgate Series of the Desert Complex (4000–250 B.P.), as defined for the Great Basin Culture Area (Drager and Ireland 1986).

Altogether, these new artifact data represent an important expansion in the diagnostic information obtained for previously recorded sites. More than half of sites with prehistoric components yielded important information on temporal and cultural affiliation that went completely unrecognized during previous recording episodes. If we were to consider only those sites that had previously recognized prehistoric components, then more than two-thirds of sites with known prehistoric components yielded crucial temporally diagnostic information when rerecorded under improved visibility conditions.

D.2.5 Change in Historical-period Artifact Types

Although they did not change in attributes nearly as often as previously recorded prehistoric components, some historical-period components were shown to have additional artifacts and artifact types that could lend additional information to their interpretation. In one case (10-OE-7986), a site's historical-period component was found to contain many more artifacts and artifact types than originally recorded and to contain numerous artifacts with trademarks and other information that could be used to infer the age range of the component (1881–1931). Moreover, of the historical-period sites that were rerecorded, three had newly discovered prehistoric components.

D.2.6 Summary of Findings from Previously Recorded Sites

In summary, the greatest changes in site recording occurred for sites with prehistoric lithic-scatter components. All of the sites that changed in size increased in size and had prehistoric

lithic-scatter components. Moreover, artifact counts and densities increased primarily for prehistoric lithic scatters and additional diagnostic information was obtained for many sites with prehistoric components. Overall, we might expect around a quarter of sites with prehistoric lithic components to increase in size and substantially so. Similarly, we might expect artifact densities to double and for additional tool types to be recognized from around half to two-thirds of sites with prehistoric lithic components.

By contrast, we can expect that sites with historical-period components will not increase in size unless harboring an unrecognized prehistoric component. Furthermore, we can expect that sites with historical-period components will remain largely unchanged around 75 percent of the time, but that for around 25 percent of sites with historical-period components, additional artifact types will be discovered that could contribute to a more comprehensive and precise assessment of site function and temporal and cultural affiliation. Because 3 of the 20 sites with historical-period components also yielded a prehistoric component that went unrecognized when previously recorded, we might expect that a small percentage of historical-period sites will yield a previously unrecognized prehistoric component when re-recorded under improved visibility conditions (15 percent, in this case).

D.3 DISCOVERY OF NEW SITES

The Clover Fire survey resulted in the discovery of 29 previously unidentified sites (Table D-6). This represents a 90 percent increase in the number of sites in the project area.

It may not come as a surprise that, given the previous discussion, newly discovered sites were largely prehistoric lithic scatters. Of the 29 newly discovered sites, 24 had prehistoric lithic-scatter components, 1 was a ceramic scatter, and another was a single Paleoindian point deemed a site due to its rarity and potential significance. By contrast, only 4 new sites had historical-period components, all of them trash scatters, and 1 also had a prehistoric lithic-scatter component. Thus, although nearly two-thirds of the previously recorded sites had a historical-period component, only 14 percent of the new sites had a historical-period component. It is easy to see that this represents a significant difference in site discovery ($\chi 2 = 12.838$; $df = 1$; $p = .00034$). In other words, resurvey during improved visibility conditions resulted in a 20 percent increase in the number of historical-period components and an increase of more than 200 percent in the number of prehistoric components (Table D-7).

In terms of site area, during initial survey around one-third of site area for sites with prehistoric components was discovered compared to approximately 60 percent of site area for sites with historical-period components. It must be kept in mind, however, that two sites with historical-period components were not relocated during resurvey, whereas four sites with historical-period components were newly discovered during resurvey. It could be the case that two of the newly discovered sites with historical-period components were in fact previously recorded but had been misplotted, in which case the original survey would have discovered a larger percentage of site area for sites with historical-period components than has been calculated here.

The main point, however, is clear. Previous survey on SCR, when conducted under typical visibility conditions, has been highly biased against the discovery of sites with prehistoric

Table D-6. Attributes of Newly Discovered Sites in the Clover Fire Project Area

Temporary Site No.	State Site No. [a]	Site Type	Site Dimensions	Prehistoric Flake Artifacts	Prehistoric Lithic Tool Artifacts	Prehistoric Ceramic Artifacts	Total Prehistoric Artifacts	Prehistoric Artifact Density	Diagnostic Projectile Point Types or Ceramic Wares
SB-05-18	9702	historical-period trash scatter / prehistoric lithic scatter	168 × 148 m	39	0		39	0.002	
SB-05-19	9703	prehistoric projectile point	1 × 1 m	0	1		1	1.273	Paleoindian projectile point fragment
SB-05-20	9704	prehistoric lithic scatter	51 × 37 m	45	0		45	0.030	
SB-05-21	9705	prehistoric lithic scatter	61 × 49 m	341	6		347	0.148	Haskett type projectile point (8500–7000 B.P.)
SB-05-22	9706	prehistoric lithic scatter	56 × 68 m	34	2		36	0.012	
SB-05-23	9707	prehistoric lithic scatter	42 × 52 m	166	2		168	0.098	Haskett type projectile point (8500–7000 B.P.)
SB-05-24	9708	prehistoric lithic scatter	102 × 95 m	244	11		255	0.034	Elko Series (4000–820 B.P.) projectile points; Haskett type projectile points (8500–7000 B.P.)
SB-05-25	9709	prehistoric lithic scatter	46 × 75 m	297	7		304	0.112	
SB-05-26	9710	prehistoric lithic scatter	26 × 25 m	21	3		24	0.047	
SB-05-27	9711	prehistoric lithic scatter	82 × 62m	415	5		420	0.105	Desert Side-notch type projectile point (1250 B.P.–historical period) of the Desert Complex
SB-05-28	9712	prehistoric lithic scatter	48 × 31 m	39	2		41	0.035	Desert Side-notch type (1250 B.P. –historical period)); Haskett type projectile point (8500–7000 B.P.)
SB-05-29	9713	prehistoric lithic scatter	41 × 47 m	63	5		68	0.045	Elko Series (4000–820 B.P.) projectile point; Haskett type projectile points (8500–7000 B.P.)
SB-05-30	9714	prehistoric ceramic scatter	12 × 9 m			14	14	0.165	Shoshoni Ware typical of the Great Basin and Idaho (Plew and Bennick 1990:108)
SB-05-31	9715	prehistoric lithic scatter	60 × 32m	292	3		295	0.196	

Temporary Site No.	State Site No. [a]	Site Type	Site Dimensions	Prehistoric Flake Artifacts	Prehistoric Lithic Tool Artifacts	Prehistoric Ceramic Artifacts	Total Prehistoric Artifacts	Prehistoric Artifact Density	Diagnostic Projectile Point Types or Ceramic Wares
SB-05-32	9716	historical-period trash scatter	18 × 56 m						
SB-05-33	9717	historical-period trash scatter	144 × 106 m						
SB-05-34	9718	prehistoric lithic scatter	31 × 36 m	373	1		374	0.427	Midland type (12,000–8000 B.P.) as defined for the Intermountain/Plateau culture area (Drager and Ireland 1986:596)
SB-05-35	9719	prehistoric lithic scatter	33 × 24 m	79	1		80	0.129	
SB-05-36	9720	prehistoric lithic scatter	114 × 47 m	150	19		169	0.040	Elko Corner-notch and Elko Series type point fragments (4000–820 B.P.)
SB-05-37	9721	prehistoric lithic scatter	61 × 46 m	24	4		28	0.013	Elko Series Type (4000–820 B.P.); Rose Spring/Eastgate Series (4000–250 B.P.) as defined for the Intermountain/ Plateau Culture Area (Drager and Ireland 1986:594–595)
SB-05-38	9722	prehistoric lithic scatter	67 × 67 m	1	4		5	0.001	Humboldt type (5920–3100 B.P.) of the Black Rock-Humboldt-McKean-Pinto Basin Series as defined for the Intermountain/Plateau Culture Area (Drager and Ireland 1986:599–600); Elko Corner-notch type (4000–820 B.P.)
SB-05-39	9723	prehistoric lithic scatter	88 × 53 m	1	4		5	0.001	Humboldt Concave-base type (5920–3100 B.P.) of the Black Rock-Humboldt-McKean-Pinto Basin Series as defined for the Intermountain/Plateau Culture Area (Drager and Ireland 1986:599–600
SB-05-40	9724	prehistoric lithic scatter	95 × 91 m	32	2		34	0.005	

Temporary Site No.	State Site No. [a]	Site Type	Site Dimensions	Prehistoric Flake Artifacts	Prehistoric Lithic Tool Artifacts	Prehistoric Ceramic Artifacts	Total Prehistoric Artifacts	Prehistoric Artifact Density	Diagnostic Projectile Point Types or Ceramic Wares
SB-05-41	9725	prehistoric lithic scatter	35 × 39 m	42			42	0.039	
SB-05-42	9726	prehistoric lithic scatter	17 × 20 m	22			22	0.082	
SB-05-43	9727	historical-period trash scatter	69 × 116 m						
SB-05-44	9728	prehistoric lithic scatter	32 × 30 m	24	1		25	0.033	Gatecliff Split-stem type (5000–3000 B.P.) as defined for the Great Basin and Upper Snake River Basin (Holmer 1986)
SB-05-45	9729	prehistoric lithic scatter	61 × 40 m	135	4		139	0.073	Elko Corner-notch and Elko Series types (4000–820 B.P.) as defined for the Intermountain/Plateau Culture Area (Drager and Ireland 1986:601)
SB-05-46	9730	prehistoric lithic scatter	60 × 20 m	44	1		45	0.048	

[a] Site numbers are preceded by 10-OE-.

Table D-7. Numbers of Site Components Discovered during Previous Survey and Resurvey in the Clover Fire Project Area

Site Components	Historical-Period Component	Prehistoric Component	Total Components
At previously recorded sites as originally recorded	20	14	34
At previously recorded sites when rerecorded	20	17	37
At newly recorded sites	4	26	30
Total components at previous and newly recorded sites	24	43	67
Percent increase in number of components as a result of resurvey	20.0	207.1	97.1

components. We can never expect to discover all sites through survey, but the evidence suggests that in previously surveyed areas where visibility was poor, as many as three times the number of prehistoric sites could be found if the area was resurveyed under improved visibility conditions.

D.3.1 Comparison of Artifact Density between Previously Recorded and New Sites

In order to test for possible variation in artifact density between previously recorded and new sites, artifact density was calculated for previously recorded sites with prehistoric components and new sites with prehistoric components, using the revised site size and artifact count data resulting from the Clover Fire survey. The comparison allows us to assess whether there are any statistical differences between the attributes of previously recorded and new sites with prehistoric lithic-scatter components. One site with a prehistoric component was excluded, as it represents a single project point of Paleoindian age.

Comparison of artifact densities indicates that artifact densities were typically somewhat larger for previously recorded than newly discovered sites (Table D-8). Because artifact density distributions are typically highly asymmetrical with long positive tails (right-skewed) and are not normally distributed, standard statistics are not necessarily meaningful in their interpretation. However, it is notable that the median, mean, and 10 percent upper trimmed mean[18] for new sites are lower than the same statistics as calculated for previously recorded sites, even though updated artifact counts and site sizes are used to calculate artifact densities for previously recorded sites, as well as new sites. Higher artifact densities for previously recorded sites are also borne out by a scaled rank-size plot (Figure D-3). Thus, it appears that new sites with prehistoric components have lower artifact densities than previously recorded sites, suggesting that these sites were missed during initial survey, in part due to a lower probability of detection than the sites that had been previously recorded (see below).

D.3.2 Change in Diagnostic Information

Moreover, substantial differences occurred in the density of diagnostic information obtained during initial survey versus as a result of rerecording of sites or recording of new sites

[18] The 10 percent upper trimmed mean is calculated by removing the largest 10 percent of observations in order to remove the bias of anomalously large observations.

(Table D-9). Slightly more than 50 percent of both new sites and rerecorded sites with prehistoric components were found to contain artifacts with important temporal or cultural affiliations. By contrast, only around one-fifth of sites originally recorded with prehistoric components had such diagnostic information. As a consequence of resurvey during better ground conditions, when visibility was excellent and several cm of surface sediments had eroded away, the frequency of datable prehistoric components increased by a factor of 2.5.

Table D-8. Comparison of Statistics on Artifact Density between Previously Recorded Sites and Newly Discovered Sites in the Clover Fire Project Area

Statistic	Previously Recorded Sites with Prehistoric Components	New Sites with Prehistoric Components[a]
N	17	25
Minimum	0.008	0.001
Maximum	0.199	0.427
Median	0.061	0.045
Mean	0.086	0.077
Standard deviation	0.07	0.091
10% upper trimmed mean	0.071	0.051
Number of observations trimmed out	2	3

[a] One site was removed from consideration as it contained only one artifact.

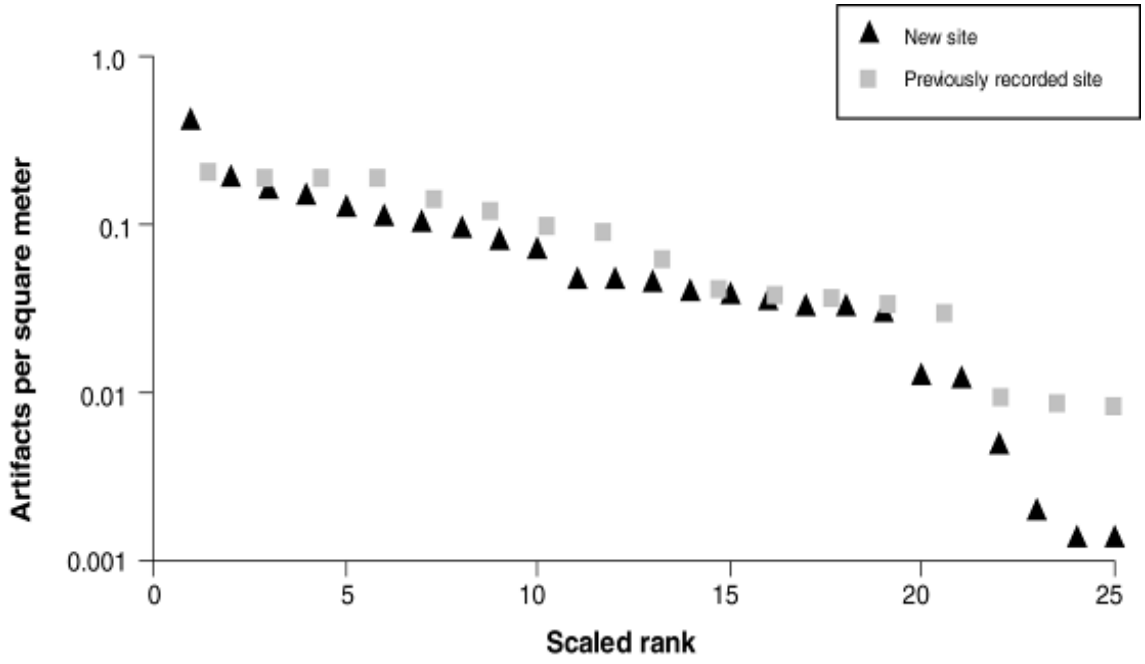

Figure D-3. Scaled rank size plot of artifact density for prehistoric lithic-scatter sites discovered during previous survey and resurvey in the Clover Fire Survey Project area.

Table D-9. Comparison of Numbers of Previously Recorded and Newly Discovered Sites with Temporally Diagnostic Artifact Information

Sample	Sites with Prehistoric Components	Prehistoric Sites with Temporally or Culturally Diagnostic Information (n)	Prehistoric Sites with Temporally or Culturally Diagnostic Information (%)
Original recording of previously recorded sites	14	3	21.4
Rerecording of previously recorded sites	17	9	52.9
Newly recorded sites	26	14	53.8

D.3.3 Differences in Site Size between Previously Recorded and New Sites

The characteristic size of newly discovered prehistoric lithic scatters was also smaller than previously recorded prehistoric lithic scatters. As with artifact densities, site sizes tend to be slightly larger for previously recorded sites in comparison to new sites (Table D-10). The mean, median, and trimmed mean of site size was smaller for new sites, in comparison to previously recorded sites. The minimum, maximum, and standard deviation were smaller for new sites as well. In addition, a rank-size plot indicates that site sizes were consistently smaller for newly recorded sites with prehistoric lithic scatters (Figure D-4).

Table D-10. Comparison of Statistics on Site Size between Previously Recorded Sites and Newly Discovered Sites in the Clover Fire Project Area

Statistic	Previously Recorded Prehistoric Lithic Scatters	New Prehistoric Lithic Scatters[a]
N	17	24
Minimum (m^2)	610.25	267.04
Maximum (m^2)	26,703.52	19,528.12
Median (m^2)	2,122.9	1,815.84
Mean (m^2)	4,033.34	3,079.94
Standard deviation (m^2)	6,285	3,971.06
10% upper trimmed mean (m^2)	2,090.57	1,904.29
Number of observations trimmed out	2	3

[a] Two sites with prehistoric components are not considered here, as they do not contain lithic scatter components.

D.4 PROBABILITIES OF SITE INTERSECTION, DETECTION, AND DISCOVERY

Archaeologists have created a substantial body of literature examining the effects of survey methodology and environmental and site characteristics on site discovery. Independently of what is actually being surveyed, site discovery can vary depending on factors such as survey parcel size and shape; spacing interval; ground conditions; artifact size, shape, and color; visibility; obtrusiveness; and other factors (Altschul and Nagle 1988; Banning 2002; Ebert 1992; Homburg et al. 1994; Judge et al. 1975; Kintigh 1988; Nance and Ball 1986; Plog et al. 1978; Schiffer and

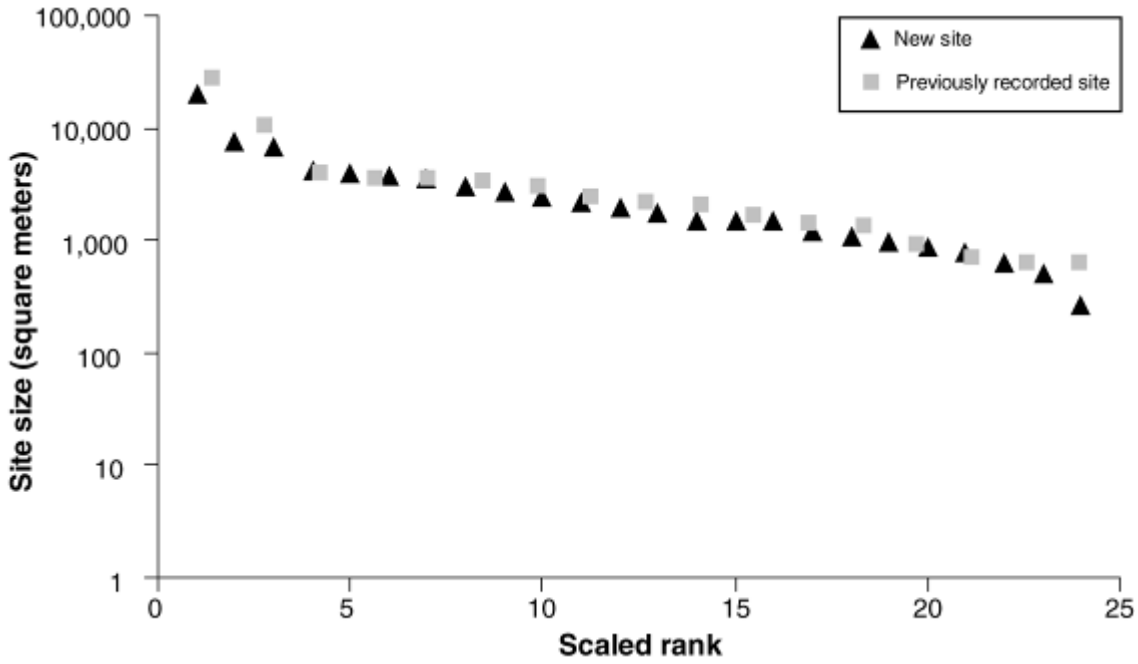

Figure D-4. Scaled rank size plot of site size for prehistoric lithic-scatter sites discovered during previous survey and resurvey in the Clover Fire Survey Project area.

Wells 1982; Schiffer et al. 1978; Wandsinder and Camilli 1992). An important distinction in the literature is the distinction between site intersection, site detection, and site discovery (Shott 1985). In brief, in order to be discovered, a site has to first be intersected by a sample unit (e.g., a pedestrian transect or shovel test), and then artifacts or features within the site have to be detected for a site to be recognized. Site discovery is thus the combined result of both site intersection and site detection.

Barring issues of crew competence or undisclosed organizational differences in survey methodology, the main factor affecting differences in site discovery between previous survey and the 2005 survey in the Clover Fire Survey Project area was visibility. After the project area had burned and vegetative cover was removed from many portions of the ground surface, visibility was vastly improved, resulting in substantially elevated detection rates.

The result of this change in visibility appears to have been a large increase in the amount of prehistoric site area and the number of sites with prehistoric components, doubling in the density of prehistoric artifacts at individual sites, and a substantial increase in diagnostic information, particularly for sites with prehistoric components. Below, we examine whether there were discernible differences for sites with prehistoric lithic components between previously recorded sites and new sites in their probabilities of intersection, detection, and discovery. It is shown that although new sites with prehistoric components tended to be smaller than previously recorded sites with prehistoric lithic-scatter components, differences in the probability of intersection were relatively minor. However, differences in the probability of detection were more pronounced, which is the combined result of smaller artifact densities and smaller site sizes for the new sites. Ultimately, the lower probability of detection for new sites results in a similarly low probability

of discovery, demonstrating that poor visibility could have been the main factor preventing these new sites from being discovered during previous survey. This analysis focuses on sites with prehistoric components, not just because these site types were shown to change to the greatest extent with resurvey, but also because the data needed for calculations (e.g., artifact density) is available only for sites with prehistoric components.

D.4.1 Probability of Intersection

For a site to be discovered, it first has to be intersected by survey. In the case of shovel test survey, the site has to be intersected by at least one STP before ultimately being discovered. In areas where pedestrian survey is common, such as in the western United States, a site has to be intersected by at least one transect in order to be discovered. Thus, for pedestrian survey, the major factor affecting whether a site will be intersected is survey interval. Essentially, sites with minimum dimensions exceeding the survey interval will be intersected 100 percent of the time. By contrast, sites with minimum dimensions less than the survey interval may be intersected less than 100 percent of the time.

For circular sites, the probability of intersection can be calculated simply as spacing interval divided by site diameter (Banning 2002). To approximate the probability of intersection for sites in the project area, we used this formula, substituting the minimum recorded dimension of each site for site diameter. Although a more accurate result could be obtained using a formula for sites of elliptical shape, we are not aware of a working formula at the present time.[19] Because the probability is calculated in the same manner for both new sites and previously recorded sites, and as most sites have dimensions larger than the spacing interval, this approach should be sufficient for the present purposes.

The dimensions of three-quarters of new sites and three-quarters of previously recorded sites (when rerecorded) were large enough to suggest that they would have certainly been intersected by survey transects spaced no more than 30 m apart. Moreover, the probability of intersection for new sites was on average only slightly smaller than the average for previously recorded sites: 88 versus 92 percent. The relative frequency of sites with a probability of intersection less than 1 was also quite similar for new sites with prehistoric components (23 percent) and previously recorded sites with prehistoric components (17 percent). Thus, the evidence suggests that the probability of intersection was fairly similar for new sites and previously recorded sites, such that the difference alone would not account for major differences in site discovery.

D.4.2 Probability of Detection

Once a site is intersected, it still needs to be detected. In other words, artifacts or features that form the site have to be detected for the site to actually be discovered. Typically, the probability of detection is modeled as the probability that at least one artifact or feature will be detected in an intersected site. As a result, a major factor influencing the probability of detection is artifact density, with higher artifact densities leading to higher detection rates. Other factors that affect

[19] Banning (2002) provides additional formulas for linear and elliptical sites but, unfortunately, these appear to produce spurious results in some cases.

site detection are ground visibility and artifact size, shape, and color (Banning 2002; Ebert 1992; Wandsinder and Camilli 1992).

Shott (1985) suggests that the probability of detection (p_d) can be modeled using the following formula:

$$\text{Eq 1.} \quad p_d = 1 - e^{-kad}$$

Where *a* is the site area being intersected or otherwise observed, *d* is artifact density, and *k* is a constant that accounts for factors such as visibility.

Using the available data, *a* and *d* are relatively easy to calculate. If we assume that transects are 3 m wide, we can estimate that a typical sample fraction for a survey unit in which a 30 m-spacing interval is used would be around 0.1, or 10 percent (see Heilen et al. 2008). Thus, we can take 10 percent of a site's size as an estimate for *a*. Artifact density for sites with prehistoric lithic scatters can be calculated using the prehistoric artifact totals and site size estimates discussed above. Estimating a value for *k* is more difficult.

To estimate a value to use for *k* in Equation 1, we used the average size and artifact density for sites with prehistoric lithic-scatter components and an estimate that 33 percent of prehistoric lithic scatters were detected. We then used this estimate for *k* as a constant to plug into the equation when estimating the probability of detection for any particular site.

Based on statistics calculated for site sizes, we can assume that sites with prehistoric lithic-scatter components are typically around 2,000 sq m in size or around 1,900 sq m in size if we remove from consideration the three multicomponent sites with prehistoric lithic-scatter components. Artifact densities for lithic scatters range from 0.001 to 0.4 artifacts per sq m and average approximately 0.045 artifacts per sq m, with nearly all sites with prehistoric lithic-scatter components having artifact densities less than 0.2 artifacts per sq m. If we assume, as was suggested by analysis of the survey data above, that around 33 percent of lithic scatters are discovered under conditions of poor visibility and that around 10 percent of a site is typically intersected using a spacing interval of 30 m, we can use the average site size and average artifact density for prehistoric lithic scatters to estimate a value for *k*. In this case, we can estimate that $k = 0.04$ when the probability of detection is 0.33, artifact density is 0.045 artifacts per sq m, and site size is 1,900 sq m.

In all likelihood, *k* is lower than 0.04 under normal conditions for the project area, as it is probable that not all sites have been discovered in the project area and the detection rate was probably less than 33 percent. However, assigning such a value to *k* at least allows us to use a reasonable and consistent value for *k* in order to calculate the probability of detection for each prehistoric site. The results clearly show that the probability of detection is substantially lower for the new sites in comparison to previously recorded sites in the project area (Table D-11 and Figure D-5). As with site size and artifact density, the mean, median, and 10 percent trimmed mean of the probability of detection are lower for new sites in comparison to previously recorded sites.

Table D-11. Comparison of Statistics on the Probability of Detection between Previously Recorded Sites and Newly Discovered Sites in the Clover Fire Project Area

Statistic	Previously Recorded Sites with Prehistoric Lithic Scatter Components	New Sites with Prehistoric Lithic Scatter Components
N	17	24
Minimum	0.066	0.02
Maximum	1	0.814
Median	0.316	0.165
Mean	0.441	0.323
Standard deviation	0.319	0.271
10% upper trimmed mean	0.419	0.294
Number of observations trimmed out	4	6

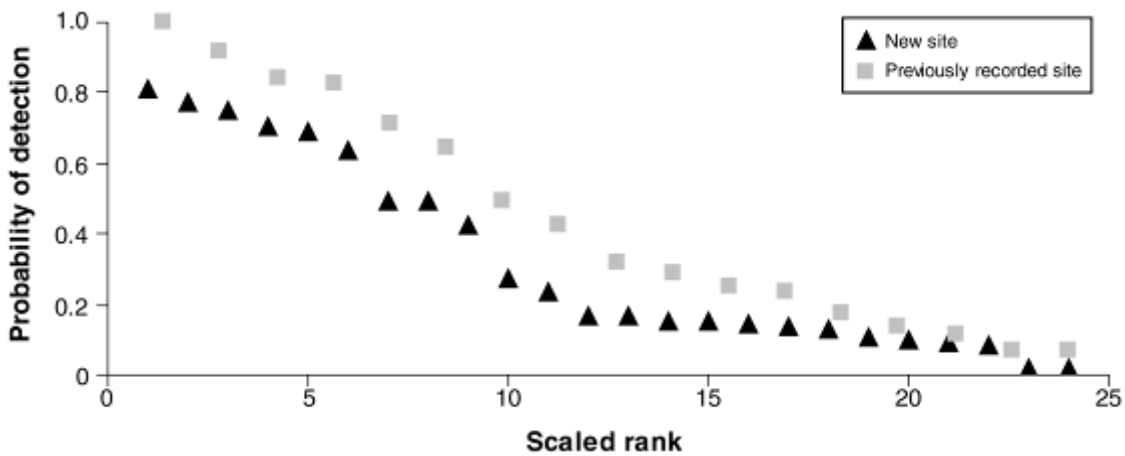

Figure D-5. Scaled rank size plot of the probability of detection for prehistoric lithic-scatter sites discovered during previous survey and resurvey in the Clover Fire Survey Project area.

D.4.3 Probability of Discovery

Shott (1985) argued that the probability of discovery is ultimately the product of the probability of intersection and the probability of detection. Thus, we can multiply the two probabilities as calculated above to derive a probability of discovery for each site with a prehistoric lithic-scatter component. Because the probability of intersection is relatively high for most sites and most sites are large enough that they are highly likely to be intersected, the probability of intersection has only minimal impact on the probability of discovery. As such, the results are similar to those obtained for the probability of detection (Figure D-6). But, they reinforce the fact that the new sites had a lower probability of discovery than the previously recorded sites due to smaller site sizes and artifact densities.

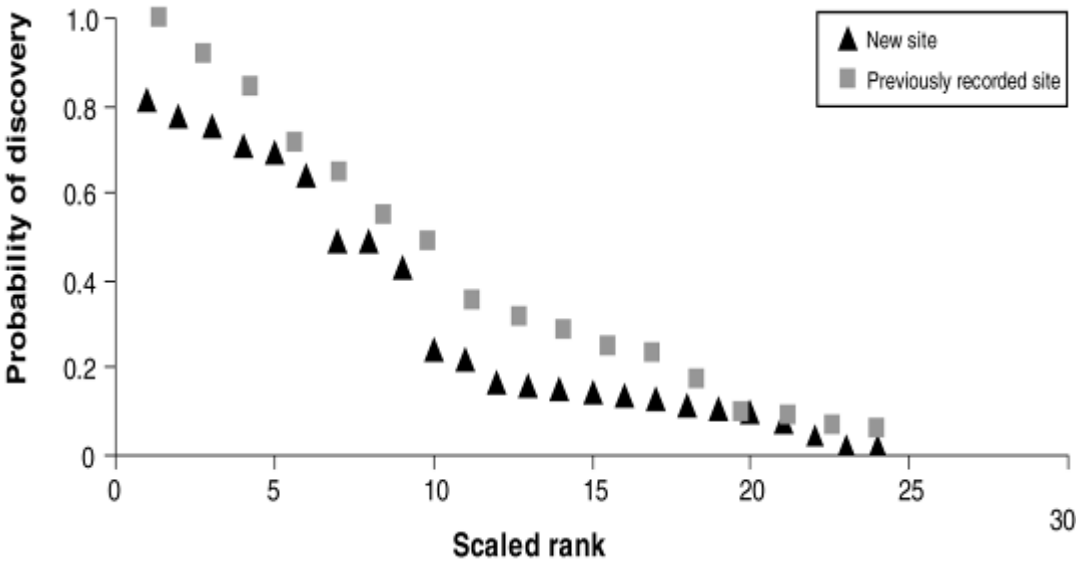

Figure D-6. Scaled rank size plot of the probability of discovery for prehistoric lithic-scatter sites discovered during previous survey and resurvey in the Clover Fire Survey Project area.

This provides some explanation as to why these sites were missed during previous survey. The implication is that the smaller size and lower artifact density of the new sites, along with their relatively unobtrusive content (relatively small stone flakes and tools as opposed to larger, bulkier metal cans and other industrially manufactured objects) contributed to these sites being missed by previous survey.

D.4.4 The Implications for Significance and Eligibility Evaluations

Despite being smaller and having lower artifact densities, the new sites yielded important diagnostic information just as often as sites that had been previously recorded (see Table D-9). At face value, this finding suggests that although smaller and lower in artifact density, these sites could be just as likely to provide significant information contributing to research. This does not appear to be the case in practice, however. Although nearly all of the sites recommended as eligible for listing in the National Register had prehistoric components, whether new or previously recorded, there were substantially different rates at which sites with prehistoric components were recommended as eligible. Fifteen of the 17 previously recorded sites with prehistoric components were recommended as eligible, whereas only 15 of the 26 new sites with prehistoric components were recommended as eligible. In a sense, this is good news, because it means that although a large proportion of prehistoric components are not represented by previous survey, eligible sites are comparatively overrepresented by previous survey. This could mean that when areas of SCR are resurveyed under improved visibility conditions, large numbers of sites with prehistoric components could be found, but perhaps around half of them would be of sufficient integrity and content as to warrant a recommendation of eligible for listing in the National Register.

D.5 MODELING VISIBILITY

Up to now, we have discussed the implications of the Clover Fire survey results for understanding the potential effects that improved visibility could have on the discovery of archaeological sites and materials on SCR. It should be clear that survey during conditions of improved visibility can result in a substantial increase in site discovery, artifact density, and diagnostic information, particularly for sites with prehistoric components. What has not yet been discussed is where we can expect similar visibility conditions to have existed in other areas of SCR, so that managers can begin to determine where on the range the problem is likely to be more or less severe.

In this section, we discuss the construction of a spatial model of archaeological visibility on SCR. The model was created using visibility estimates derived from survey reports for a sample of survey parcels and environmental data on vegetation types and soil types derived from recent environmental GIS datasets. The statistical approach used to develop the model is a relatively new modeling technique referred to as Random Forests (Breiman 2001; Prasad et al. 2006), discussed below.

It will be shown that, although it is still fairly error prone, the model provides a reasonable first approximation of where poor visibility areas can be expected on SCR. Furthermore, the model also indicates that, in comparison to previously recorded sites, a large proportion of new sites in the Clover Fire Survey Project area were discovered in areas estimated to have poor visibility during previous survey. This provides further support that a major factor influencing variation in site discovery on SCR has been visibility and that the model helps to explain some variation in survey results.

D.5.1 The Dependent Variable: Reported Visibility of Previously Surveyed Land Parcels

Limited data on archaeological visibility are presented in a series of reports detailing the results of survey on SCR. We were able to obtain visibility data at the level of a quarter-section (160 ac or 64.75 ha) from four separate archaeological survey reports documenting surveys conducted in 1998, 1999, 2000, 2003 (Rudolph and Bennick 1999, 2000, 2001; Rudolph et al. 2004). Together, these visibility data are relatively broadly distributed across SCR, covering approximately 50 percent of the range (Figure D-7). Visibility data are rare to absent, however, within the Exclusive Use Area, as well as along the northeastern and southeastern borders of the range.

Three of the reports from which we obtained visibility data provided maps showing each quarter-section surveyed according to three ordinal visibility categories: 0–50 percent, 51–75 percent, and 76–100 percent. By contrast, one survey report presented visibility in increments of 5 or 10 percent (i.e., 20 percent, 40 percent, 65 percent, and so forth) (Rudolph and Bennick 1999). Because no similarly quantified data were available for the other surveys, visibility estimates for this survey were converted into the ordinal categories used for the other surveys.

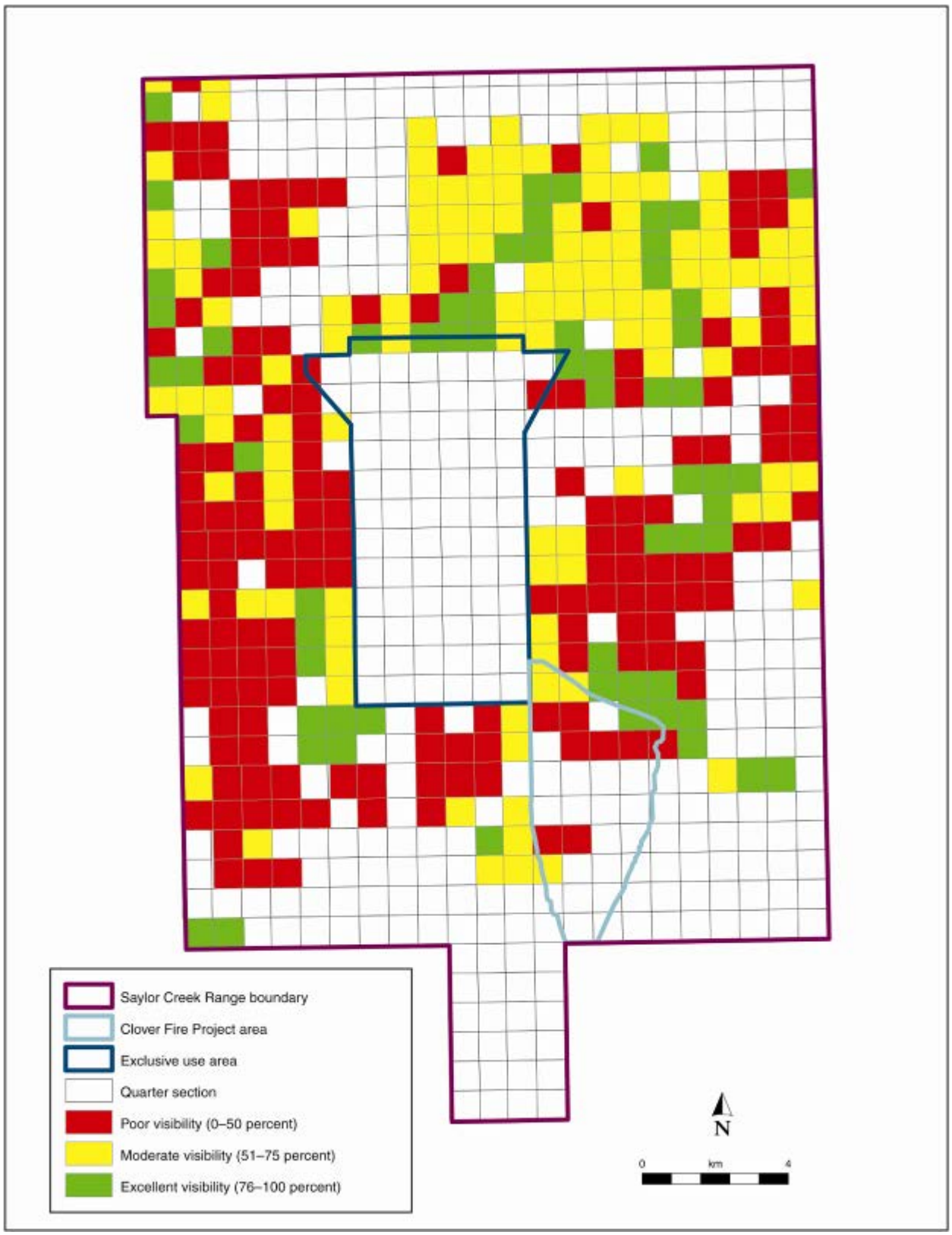

Figure D-7. Quarter section units characterized by previous survey as of poor, moderate, or excellent visibility.

Unfortunately, very little information is presented in the reports concerning how visibility was determined. More than likely, visibility estimates were essentially subjective estimates based on judgments made in the field during the course of survey. Thus, it could be the case that estimates made by different investigators or at different times will have varied based on variation in estimation methods or the impressions of investigators, rather than based on directly measured attributes of the environment. However, because visibility estimates are relatively coarse grained and are based on broad ordinal categories, the effect of inter-observer error may be somewhat minimized. Moreover, as will be discussed below, relatively strong models could only be developed when visibility scores were treated as a binary variable, corresponding to poor visibility (0–50 percent) and moderate to excellent visibility (51–100 percent). Therefore, the effects of uncontrolled inter-observer error and measurement error are minimized by lumping visibility estimates into one of two broad categories.

D.5.2 Independent Variables

Given the importance of vegetation and sediments in determining archaeological visibility, we focused on developing variables from available vegetation and soils mapping data. The vegetation data were derived from the existing vegetation layer of the LANDFIRE vegetation map. Mapping units in the layer are derived from NatureServe's terrestrial ecological systems classification, a national system for classifying ecological systems (USFS 2006). Soil data were derived from the National Resource Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (NRCS 2008c). Soils data for the SCR are presented in Appendix J and Appendix K.

To develop the independent variables for model development, we first calculated the amount of area of each vegetation type and soil type occurring within each visibility class (poor, moderate, or excellent). Soil types were lumped into soil families due to the large number of soil types on the range and the comparatively small number of sample units (i.e., quarter-sections). Z-Score tests of proportion were run for each visibility class in order to test whether the proportion of a given vegetation type or soil type was significantly different between a visibility class and the overall sample. To calculate a Z-Score test for proportions, a pooled sample proportion (p) is calculated using the proportion for the two samples to be compared (p_1, p_2) along with the size of each sample (n_1, n_2):

$$p = ([p_1 * n_1] + [p_2 * n_2]) / (n_1 + n_2)$$

The standard error (SE) of the difference between the two proportions is then calculated using the pooled sample proportion (p) and the sample size for each distribution:

$$SE = \text{sqrt}\ (p * [1 – p] * [(1/n_1) + (1/n_2)])$$

A Z-Score (Z) is then calculated using the proportions for each sample and the standard error of the difference between the two proportions:

$$Z = (p_1 - p_2) / SE$$

A Z-Score greater than or equal to 1.96 indicates a proportion that is significantly higher at the 95 percent confidence level than the expected proportion; a Z-Score less than or equal to -1.96 indicates a proportion that is significantly lower at the 95 percent confidence level than the expected proportion (Ott and Longnecker 2001). The results indicated significant differences among visibility classes for 9 of the 15 vegetation types present within the sampling frame and for 12 of the 19 soil families (Table D-12 and Table D-13). Differences were considered significant if Z-Scores were greater than 1.96 or less than -1.96, representing a difference that is significant at two standard deviations. In the case of soils, only 5 of the 12 soil families considered to exhibit significant differences in their distribution were used in modeling, as 7 of these soil families covered very small and relatively discrete areas of the installation.

Table D-12. Z-Score Tests of Proportion Results for Quarter Sections Classed as Having Poor, Moderate, and Excellent Visibility on Saylor Creek Range, Per Vegetation Type

Vegetation Type	Proportion of Vegetation Type in Sample Frame	Poor Visibility	Moderate Visibility	Excellent Visibility
Barren	0.00	-0.01	0.00	-0.01
Inter-Mountain Basins Sparsely Vegetated Systems	0.00	0.03	0.06	-0.15
Inter-Mountain Basins Big Sagebrush Shrubland	0.33	-22.90	18.65	8.53
Inter-Mountain Basins Mixed Salt Desert Scrub	0.11	5.78	-8.34	-0.55
Rocky Mountain Lower Montane-Foothill Shrubland	0.00	-0.04	—	0.01
Columbia Plateau Steppe and Grassland	0.01	0.44	1.29	-4.60
Inter-Mountain Basins Big Sagebrush Steppe	0.25	-10.34	15.05	-5.47
Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.01	0.53	-0.75	-0.05
Inter-Mountain Basins Greasewood Flat	0.01	0.78	-2.42	0.37
Inter-Mountain Basins Montane Riparian Systems	0.04	-5.33	1.26	-1.00
Rocky Mountain Subalpine/Upper Montane Riparian Systems	0.01	0.29	—	0.28
Introduced Upland Vegetation–Annual Grassland	0.15	4.71	-33.66	-9.49
Introduced Upland Vegetation–Perennial Grassland and Forbland	0.04	0.20	2.15	1.31
Introduced Upland Vegetation–Annual and Biennial Forbland	0.04	3.41	-10.84	0.02
Artemisia tridentata ssp. *vaseyana* Shrubland Alliance	0.01	0.16	—	—

Table D-13. Z-Score Tests of Proportion Results Quarter Sections Classed as Having Poor, Moderate, and Excellent Visibility on Saylor Creek Range, Per Soil Type

Soil Family	Proportion of Soil Family in Sample Frame	Poor Visibility	Moderate Visibility	Excellent Visibility
Unspecified	0.13	-3.64	-0.51	6.25
Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Durinodic Xeric Haplocalcids	0.01	-3.34	0.11	0.88
Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Typic Haplocalcids mesic, Typic Calciorthids	0.00	—	—	-0.65
Coarse-loamy, mixed, superactive, mesic Xereptic Haplodurids	0.06	-0.15	-0.20	0.53
Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	0.07	-7.98	5.82	3.13
Coarse-silty, mixed, superactive, mesic Xereptic Haplodurids	0.00	-0.23	—	—
Coarse-silty, mixed, superactive, mesic Xeric Haplocambids	0.20	-0.86	-14.13	16.06
Coarse-silty, mixed, superactive, mesic Xeric Haplodurids	0.00	—	—	-0.07
Fine, smectitic, mesic Abruptic Xeric Argidurids	0.01	-0.13	1.55	-4.14
Fine-loamy, mixed, superactive, mesic Xeric Argidurids	0.02	1.20	-1.77	0.11
Fine-silty, mixed, superactive, mesic Durinodic Xeric Haplargids	0.15	-7.07	14.50	-14.75
Fine-silty, mixed, superactive, mesic Haploxeralfic Argidurids	0.23	16.17	-3.35	-29.07
Fine-silty, mixed, superactive, mesic Xeric Calciargids	0.01	0.92	-2.52	0.49
Loamy, mixed, superactive, mesic Lithic Xeric Haplocambids	0.00	-0.90	0.36	—
Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	0.03	-1.40	-0.77	2.52
Loamy, mixed, superactive, mesic, shallow Xeric Haplodurids	0.01	-2.99	—	0.59
Mixed, mesic Xeric Torripsamments	0.01	1.75	-5.29	0.93
Sandy, mixed, mesic Xereptic Haplodurids	0.03	3.20	-6.86	-0.34
Sandy, mixed, mesic Xeric Haplocambids	0.01	0.62	-0.01	-1.24

Each of the 9 vegetation types and 5 soil types that were demonstrated to be significantly more or less common for one or more visibility class was used to create a continuous variable for modeling. Each of the 9 vegetation types and 5 soil types were converted into a binary raster, where the vegetation type or soil type of interest equaled 1 and all other cells were made to equal 0. Zonal statistics were then run on each of the binary rasters per quarter-section in which visibility estimates were made, with each quarter-section defined as a zone. The mean value for each binary raster within each zone (or quarter-section) represents the proportion of a given vegetation or soil type occurring within the quarter-section. These data—the visibility estimates per quarter-section and the proportion of each vegetation type per quarter-section—formed the training and testing data for developing a predictive model.

To map the predictive model in space, a comparable continuous variable was developed in a GIS for each of the 9 vegetation types and 5 soil types. Using the binary rasters for each vegetation

type discussed above, we calculated neighborhood statistics for each of the binary rasters, using a rectangular window of dimensions equivalent to the median dimensions of a quarter-section in the project area. This turns out to be 27-by-27 cells (162.1 ac). Calculating the raster layers in this manner allowed each of the 9 vegetation types and 5 soil types to be represented as a continuous variable across the project area and scaled in a manner identical to the way the variable was measured by quarter-section. At the same time, this allows us to map the variation continuously across space at the resolution of the raster grids (30-by-30-m cells), rather than at the resolution of quarter-sections in the quarter-section grid. In other words, this allows us to make spatial predictions at the scale of the cells in the vegetation and soil layers (30-by-30 m cells) instead of at the scale of quarter-sections (27-by-27 cells or 810-by-810 m).

D.5.3 Random Forest Modeling

The modeling approach chosen for the visibility modeling is a recently developed statistical approach referred to as Random Forests (Breiman 2001; Prasad et al. 2006). As discussed in Section 5.4.1.2, Random Forests are a kind of Classification and Regression Tree (CART) analysis that performs classification or regression analysis by bootstrapping variables and cases to create hundreds or thousands of decision trees that are ultimately combined to create a predictive model.

Initial attempts at developing a Random Forests model using the three visibility classes discussed above proved disappointing, mainly due to the relatively small number of quarter-sections assigned to the excellent visibility class and the relative coarseness of the visibility data. Thus, we reduced the number of visibility classes to two, corresponding to poor (0–50) or moderate to excellent (51–100). Using this binary classification, model predictions were much better and produced intuitively reasonable results. However, it should be noted that the misclassification rates remain relatively high, on the order of 30+ percent, and the area under the receiver operating characteristic (ROC) curve is only 76 percent for the best iterations of the model, indicating that the model works reasonably well but is neither very sensitive nor very specific. In other words, the true positive rate is not as high as would be expected for an excellent model and the false positive rate is higher than would be expected for an excellent model. Values above 90 percent for the area under the ROC are generally considered to represent excellent models with mostly true positives and very few false positives.

To derive the best-performing model, multiple models were run by first using all the variables (9 vegetation-derived and 5 soil-derived variables) and then removing variables based on measures of variable importance. However, removing variables did not markedly improve model performance and generally tended to weaken performance. This may be because the variables had already been preselected as statistically meaningful based on the Z-Score tests of proportion presented above. Therefore, the model selected as the best performer used all 9 vegetation-derived and all 5 soil-derived variables (Figure D-8). This model had 74 percent of area under the ROC curve, indicating that it works reasonably well, but that false positives occur at a fairly high rate. False positives occurred at a rate 27 percent and false negatives at a rate of 36 percent (Table D-14).

Despite the fairly high false positive and false negative rates, which are understandable given the coarse-grained and subjective nature of the visibility data, the model appears to produce a

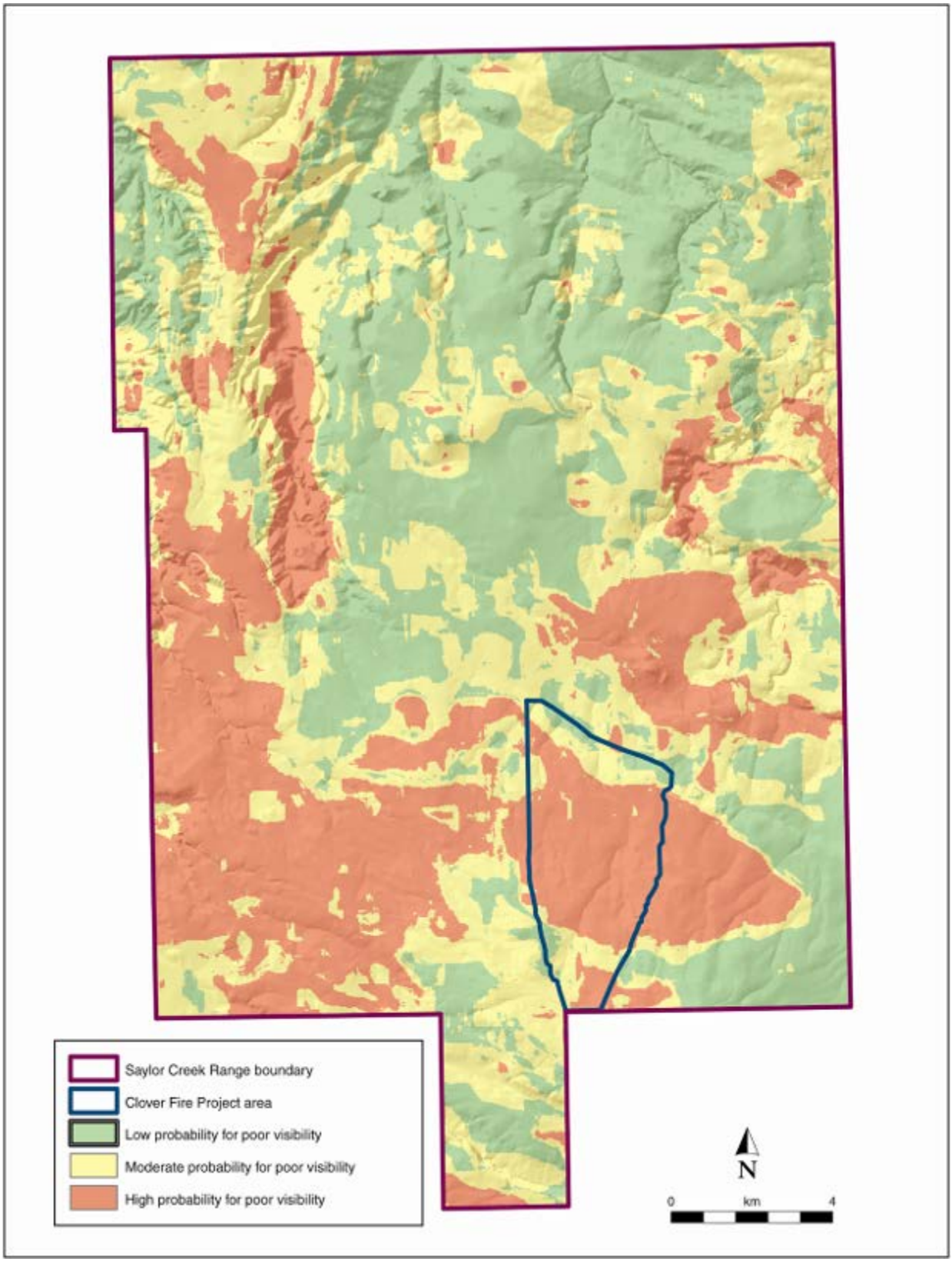

Figure D-8. The Random Forest model of archaeological visibility during previous survey on SCR.

Table D-14. Confusion Matrix for the Random Forest Model of Archaeological Visibility for Previous Survey on the Saylor Creek Range

Observation	Negative Prediction	Positive Prediction	Class Error (%)
Negative observation	133	50	27.3
Positive observation	57	101	36.1

reasonable approximation of archaeological visibility. The model predicts that a large, relatively continuous area in the southern and western portions of SCR is most likely to contain areas where archaeological visibility would have been considered poor during previous survey. Other large areas in the eastern-central portion of the range—as well as patches in other portions of the range—are predicted to have been characterized by poor visibility as well. By contrast, large areas in the central and northern portions of the range, as well as smaller areas, are predicted not to have been characterized by poor visibility and thus would have most likely been considered to have been of either moderate or excellent visibility.

In addition, visual comparison of the quarter-section visibility estimates with model predictions shows that the model closely matches predictions. For instance, in cases where an isolated quarter-section was judged to be of poor visibility, but nearby quarter-sections were judged to be of moderate or excellent visibility, there is often an area within that quarter-section that the model has predicted as being of poor visibility, suggesting that the model works about as well as it can with the quarter-section-scaled data.

Several model performance measures adopted for the ESTCP project were used to further evaluate the model performance: S, Gain over Random (GOR), and Gain. The main quantitative metric used to evaluate model performance for the project is the S or the Sensitivity Score. S is a ratio of the proportion of area encompassed by a sensitivity zone to the proportion of targets (e.g., archaeological sites or areas of poor visibility in this case) located in that sensitivity zone. Assuming that each sensitivity zone has at least 1 target, S varies from 0 to infinity. The higher the proportion of targets to the proportion of land covered by a sensitivity zone, the closer S is to 0.

For example, if 10 percent of the area encompassed by the model is considered the high-sensitivity zone, and it contains 90 percent of all the sites found in the model area, then the S Score for the high-sensitivity zone is 0.11. At 1.0, the proportion of archaeological sites in the sensitivity zone is the same as the proportion of land to the total sample universe; in essence, the model is no better predictor than random guesses. Beyond 1.0, the higher the S Score, the greater the proportion of land area in the sensitivity zone to the entire sample universe to the proportion of archaeological sites in the sensitivity zone. A good model then has a low S Score for high-sensitivity zones, a score below 1.0 for medium-sensitivity zones, and a score substantially greater than 1.0 for low-sensitivity zones.

It should be noted that S was developed in order to test the performance of models of archaeological site location and that the expected scores for different sensitivity zones do not necessarily apply to the current situation in the same way as they do to models of archaeological site location. This is because optimization of S attempts to place the greatest number of

archaeological sites within the smallest possible area. In the case of archaeological visibility, there is no need to expect that the model will reduce the amount of poor visibility area to the smallest area possible, as areas of poor visibility cover large portions of the range. Indeed, 48 percent of visibility samples were considered to be of poor visibility. Moreover, it may be useful to SCR to take a relatively conservative approach in considering which areas could have been of poor visibility.

In the case of SCR visibility model, the S Score for areas considered to be of high probability for poor visibility was 0.53 (Table D-15). The S Score for areas that are medium probability for poor visibility is 1.02 and the S Score for areas that are low probability for poor visibility is 4.06. These scores are generally in the range of where we would want them to be, but if this were a model of archaeological site location, we would want the S Score for areas predicted to be of high and medium sensitivity for poor visibility to be lower.

Table D-15. Performance Metrics Calculated for the Random Forest Model of Archaeological Visibility for Previous Survey on Saylor Creek Range

Visibility Zone	Proportion of Model Area	Proportion of Poor Visibility Quarter Sections in Model Zone	S	Gain Over Random	Gain
Low sensitivity for poor visibility	0.36	0.09	4.06	-0.27	-3.06
Moderate sensitivity for poor visibility	0.32	0.31	1.02	-0.01	-0.02
High sensitivity for poor visibility	0.32	0.60	0.53	0.28	0.47
High or Moderate sensitivity for poor visibility	0.64	0.91	0.70	0.27	0.30

The other two metrics used to assess model performance are Gain and GOR, both of which are closely related to the S Score. The Gain statistic was defined to indicate whether a predictive model demonstrates "gain (e.g., in terms of percent correct predictions) over a purely random model with no predictive capacity" (Kvamme 1988:329 [emphasis in original]). Gain is defined as follows:

Gain = 1– (percentage of total area covered by model/percentage of total sites within model area)

As the Gain statistic approaches +1.0 the model's predictive accuracy improves. A Gain Score near 0.0 signifies the model has little to no predictive accuracy. A negative Gain Score means the model is actually a worse predictor than random guesses. When calculated per sensitivity zone, it is expected that a high-sensitivity zone should have a positive Gain, a medium-sensitivity zone should have a Gain that is weakly positive or close to zero, and a low-sensitivity zone should have a negative Gain. This is because we would expect that the majority of sites would be found in a comparatively small high-sensitivity zone, while the discovery of sites in a medium-sensitivity zone should be closer to a random model. A minority of sites should be found in a comparatively large low-sensitivity zone, a situation that should correspondingly result in a negative Gain.

GOR is a related statistic that uses a random sample of surveyed areas to calculate an index value based on the difference between the percentage of correct predictions and the percentage of model area (Kvamme 1992). GOR is defined as:

GOR = (percentage of sites within model area – percentage of area covered by model area)

The Gain of the model as calculated for areas highly likely to be of poor visibility is 0.47. For both areas that are moderately or highly likely to be of poor visibility, the metric is 0.30. Together, these metrics suggest that model has a moderate to low predictive capacity. Similarly, the GOR statistic is 0.28 for areas highly likely to be of poor visibility and 0.27 for areas that are moderately or highly likely to be of poor visibility, combined. Thus, the model definitely works better than random and has some predictive capacity. The model can only be treated as a reasonable first approximation of where poor visibility areas are likely to have been during previous survey, however.

D.5.4 Evaluation of the Model in the Clover Fire Survey Project Area

As mentioned above, the visibility model appears to be a reasonable first approximation of visibility conditions during previous survey, but cannot be considered highly accurate. Thankfully, the predictions of the model cover fairly large, continuous areas rather than highly patchy and discontinuous areas. Thus, at the very least, the model suggests general areas of SCR where visibility is likely to have been better or worse.

Even though the model is a fairly gross approximation of archaeological visibility (and again this is to be expected given the characteristics of the available data), the distribution of the model in the Clover Fire Survey Project area converges closely with what we might expect. We might expect that new sites discovered after the fire would have more often than previously recorded sites been in areas previously considered to be of poor archaeological visibility. Indeed, 17 of 32 previously recorded sites fall in areas highly likely to have been of poor archaeological visibility during previous survey, or roughly 50 percent (Figure D-9). By contrast, 25 of 29 new sites occur in areas highly likely to be of poor archaeological visibility, or 86 percent. This suggests the model could be keying into real properties of the archaeological landscape and that new sites may have been missed, in part, because they occurred in areas where visibility was worst.

D.6 SUMMARY AND RECOMMENDATIONS

The Clover Fire survey (Polk and Weymouth 2006) provided some surprising results that demonstrate what could potentially be found in previously surveyed areas when those areas are resurveyed under improved visibility conditions. Of course, organizational differences in survey were sometimes substantially larger than previously recorded, and that these sites contained a much greater abundance and diversity of artifacts than previously recorded. Moreover, the biases evident in the results of previous survey were primarily evident in prehistoric sites.

Additional analysis of the data revealed that resurvey under similar conditions could result in as much as three times as much site area for prehistoric sites as originally recorded, with some site

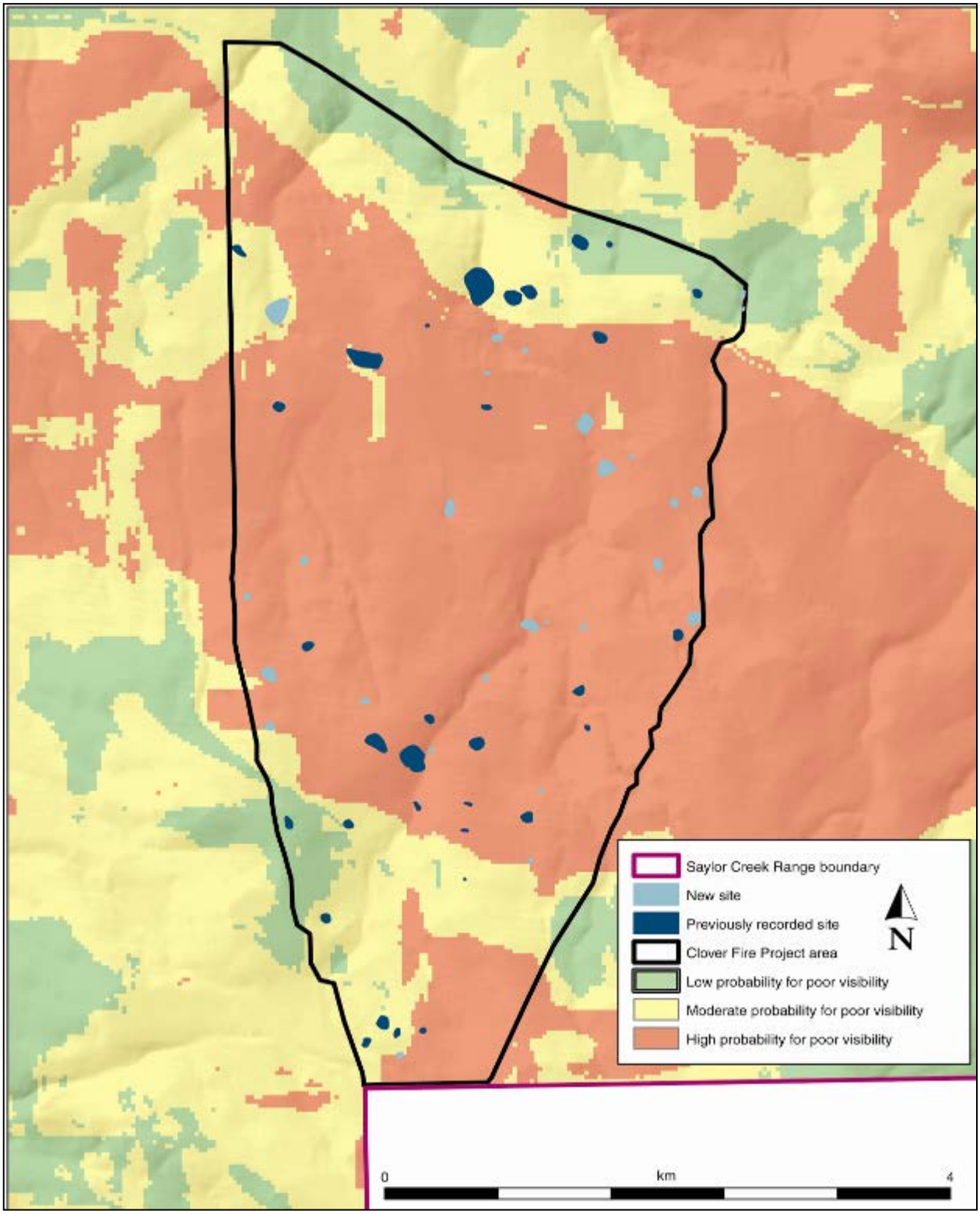

Figure D-9. Close-up of a portion of the Random Forest model of archaeological visibility, showing the location of previously recorded and newly discovered sites in the Clover Fire Survey Project area.

boundaries expanding to several times their original size, and artifact densities twice as large as recorded previously. In addition, many more diagnostic artifacts were discovered when sites were rerecorded, suggesting that resurvey of previously surveyed areas could result in drastically different eligibility evaluations. New sites with prehistoric components were less often determined eligible, however, suggesting that previously recorded sites (at least prehistoric sites), are more likely to be determined eligible than sites that were missed by previous survey.

Evaluation of probabilities of intersection, detection, and discovery suggested that, although most sites were likely to be intersected by survey, the typically smaller size and lower artifact density of the new sites resulted in lower probabilities of detection, and ultimately, lower probabilities of discovery. Coupled with the fact that these sites were overwhelmingly located in parts of the project area where poor archaeological visibility was most likely to have occurred during previous survey, it seems that these sites truly were missed due to poor visibility and had probabilities of discovery lower than sites that had been previously recorded.

As discussed above, we were able to develop a preliminary model of archaeological visibility using available data from previous survey on archaeological visibility, which were recorded at the level of a quarter-section. There is little doubt that these visibility data are coarse grained and fairly subjective. Nonetheless, they were useful in developing a model that provides a first approximation of where areas of poor visibility are likely to have occurred during previous survey. As is, the current model provides an indication of where conditions similar to what was encountered during the Clover Fire Survey Project can be expected. A more refined model could possibly be developed using visibility data that were obtained in a more systematic fashion, but those data would likely be more representative of the conditions that exist today, rather than the conditions that existed during previous survey. Nonetheless, given the extent of the problem, it would be useful for SCR to integrate a program of systematic measurement of archaeological visibility with ongoing survey and evaluation projects, so that more data could be collected to assess the problem.

Having only a single project area with which to assess the visibility problem and its effects on archaeological discovery is also somewhat problematic. Some of the differences in discovery could be highly specific to the project area and not generalizable to the rest of SCR. However, the patterns emerging from analysis of the project results are fairly clear, suggesting that they could be at least partially representative of conditions existing elsewhere on the range. There appears to be a strong bias against the discovery of prehistoric lithic scatters with perhaps no more than 33 percent of such components having been discovered. This may be acceptable for the management of the range, depending on its management needs, but it does suggest that much less is known about prehistoric sites that could be known if such sites were discovered and documented under improved visibility conditions.

Given the surprising results of the Clover Fire Survey Project and their implications for the results of previous survey on other parts of SCR, it would be advisable to continue to resurvey previously surveyed areas after fires. Doing so would provide a larger sample of observations from different parts of the range on the effects of a change in visibility on site discovery and recordation. Disparities between pre- and post-fire results could be quantified and evaluated with reference to the predictions of the visibility model presented in this chapter. If the magnitude and

direction of differences between previous survey and resurvey (in variables such as site size, artifact density, tool counts, and number of diagnostic types) are consistent with the predictions of the model, then greater confidence can be placed in the ability of the model to predict the reliability of previous survey. In other words, if differences between previous survey and resurvey are largest and positive for areas predicted to have been of poor visibility and smallest for areas not likely to have been of poor visibility, then it could be concluded with greater confidence that the model is working.

Another way to test the model would be to evaluate the size, content, and discovery probabilities of sites found in different visibility zones across the range. This would allow for an objective assessment of whether variation in predicted visibility has systematically affected the quality and quantity of archaeological observations during previous survey.

APPENDIX E:
RED FLAG MODEL: AN ETHNOGRAPHIC PREDICTIVE MODEL FOR THE UTAH TEST AND TRAINING RANGE[20]

E.1 INTRODUCTION

Section 110 of the National Historic Preservation Act, added as an amendment in 1980, makes explicit the responsibilities of federal agencies to identify and protect historic properties on agency lands. Hill Air Force Base (AFB) works to meet its obligations under Section 110 of the NHPA through the identification and management of surface and subsurface archaeological sites and traditional cultural properties (TCPs) (Parker and King 1998). Whereas archaeological sites have been part of a long history of research in Utah, TCPs are a relatively new concept in cultural resources. Parker and King (1998:1) define a TCP as "one that is eligible for inclusion in the National Register because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community."

Hill AFB manages the Utah Test and Training Range (UTTR), encompassing some 1,502.7 sq mi of land (961,757.6 ac), including UTTR-North, UTTR-South, and the Wendover Auxiliary Area (Figure E-1). The 2007 Hill AFB Integrated Cultural Resources Management Plan (ICRMP) noted that Hill AFB manages 485 archaeological sites located on the UTTR. Of these, 231 are eligible for listing in the National Register of Historic Places (NRHP); 204 of the 231 are prehistoric, 25 are from the historical period, and 2 are multicomponent prehistoric and historical period (United States Air Force Materiel Command [USAFMC] 2007). Locating, testing, and managing cultural properties scattered across such a wide area is a daunting challenge, to say the least. This obligation is met in part through the execution of systematic Phase I pedestrian survey and Phase II subsurface testing (e.g., Arkush 1997; Carter and Young 2002). As of 2007, 124 cultural resource projects (inventory, testing, monitoring, etc.) had been carried out on Hill AFB lands (US AFMC 2007).

E.1.1 Prehistoric Culture History of UTTR[21]

People have been a part of the Great Salt Lake Desert (GSLD) landscape and the UTTR area for more than 13,000 years. Archaeologists working in the eastern Great Basin, within which the GSLD is the prominent feature, divide the prehistoric record into distinct cultural eras that emphasize similarities in adaptive strategies documented across western North America. Although these cultural eras were defined independently of chronological divisions, archaeologists have found a close relationship between cultural process and chronological patterning of artifact and feature types (e.g., hunting technology, house types, rock art styles).

[20] Analysis and report by Joshua R. Trampier, William E. Hayden, and Michael K. Lerch, Statistical Research, Inc.

[21] This section on the Prehistoric Culture History of the UTTR is cited directly from Young (2008), *The Archaeology of Shifting Environments in the Great Salt Lake Desert: A Geoarchaeological Sensitivity Model and Relative Chronology for the Cultural Resources of the US Air Force Utah Test and Training Range*, Far Western Anthropological Research Group, Inc., Davis, California.

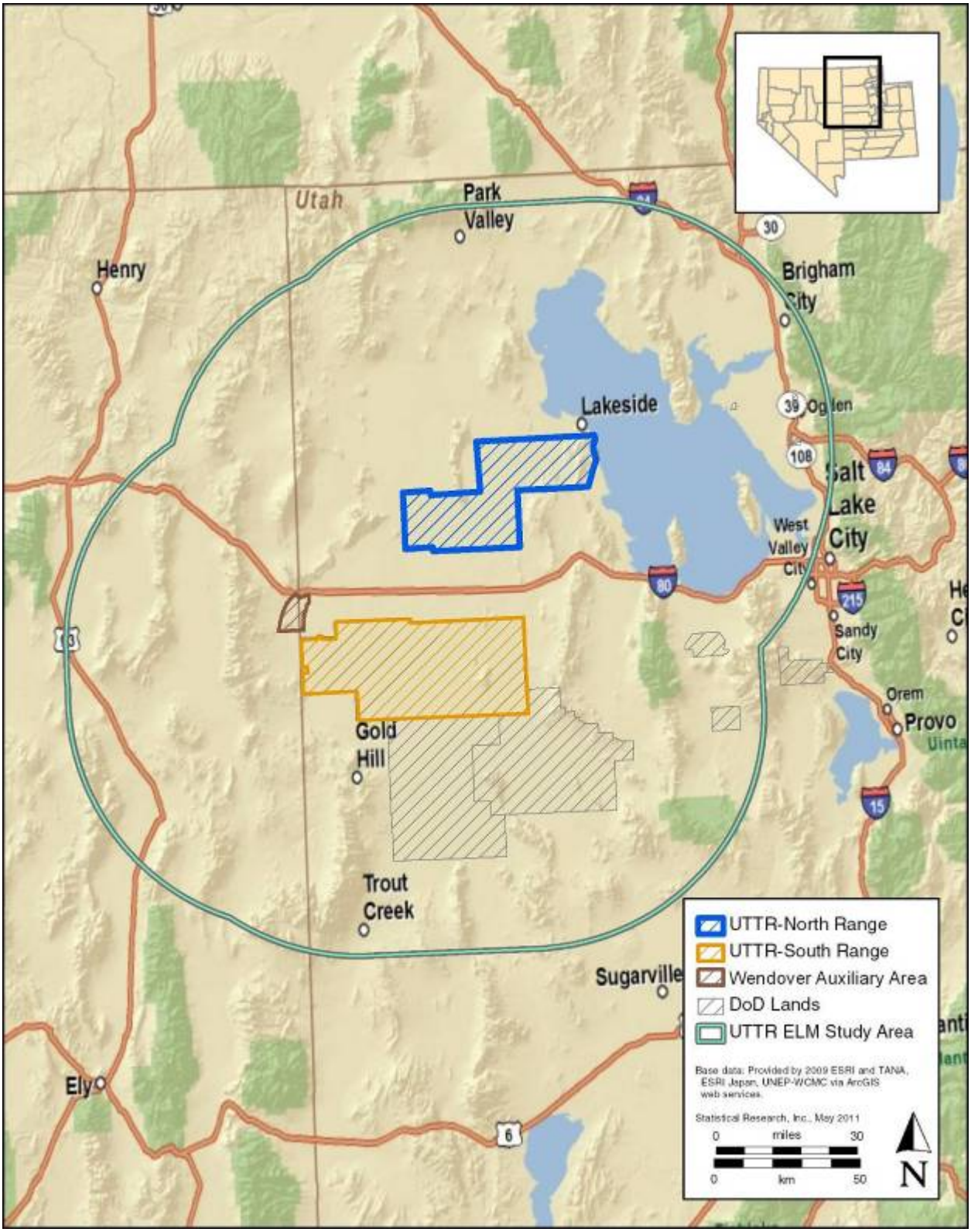

Figure E-1. Location map of UTTR ELM study area.

Regional periods emphasize the local chronological variability within and between archaeological assemblages found throughout the eastern Great Basin.

Great Basin peoples have lived primarily as mobile hunter-gatherers throughout prehistory, adapting through time to changing environmental conditions and population densities. The eastern part of the basin, however, is unique for its archaeological expression of the Fremont Period, during which a relatively sedentary, horticultural to agricultural way of life occurred alongside (and incorporated aspects of) Late Archaic hunter-gatherer strategies. Cultural Resources Inventories in the UTTR (see Figure 2 and Figure 3) identify sites from throughout prehistory, with Bonneville and Wendover period assemblages overwhelming much of the archaeological record (e.g., Arkush and Pitblado 2000; Carter 1999; Carter et al. 2004; Young et al. 2006). These sites are associated with the extinct Old River distributary system, which maintained a productive wetland in the early Holocene that encompassed much of what are now the UTTR lands; significant sites from more recent periods are found in the dune and spring environments in and around the GSLD (e.g., Aikens and Madsen 1986; Carter et al. 2005; Madsen and Schmitt 2005; Young et al. 2008).

Throughout this document, chronological control is based on calibrated calendar years (years ago or years B.P.) prior to AD 1950. Compilation of radiocarbon data, providing direct chronological information on landforms which are the foundation of the geoarchaeological model presented here, relied on calibrations provided by radiocarbon lab results, citations of various authors, and calibration calculations using CALIB 5.0.1 (Stuiver and Reimer 1993) and CALPAL (Weninger et al. 2007) software packages. Temporal periods that divide the Eastern Great Basin Culture Sequence (see Table 1) are likewise presented in calibrated calendar years. Although uncalibrated results provide an initial point of comparison, calibration to and reliance on calendar years allows use of data sets with differing temporal resolutions. It allows relative comparisons between the calibrated results of radiometric techniques (radiocarbon and optical luminescence) and time-dependent physical and biological processes such as obsidian hydration and dendrochronology. In the end, use of calendar years is required because archaeology is the study of human behavior operating on the interval scale of the annual cycle. The periodicity of geomorphic processes should also be measured in calendar-scaled intervals. In this chapter, we present the long-standing taxonomy of regional periods (Aikens and Madsen 1986), a time-based culture history focusing on technology, land use, and subsistence as documented in the regional archaeological record.

E.1.1.1 Paleoindian Period (pre–13,000 B.P.)

This period in the eastern Great Basin is poorly understood. Although fluted projectile points similar to those of the Clovis and Folsom traditions have been found in the region (Taylor 2003; Willig and Aikens 1988), these are largely surficial and lack chronological resolution. Among the nearly 1,000 Paleoindian stemmed points from the UTTR accounted for in this study, only a single fluted point (bearing similarities with Folsom) has been found (Young et al. 2006). A small handful of others are known in the greater region (Copeland and Fike 1988). Fluted point assemblages from the Sunshine Locality (Beck and Jones 1997) and Jakes Valley (Estes and Goebel 2007) in eastern Nevada, and the Hell'N Moriah site near Delta, Utah (Davis et al. 1996) are notable. Fluted points in the Great Basin are usually found on old shorelines, and not in

upland settings, but their distribution is sparse and indicative of only fleeting occupations. There is little else to distinguish this period, and its technological and chronological relationship with the Western Stemmed Tradition remains the subject of debate (e.g., Jones and Beck 1999; Willig and Aikens 1988).

E.1.1.2 Bonneville Period (13,000–10,800 B.P.)

The diagnostic hallmarks of the Bonneville Period are large projectile points of the Western Stemmed Tradition (WST; see Table 1). Temporal data attributed to this period are limited to shelter and cave deposits, most of which are on the margins of pluvial Lake Bonneville. Early dates from Danger Cave (Jennings 1957) and Bonneville Estates Rockshelter (Graf and Schmitt 2007), along with dates from nearby Smith Creek Cave (Bryan 1979), provide direct temporal evidence of Bonneville Period occupations.

As the period name implies, pluvial Lake Bonneville was the central environmental feature related to land use at the Pleistocene-Holocene transition centered around 13,000 years ago. Bonneville Period artifacts associated with the WST dominate the archaeological record of UTTR South (Arkush 1994, 1995, 1997; Arkush and Pitblado 2000; Carter 1999; Carter and Young 2002; Carter et al. 2004; Carter et al. 2005; Duke 2003; Workman 1992, 1993a, 1993b; Young et al. 2006). Madsen (1982) suggested that lake-margin marshes were sufficiently rich to have supported semisedentary land use in the Bonneville Basin. Duke and Young (2007) have demonstrated that extended marsh occupations likely accounts for the rich early record west of Wildcat Mountain.

There is on-going debate on the appropriate rubric for the earliest adaptive strategies present in the Great Basin as discussed most recently in Graf and Schmitt (2007). We rely on the term "Paleoarchaic" (Beck and Jones 1997; Willig 1989) to emphasize the relative continuity of resource focus and technology exhibited by the region's Paleoindian and Early Archaic occupants. The people living in the eastern Great Basin at the time of the Pleistocene-Holocene transition were not practicing either Paleoindian or Archaic adaptations in the classic sense. Resource strategies were oriented toward lake margins and adjacent marsh areas rich in high-value plants, fish, waterfowl, and terrestrial animals; seed processing was a low to nonexistent priority as evidenced by a lack of ground stone. Bedwell (1973) referred to this adaptation in the northwestern Great Basin as the "Western Pluvial Lakes Tradition." It is unlikely, however, that Paleoarchaic strategies were strictly focused on lake-margin marshes, and indeed Paleoarchaic assemblages have been reported from upland settings (e.g., Elston 1994; Heizer and Elsasser 1953; Rusco et al. 1979). Still, many such sites are located in valleys that would have contained lake- or delta-associated marshlands. The more restrictive Western Pluvial Lakes nomenclature has fallen out of favor among archaeologists; even so, Paleoarchaic land use appears to have been conditioned to a great extent by wetland productivity in and around lakes and drainages (Willig 1989; Willig and Aikens 1988).

A focus on fixed resources suggests limited residential movement, but the material record indicates that Paleoarchaic groups practiced a significant level of mobility. One line of evidence is the presence of culturally modified obsidian at considerable distances from its geologic source, obsidian that had to have been transported by humans (Beck and Jones 1990; Jones and Beck

1999; Jones et al. 2003). Beck and Jones (1990) found most of the obsidian in Butte Valley, Nevada to be from the Browns Bench source, some 200 kilometers to the north. Arkush and Pitblado (2000) documented similar transport distances for Browns Bench obsidian at the UTTR. It is believed that obsidian was obtained through direct procurement by Paleoarchaic groups, rather than through exchange (Arkush and Pitblado 2000; Beck and Jones 1990). Jones et al. (2003) suggest a north-south range of up to 500 kilometers for these populations. Early occupants of the eastern Great Basin may have possessed this freedom of movement because population density was much lower than it would be in subsequent periods (Elston 1982).

The stemmed projectile points of the WST can come in refined forms, but they are often crudely worked. Roughly shaped, stemmed dart points are common throughout the southern extent of the GSLD, including portions of the UTTR (Arkush and Pitblado 2000; Carter 1999; Duke and Young 2007; Duke et al. 2004; Young et al. 2006). This concentration of WST assemblages in the paleo-wetland environment implies reduced residential movement (Duke and Young 2007). The common occurrence of rudimentary points and associated tools made from relatively coarse-grained material such as basalt and similar volcanic rocks, counters the notion that mobile toolkits were highly curated and maximized high-grade, fine-grained stone (e.g., Goodyear 1997; Kelly and Todd 1988). Away from the Bonneville basin, elements of the Paleoarchaic toolkit, such as some flake tools, scrapers, and bifacial cores, were highly curated and made from cryptocrystalline silicates (CCS; Beck and Jones 1990). More coarse-grained stone may have been preferred in some areas, but the Great Basin pattern reflects the fact that the most regionally abundant toolstone is preferred. Obsidian in particular was preferred for projectile points when available (Amick 1995; Beck and Jones 1997).

While the interplay among variables such as lake-margin versus upland land use, reliance on plants and small animal versus large game, and expedient versus curated technologies, are not completely understood for the Paleoarchaic, it is clear that these people were focused on wetland environments: the WST toolkit, and activities associated with it, appear to have diminished with the final regression of pluvial lakes and the gradual desiccation of their wetland margins.

E.1.1.3 Wendover Period (10,800–6800 B.P.)

The Wendover Period of the eastern Great Basin marked the gradual transition of Paleoarchaic strategies, especially those focused on lake-margin resources, to more generalized Archaic settlement and subsistence patterns. During this transition, wetlands continued to be emphasized as long as spring discharge maintained resource productivity at distal fan and distributary delta locations (Madsen 1982a; Oviatt et al. 2003). In western Utah, caves were used extensively to access these resource areas, and both Danger Cave (Jennings 1957) and Hogup Cave (Aikens 1970) contain strong Wendover Period deposits reflecting Paleoarchaic or “Early Archaic” strategies (Aikens and Madsen 1986). Danger Cave in particular contains an extensive Wendover Period component.

Wendover Period sites also show greater use of upland areas. As the lakes dried, animal populations shifted to water sources at higher elevations, and human hunting strategies changed in response (Aikens and Madsen 1986). Overall, however, Wendover Period sites resemble preceding periods more than later ones, even with a likely regional increase in population

(Simms 1977). Diagnostic artifacts of the Wendover Period include Pinto, Humboldt, and Large Side-notched forms, and it is likely that WST points continue for at least the first 1,000 years of this period according to the results of this study. Basalt and obsidian continued to be used for stone tools. Ground stone in the form of hand stones and milling slabs is common in cave sites, indicating a general increase in the reliance on milled seeds, such as pickleweed. Perishable artifacts such as coiled basketry, cordage, and bone tools are often found in Wendover Period cave sites. These items are generally simple and portable in nature (Aikens and Madsen 1986). Coiled basketry for containers and trays dominated, but twined basketry items were also produced.

E.1.1.4 Black Rock Period (6800–1600 B.P.)

The Black Rock Period of the eastern Great Basin, spanning more than 5,000 years of prehistory, encompassed a wide range of site types reflecting relatively high variability in technology and land-use strategy (Aikens and Madsen 1986). In fact, defining a single period across the broad range of archaeological assemblages and strategies of this period may mask much of the variability that is revealed in recent documentation and study. In any case, a generalized Middle Archaic strategy resembling those documented throughout the Great Basin appeared in the GSLD soon after 7,000 years ago. Widespread use of upland areas began and soon became an integral part of seasonal patterning. Land use emphasized significant residential movements tied to plant productivity and animal movements, now encompassing a much broader range of resources across space and time. At residential locations such as Mosquito Willies, on the eastern margin of the GSLD, Middle Archaic strategies appear to have focused on large game, especially bighorn sheep (Young et al. 2008). Cave sites, such as Danger and Hogup, continued to be used, but no longer played a central role in regional settlement organization.

Closing a relatively long drought cycle, wetter conditions returned to the eastern Great Basin by 4,800 years ago (Wigand and Rhode 2002). The Neopluvial period likely encouraged upland land use by increasing moisture, as lake margins apparently became less productive (Currey and James 1982). Once-productive seed resources were flooded out, and many lower spring locations may have been inundated by expanding lakes. Diminished diet breadth is indicated at several caves sites in the GSLD area, suggesting that rising lake levels encroached on the spring-fed drainages that had supported the marshlands (Harper and Alder 1972; Mehringer 1986). Site occupations were reduced at Danger and Hogup caves (Madsen and Berry 1975), and human coprolites from Hogup Cave indicate that only a few plant species were being eaten. Sites such as Fish Springs Cave, situated well above the maximum Neopluvial lake level, continued to be used intensively (Madsen 1982b). Abundant Elko- and Gatecliff-style projectile points suggest a population increase and expansion into upland areas during the early Black Rock Period.

E.1.1.5 Fremont Period (1600–650 B.P.)

The Rosegate projectile point series, consisting of the synchronous Rose Spring and Eastgate styles, marks the introduction of the bow and arrow and a prominent shift in strategy and technology for the Late Archaic Fremont Period. The relatively late date range for Rosegate series points presented by Thomas (1981) is probably too conservative for the eastern Great Basin, where it appears that a technological shift was initiated as early as 1,600 or perhaps even

1,800 years ago (Holmer 1986; Holmer and Weder 1980; Janetski et al. 1997; Madsen and Simms 1998). The Late Archaic across much of the Great Basin is recognized as a hunter-gatherer adaptation but in the eastern areas, especially in Utah, Fremont horticultural-agricultural strategies were in use in the GSLD vicinity by 1600 B.P. (Fry and Dalley 1979).

Late Archaic adaptive strategies undoubtedly evolved in concert with the new technology, and in response to frequent wet-dry cycles that punctuated the late Holocene, beginning in earnest in the late Black Rock Period. Arrow-point styles became prevalent during this time, though Elko dart points still occurred in reduced numbers. Unlike Middle Archaic strategies, the Late Archaic in the GSLD area appears to have seen a broadened diet breadth, with a wide array of resources including rabbits, fish, rodents, and waterfowl (Young et al. 2008). The use of local sources of toolstone, especially cryptocrystalline stone, became more common, indicating land-use intensification. Other technological changes (e.g., in basketry and milling gear) were relatively minor.

A distinct cultural transition took place in the region with the appearance of the Fremont pattern. This is the period of transition from semi-sedentary to sedentary horticultural groups, and traits associated with that transition are found in the archaeological record superimposed on the record of Late Archaic strategies. At the onset of the period, the Late Archaic settlement system was relatively unchanged; the same sites were used, but pottery and maize, the hallmarks of the Fremont pattern, began to appear (Aikens and Madsen 1986). Madsen and Simms (1998) argue that Fremont is best thought of as a “behavioral complex” that was adopted only as local conditions demanded.

In certain areas around the GSLD, the presence of high-ranking wetland resources and game animals may have been sufficient to offset the need for a horticulturally based, classic Fremont lifeway (Barlow 1998; Madsen and Simms 1998). In fact, the Sevier and Great Salt Lake variants of Fremont have much more in common with the relatively intensive, broad-based Late Archaic strategy found in the central Great Basin to the west. Sites here often include short-term camps and small residential villages with shallow, temporary structures (Fry and Dalley 1979; Young et al. 2008).

Maize use increased in some of these locations, but remained relatively minor (Smith 1994). Where longer-term sedentism did occur, more-complex architectural forms, including substantial pit houses with ventilator features and overlapping storage facilities, are found (Marwitt 1986). Ceramics, especially gray ware varieties, are Fremont hallmarks. Ceramic utensils and figurines are often accompanied at Fremont sites by Rosegate series projectile points. After about 1,000 years ago, Small Side-notched series points appeared as local variants such as Bear River, Uinta, and Nawthis (Holmer and Weder 1980), and began to replace Rosegate series points. This replacement likely pre-dated the shift from Rosegate to Desert series styles, including Desert Sidenotched and non-notched Cottonwood varieties, outside of the Fremont region. Other items unique to Fremont assemblages include specialized milling gear, such as troughed milling slabs and well-crafted hand stones.

Although the archetypal Fremont pattern of sedentary horticulture was once the conventional picture held by most archaeologists, a wider strategy of adaptive flexibility is now apparent in the regional record (Madsen and Simms 1998; Young et al. 2008). Fremont assemblages occur alongside, and mixed into, Late Archaic assemblages, revealing that resource diversification continued as people moved into and out of horticultural poses, adopted new subsistence ideas and technologies, or simply retained a hunter-gather lifeway. The Fremont Period encompassed all of this, and remains a focus of intensive archaeological inquiry.

E.1.1.6 Late Prehistoric Period (650–150 B.P.)

Hunter-gatherer strategies prevailed as horticultural activities subsided at about 650 years ago. The Late Prehistoric record can be associated with people ancestral to the Shoshone and Paiute who have connections to the region today. It is not clear whether these groups replaced the horticulturalists, or the shift represented in situ cultural change or carry-over from Late Archaic strategies of the Fremont Period. Linguistic data suggest there was an influx into the area of Numic speakers from southeastern California and Nevada (Madsen and Rhode 1994), but good archaeological evidence of an ethnic replacement has not been found (Duke et al. 2001; Elston 1994).

An annual round of small mobile groups using upland settings in the summer, congregating in the fall to harvest piñon, and forming large winter groups, seems likely for most areas (Steward 1938). Late Prehistoric archaeological patterning is similar to the non-horticultural pattern of the preceding periods, but the use of more confined areas is apparent. This probably was a result of increased population densities (Elston 1982). Late Prehistoric groups exhibited greater resource intensification as hunter-gatherers, through elaborations in ground stone and basketry technology and increases in diet breadth to include foods previously neglected or ignored (Bettinger and Baumhoff 1982). Lower-ranked seed items were incorporated into the diet through more sophisticated processing techniques, and the role of hunting was diminished. This basically continues the trend of Fremont Period hunter-gatherers, and is to be expected from peoples on the edge of, or familiar with, horticulture (Barlow 1998). As Desert Side-notched and Cottonwood arrow points became prevalent, the overall lithic technology also reflected a more circumscribed land-use pattern. Increased use of small local tool stone sources is apparent in the archaeological record. Reduction strategies became less refined alongside a reduced need for curated tools, with greater emphasis placed on local materials of variable quality.

E.1.2 Traditional Cultural Properties

Thus far, no TCPs have been identified on Hill AFB lands. Some of the 19 American Indian groups whose traditional territories include Hill AFB, however, have expressed concern regarding three types of ethnographic resources: (1) archaeological sites; (2) natural features such as mountains, caves, springs, freshwater marshes, lakes, and islands of former pluvial lakes; and (3) landscapes of ancestral homelands (Sucec 2007:149−156). There is a designated sacred site, Homestead Cave, on UTTR-North, and Beacon Ridge Village on the Wendover Auxiliary Area may be considered an ancestral village (Jaynie Hirschi, personal communication 2011). Among these ethnographic resources could be potential TCPs.

It has been long been recognized that survey and testing efforts can be optimized by predictive modeling of surface and subsurface archaeological site location and visibility. Toward that end, Hill AFB previously developed its own "probability model for prehistoric site occurrence" on UTTR-North and UTTR-South (USAFMC 2007:3-20–3-25). That model is now outdated and no longer used for probability purposes on the UTTR. It has been superseded by a weights-of-evidence model developed more recently by Far Western Anthropological Research Group (Far Western) to predict sensitive areas for prehistoric surface sites, shelter sites, and buried sites. The integrated surface/subsurface model represents the combination of a surface model, a subsurface model (based on the location of known buried sites), and a "shelter sites" model, based on the location of rock-shelter sites (essentially, a red flag model). The integrated model incorporates detailed geomorphic data and dynamic environmental landscapes, which provide solid grounds for an effective predictive model (Young 2008).

The Far Western predictive model serves as a useful tool for site management and planning future survey and testing efforts. However, because the model focuses exclusively on prehistoric sites, it does not necessarily predict the locations of all ethnographic resources of interest to the native groups associated with the UTTR, particularly villages recorded in the ethnohistoric/ethnographic record. Omitting such properties, some of which could be considered TCPs, in modeling efforts could lead to considerable management challenges down the road, particularly if TCPs are identified late in the planning process. To aid in Hill AFB efforts toward Section 110 compliance and managing areas with potential ethnographic resources, we developed an ethnographic land-use model (ELM) to complement the UTTR's existing models for prehistoric sites. Put succinctly, the aim of the UTTR ELM is to predict areas of high, moderate, and low sensitivity for containing unrecorded, ethnohistoric residential sites. The UTTR ELM study area consists of the UTTR itself as well as a buffer of 50 mi beyond the UTTR North and South ranges (see Figure E-1); reasons for this delineation are discussed in Section E.4.1.

Of the three types of ethnographic resources documented by Sucec (2007:149−156), the first (archaeological sites) and portions of the second (caves and shelters) are addressed in the Far Western model. The third type of ethnographic resource of concern to the consulted tribes, landscapes of ancestral homelands, can be addressed to some extent by considering the mapped locations of ethnohistoric residential sites in nearby areas and predicting where locations with similar characteristics are found on the UTTR. As none of the applicable sources in the ethnographic literature (see discussion below) depict any known ethnographic village locations within the UTTR, the ELM can highlight areas most likely to contain such resources. Although village locations are not necessarily TCPs, they do indicate areas where ethnographic activities occurred, and because they are mapped in some accounts, they are amenable for use in predictive models. Other types of ethnographic resources that could be considered TCPS, such as places important in creation accounts or other oral history, may not contain sufficient geographic information to be mapped using Geographic Information System (GIS) software.

The primary point of reference for the UTTR ELM is the landmark study of hunter-gatherer groups in the Great Basin, *Basin-Plateau Aboriginal Sociopolitical Groups (*hereafter *Basin-Plateau*), by Julian Steward (1938). Steward's study of Shoshone and Paiute peoples has long been acknowledged as a significant contributor to framing anthropology as a social science, as it

embodies several of his key contributions to the field: the concepts of hunter-gatherers, adaptation, and cultural ecology (Clemmer et al. 1999). A close examination of Steward's work shows that he recorded no ethnographic residential bases on UTTR lands, nor have other ethnographic or ethnohistoric studies (Sucec 2007). Despite Steward's methodical fieldwork, recent studies have shown that there are significant gaps in his information, meaning that his record of nineteenth- and twentieth-century villages is likely not exhaustive. Based on our experiences grappling with Steward's data at the Nevada Test and Training Range (NTTR; Altschul et al. 2006), we suggest that there is strong potential that unmapped ethnographic villages do in fact exist in areas where Steward did not record them. This issue is explored in greater detail in the following sections. By building upon information collected in Steward's study, we hypothesize that it is possible to model the cultural preferences for ethnographic village locations from the physical and environmental characteristics of the land and those resources preferred by its inhabitants. Applying our understanding of Goshute-Western Shoshone preferences, we created a neural network classification method that models areas as high, moderate, and low sensitivity in containing recorded and unrecorded ethnographic villages.

The ELM could contribute to the management of UTTR cultural resources in five ways. First, as a "red-flag" model (Altschul 1990), it can identify resources or areas that can adversely affect mission success. Second, building a predictive model within a GIS utilizing spatial statistical techniques brings the management of ethnohistoric village locations in line with other environmental resources managed by the DoD. Third, without predictive models, prior knowledge about archaeological resources gathered at considerable cost is not efficiently or effectively used. Fourth, models can incorporate resource significance criteria and provide a framework for prioritizing treatment options. Finally, site detection models can also help demonstrate adequacy of inventory efforts to American Indian and other stakeholders and identify areas needing to be investigated.

In short, UTTR lands have been identified as part of the traditional lands of several American Indian tribes. Affiliated tribes have a close connection with the land but have not previously indicated the locations of specific traditional sites. Still, Hill AFB and interested tribes place a high priority on determining if and where such sites exist. Future archaeological surveys can thus target highly sensitive areas to determine if sites affiliated with consulting tribes can be identified. Lastly, as with previous efforts to model prehistoric site locations, the UTTR ELM can support long-term efforts in installation-wide NHPA and NEPA compliance and eligibility determinations for the NRHP. Overall, we anticipate the ELM can provide clear guidance for project planning and regulatory compliance in the management of ethnographic villages, a significant subset of the sorts of potential TCPs that might be present on UTTR lands.

E.2 AMERICAN INDIAN TERRITORIES AND THE UTTR

UTTR lands have provided a home to Native American populations for millennia (Ezzo 1999; Ezzo et al. 1999). Ethnographic documentation has suggested a strong connection between sustenance and lifeways of the Goshute-Shoshone tribes living in the area. Studies and summaries by Powell and Ingalls (1874), Chamberlin (1911, 1913), Steward (1938), Sucec (2007), and others provide snapshots of the traditions and customs of tribal villages in the region. Steward's study supplies the most detailed and concrete view of these peoples, though more

recent critiques (Clemmer 2009) have called into question the completeness and veracity of his account. Indeed, SRI's own research experience in the NTTR discovered a large number of habitation sites and TCPs that were not recorded by Steward, even though Steward's maps covered lands contained within the NTTR (Altschul et al. 2006). This finding supports our assertions that unrecorded ethnographic villages could be found on UTTR lands and may be discovered through predictive modeling.

In an ethnographic study conducted by the National Park Service (Sucec 2007), 19 American Indian groups were identified as having ancestral territories on Hill Air Force Base lands. These American Indian groups include:

- Blackfeet Tribe
- Confederated Tribes of the Goshute Indian Reservation
- Crow Tribe of Montana
- Eastern Shoshone Tribe
- Hopi Tribe
- Navajo Nation
- Northern Arapaho Tribe
- Northwestern Band of the Shoshone Nation
- Paiute Indian Tribe of Utah
- Pueblo of Zuni
- San Juan Southern Paiute Tribe
- Shoshone-Bannock Tribes of the Fort Hall Reservation
- Shoshone-Paiute Tribes of the Duck Valley Reservation
- Skull Valley Band of Goshute Indians
- Te-Moak Tribe of Western Shoshone Indians
- Ute Indian Tribe
- Ute Mountain Ute Tribe
- Confederated Salish & Kootenai Tribes of the Flathead Reservation (Deferred to other consulting American Indian Tribes)
- Wells Band of Western Shoshone (Identified through consultations with the Te-Moak Tribe of Western Shoshone Indians)

Many of these tribal groups are historically connected to the UTTR lands through exchange with local inhabitants and gathering of local resources. Our ethnographic land-use model is centered on the Goshute-Western Shoshone peoples who spoke a Numic language and inhabited villages in the region documented within the past century or so. As such, the current modeling effort focuses upon residential locations from the past 150 years that have been mapped (Steward 1938) and are mappable within a GIS. It does not (though it could) consider more ephemeral or non-material traces of the movement of peoples, goods, or ideas through the area, such as sacred places, resource extraction locations (e.g., for salt collection), or festivals. Such TCPs, often related anecdotally, do not always lend themselves to being mapped as discrete areas. Nevertheless, previous ethnographic studies do provide a good place to start, despite being an incomplete record of the places where people gathered and lived.

E.3 PREVIOUS STUDIES OF THE GOSHUTE-WESTERN SHOSHONE

The designation "Western Shoshone" has been in use for approximately 150 years to describe peoples inhabiting the area from Death Valley in the west, through the mountains of central Nevada and extending to northwestern Utah in the east. Older designations that refer to people of specific areas include Walkers, Diggers, Shoshonee Diggers, Shoshoni, and Western Shoshonee. Shoshoni and Western Shoshonee become common referents by 1865 (Allen and Warner 1971:262, 279). Goshute or Gosiute has been used to describe Western Shoshone peoples inhabiting the area to the south and west of the Great Salt Lake and the Great Salt Desert (Allen and Warner 1971:280). The term "Goshute-Western Shoshone" will be used hereafter to refer to the tribes and bands that inhabited this area in the nineteenth and twentieth centuries. Ethnographic studies by Powell and Ingalls (1874), Chamberlin (1911, 1913), Steward (1937, 1938, 1943), and others summarized by Thomas et al. (1986) have documented places in northwestern Utah used by the Goshute-Western Shoshone. These sources do not indicate any known village locations on the UTTR. Most sources paint a picture of a relatively inhospitable land, argued to be conducive to low population density, high mobility, and a simple social structure adopted by its inhabitants (Steward 1938:241). This assertion is somewhat countered by the critique that Steward's textbook documentation of Goshute-Western Shoshone society subsistence was of a people already fractured by Euro-American subjugation (Clemmer 2009).

The earliest contacts between Euro-Americans and Goshute-Western Shoshone occurred in the 1820s as fur trappers entered northwestern Utah. Mormon arrival in 1847 brought waves of new homesteads, ranches, and farmsteads over subsequent decades. Conflicts between Euro-American and aboriginal interests prompted the U.S. Commissioner of Indian Affairs to send a special mission to Utah and Nevada in 1873, headed by John Wesley Powell and George W. Ingalls (Allen and Warner 1971:108−109). Even as their report recommended strategies for aboriginal relocation onto reservations, Powell and Ingalls (1874:431) noted the fragmented state of Goshute-Western Shoshone society: "They are broken into many small tribes, and their homes so interspersed among the settlements of white men, that their power is entirely broken and no fear should be entertained of a general war with them. The time has passed when it was necessary to buy peace." At the time of Powell and Ingalls' report, the population of the Western Shoshone was 2,405; of them, the Gosiute maintained a population of 460 (Powell and Ingalls 1874:2, 11, 17−18, 41−75).

Detailed information on Goshute-Western Shoshone subsistence and place names was collected by botanist Ralph V. Chamberlin (1911, 1913). He characterized their relationship with the landscape as such:

> Living close to nature and impelled by strict necessity, native peoples knew the plants of their region with a detail truly surprising. From root to fruit, they knew the plants in form and color, texture and taste, and according to season and habitat. Whatever portion of a plant could serve in any degree for food they quickly discovered. What portion of a plant would poison or injure them, they knew how to avoid or eliminate. From plants, too, they obtained most of their medicines, which were many, as well as the materials for making most of their household and other utensils [Chamberlin 1911:337].

Chamberlin's writings are a crucial source for understanding Goshute-Western Shoshone ethnobotany and historical geography. He recorded the local names for each spring, mountain range, creek, canyon, and desert of northwestern Utah and eastern Nevada (1913). Chamberlin also provides information on plant communities resident in the alkaline flats, sagebrush zone, piñon-juniper forest, valleys and brackish swamps, as well as anecdotal evidence on rabbit and pronghorn antelope drives that occurred each fall to obtain meat and animal hides. The appellation "digger" for the Goshute-Western Shoshone that became common in the nineteenth century arose from the digging of sego lily (*Calochortus nuttallii*) bulbs in the spring for food (Chamberlin 1911:338). Yamp or yampa (*Carum gairdneri*) was "one of the most highly prized of all food plants," growing in the mountains to produce edible roots that could be cached over winter (Chamberlin 1911:339). Unlike the native peoples of California, Chamberlin reports that acorns of the scrub oak were eaten only in season and not stored over winter (Chamberlin 1911:344). The tree nut most vital to Goshute-Western Shoshone sustenance is reported to be the piñon pine nut (*Pinus monophylla*) (Chamberlin 1911:343). Goosefoot (*Chenopodium* spp.), saltbush (*Atriplex* spp.), and hedge mustard (*Sisymbrium canescens*) furnished edible seeds, as did plants of the Compositae or Asteraceae family (e.g., sunflowers). Seeds were gathered in baskets, threshed, roasted, winnowed to remove charcoal, and stored; before use, seeds were ground on a flat stone (i.e., metate) with a "sub-cylindrical grinder (i.e., a *mano*) (Chamberlin 1911:343). The service-berry (*Amelanchier alnifolia*) was reportedly the most important fruit (Chamberlin 1911:343). Beyond mammals and vegetation, insects such as the locust, cicada, and black cricket (*Anabrus simplex*) also provided sustenance (Chamberlin 1911:336). Hundreds of practical and medicinal uses for hundreds of plant species, as well as local names for these plants, are provided by Chamberlin.

Steward's (1938) account of Western Shoshone and Paiute peoples, *Basin-Plateau*, has become a classic anthropological study of hunter-gatherer subsistence and social organization. Through a network of informants, Steward documented individual families and villages and came to identify two types of socio-political cohesion. The first type was organized around the village and limited to the cooperation of its inhabitants. The second type he termed the "band," which maintained a central authority and group identity linked to a geographical territory (Steward 1937a:628, 1938). Within these groups, a sexual division of labor predominated, and there was no craft specialization. By and large, each family manufactured its own tools. He identified the limited scope of socio-political organization as a direct outcome of limited socio-economic activities. That is, he argued that a confluence of low population density, poor transportation, and above all, strategies to procure food in a hostile environment kept social organization at a bare minimum (Steward 1937a:628–629, 1938:44). In his words,

> It is important to an understanding of the entire Shoshonean culture that it was stamped with a remarkable practicality. So far as its basic orientation is definable, it was "gastric." Starvation was so common that all activities had to be organized toward the food quest, which was carried on mostly by independent families. Whether other fundamental drives could have been implanted is not known. They had not been except among the eastern groups, Shoshoni and Ute, who attached some importance to warfare. Others carried on activities which were largely devoid of ritual, and of prestige value [Steward 1938:46].

Like Chamberlin, Steward identified the piñon nut as "without question the major food" that "induced a comparatively unsettled life" for the Goshute-Western Shoshone (Steward 1937a:629). Yields of nuts far exceeded what one family or village could gather and store. Steward estimated that a family of four could gather about 1,200 pounds of piñon nuts during the fruiting season in the fall (Steward 1938:27), a supply that could last up to four months during the winter. Due to logistical difficulty of transporting so much food, winter villages developed in the higher elevations around piñon nut caches. Because the interval between yields varied between two and four years, people often traveled each year to areas where "the crop was most convenient or the harvest most promising" (Steward 1937a:629). Besides group harvesting of piñon nuts, communal rabbit drives in the fall and antelope drives in the spring brought relatively large groups of people together. Indeed, "most gathering occurred when cooperative collecting produced an abnormally large food supply for a brief period" (Steward 1937a:629). Notably (and somewhat ironically), he offered that the incursion of Euro-Americans into Shoshone territory contributed to greater social cohesion, the fusion of several villages, and the introduction of warfare that had been "unknown in aboriginal days" (Steward 1937a:630).

Drawing extensively from Chamberlin, Steward noted other plant and animal species that were significant portions of the Goshute-Western Shoshone seasonal diet (Steward 1938:14–44). In the spring, early shoots found along streams, lakes, and low hills subsidized winter stores. In the early summer, people often left their winter villages to harvest seeds from valleys and mountains, often roasting and caching them as described above. Seed-bearing plants such as goosefoot and blazing star (*Mentzelia dispersa*) were also deliberately cultivated (Steward 1941:232; Thomas et al. 1986:267). Roots and berries also provided sustenance in the late summer, and early fall provided a bounty of piñon nuts. These were stored in a winter village nearby, though village locations could vary annually depending on the piñon fruiting cycle (Steward 1938:19–20). Important for this study, Steward provided base maps of these winter and summer village locations. Three of these maps have been used for this study to map ethnographic village locations in the UTTR ELM study area—Figures 9, 11, and 12 in *Basin-Plateau*. Steward's Figure 9 (Figure E-2) covers the southwestern corner of the project area, while his Figure 11 (Figure E-3) overlaps with the western portion of the ELM study area. His Figure 12 (Figure E-4) covers almost the entire ELM project area. Methods for digitizing these maps are discussed in Section E.4.1.

E.3.1 Critiques of Steward and the *Basin-Plateau* Maps

Subsequent works have drawn heavily upon Steward's influential study to characterize Euro-American interactions (Allen and Warner 1971) or to generalize about Western Shoshone socio-political organization and culture (Thomas et al. 1986). Since its publication, critiques varying in scope have been leveled at *Basin-Plateau*, ranging from its characterization of Shoshone culture as "low" within a neo-evolutionary schema (Crum 1999) to its arguably false assertion that the Western Shoshone would inevitably be assimilated (Clemmer 1999). Such critiques and polemics aside, it is vital for this modeling effort to understand the limitations and representativeness of Steward's data. While not detracting from the scope and results *of Basin-Plateau*, we identify two related sources of error that suggest Steward's village distribution maps are incomplete. The first source is Steward's heavy reliance on local informants coupled with his

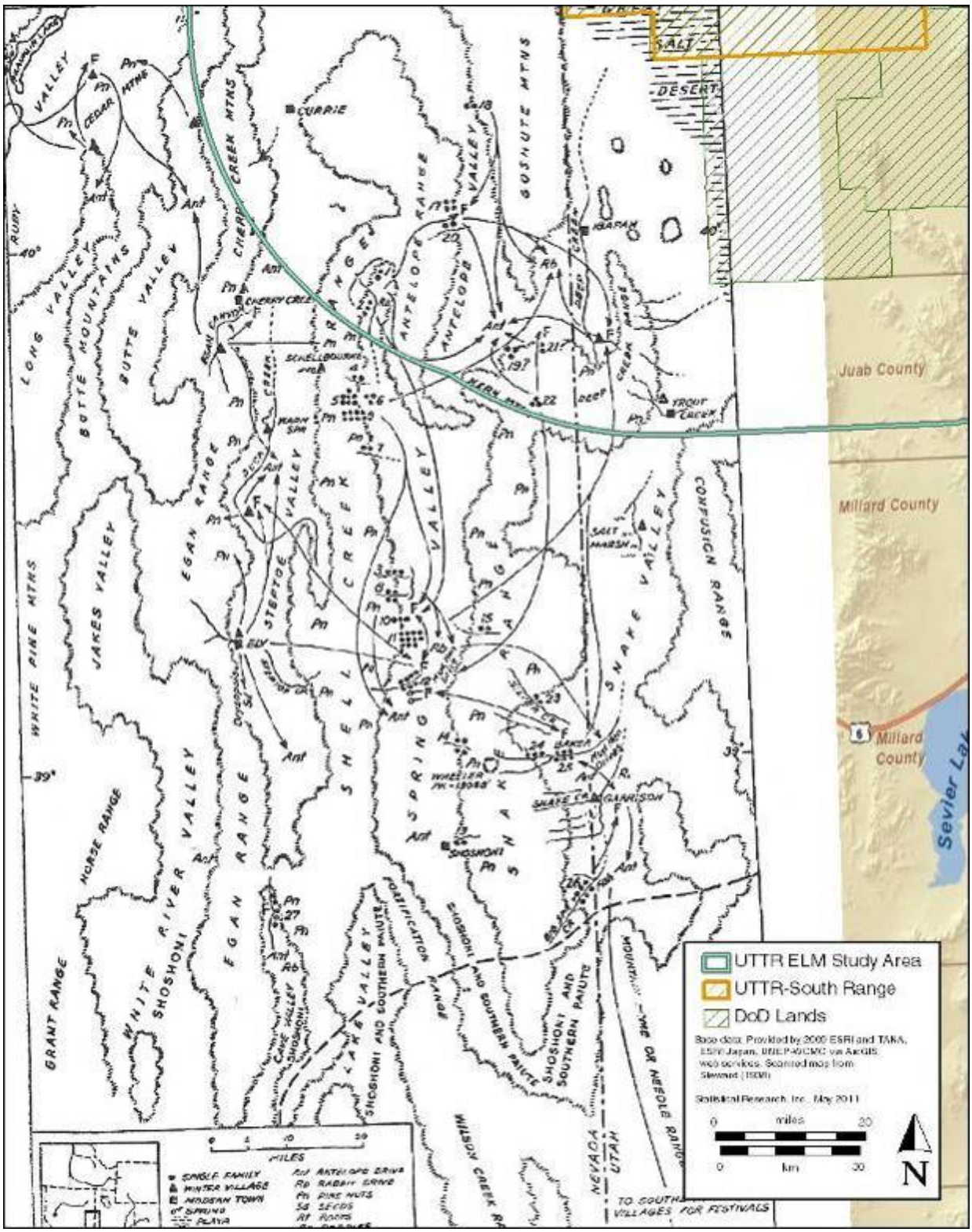

Figure E-2. Figure 9 from Steward's *Basin-Plateau* (1938) georeferenced to UTTR ELM study area and DoD lands.

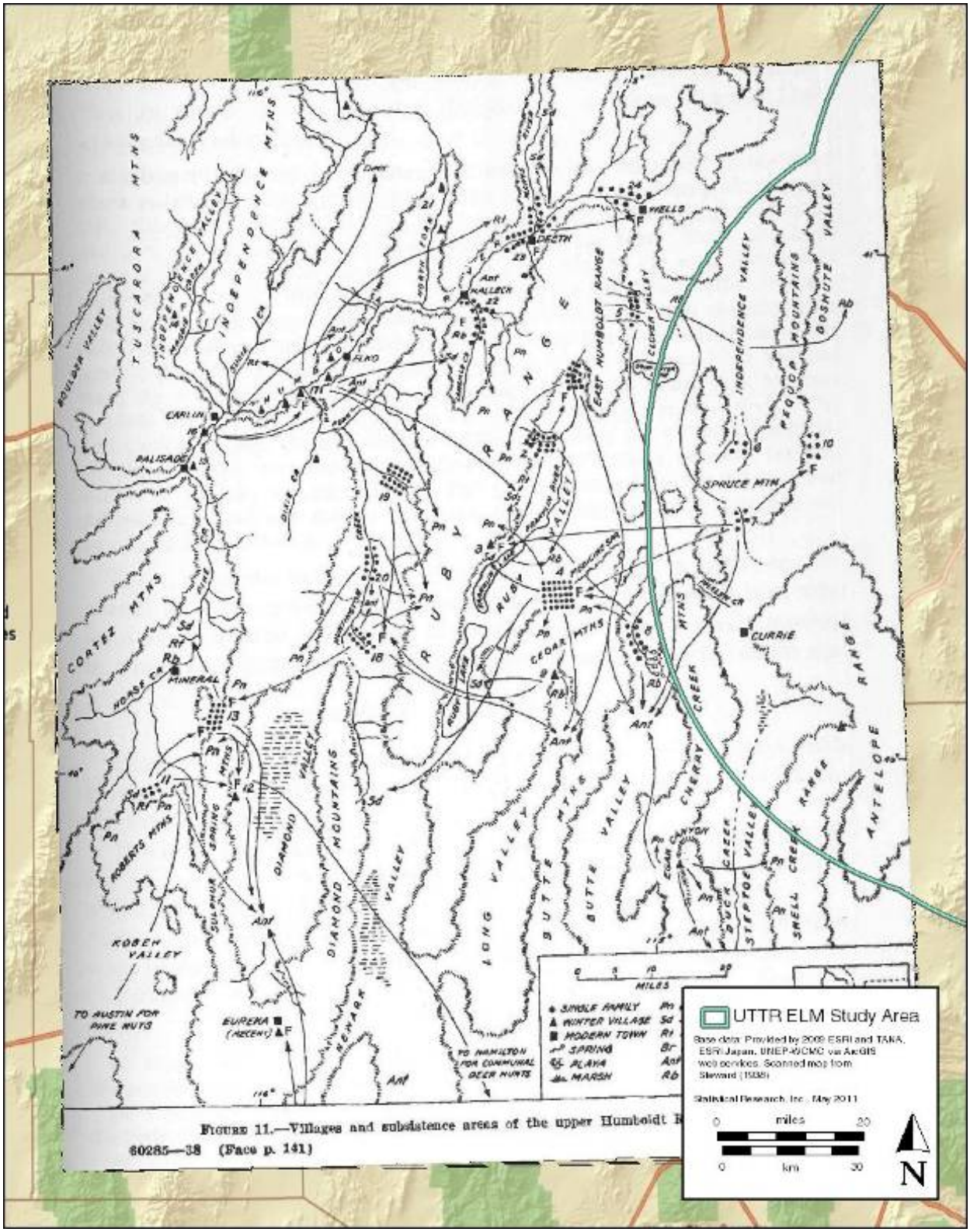

Figure E-3. Figure 11 from Steward's *Basin-Plateau* (1938) georeferenced to UTTR ELM study area and DoD lands.

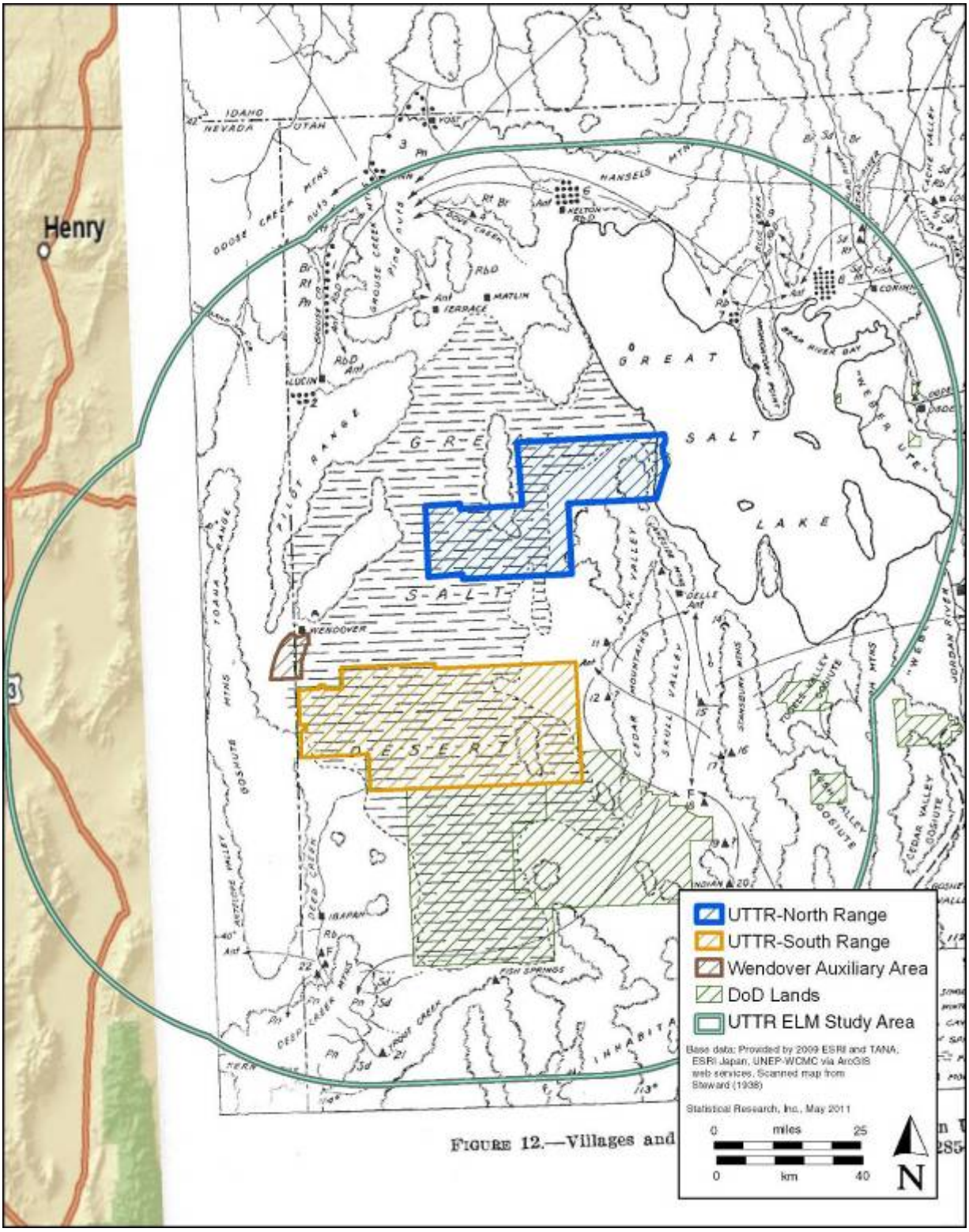

Figure E-4. Figure 12 from Steward's *Basin-Plateau* (1938) georeferenced to UTTR ELM study area and DoD lands.

short stay in the area that potentially contribute to errors of omission (Kerns 2003, 2010). The second source of error arises from Steward's preference to document an "ethnographic present" that ignores the historical circumstances which arguably produced the very picture of deprivation he documents (Clemmer 2009).

First, the work has been critiqued for several factual inaccuracies and omissions that resulted from Steward's reliance on second-hand data from informants, rather than his personal experience. To a large extent, the social organization, families, and villages of Paiute and Shoshonean societies described in *Basin-Plateau* originate from Steward's interviews of elderly aboriginals residing on ranches, mining camps, and reservations recalling distant times and places. One illustrative case is Steward's experience with the Panamint Shoshone in Death Valley. There, Steward received conflicting reports from informants as to the age of a certain camp and how many people were resident there at a given time, overlooking the historical and archaeological evidence that could have clarified this issue. Fowler et al. (1999:56) attribute this oversight to the fact that "he did not visit the area himself or talk directly to any of the inhabitants" and that he was "more concerned about the ethnicity of the area." In other cases in the same area, Steward mischaracterized the subsistence strategies of the Shoshone, overlooking the influence of nonindigenous vegetables on local diet. Since he did not visit the village locations with his informants, it is suggested that he "must have worked carefully with some type of maps to which his consultants would relate" (Fowler et al. 1999:58). These were likely the several United States Geological Survey (USGS) 60-minute quadrangles then available for the region (Altschul et al. 2006:4). Yet time constraints imposed by the scope of his study and his other responsibilities resulted in relatively cursory visits with his informants. With respect to the Goshute-Western Shoshone in our study area, Steward seems to have spent three days at the Skull Valley Indian Reservation interviewing a gentleman named Mudiwak, or Moody (Kerns 2010:274−277). Leaving Skull Valley, he drove to Deep Creek Reservation, speaking with a consultant named Frank Bonamont for two or three days (Kerns 2003:202−203). From these five or six days of interviews, Steward reconstructed the settlement history, family history, and lifeways of the Goshute-Western Shoshone. Yet this short amount of time did not afford Steward the opportunity to visit individual places, interview other people, or learn more about the area.

Second, Clemmer has questioned Steward's focus on an ethnographic present that ignored the historical factors contributing to Western Shoshone destitution. Rather than viewing the Western Shoshone as "pristine aborigines," Clemmer characterizes the people that Steward described as "victims of progress" (Clemmer 2009:850). He supports his argument by citing Euro-American activity during the nineteenth century that gradually eroded the subsistence base of the Western Shoshone and resulted in Steward's image of peoples with a simple culture resulting from resource scarcity. Among his examples are beaver-trapping in the Humboldt River that usurped and eventually depleted this important resource and the drastic impact of the Pony Express and Euro-American settlement on the Shoshone seasonal round and the availability of pronghorn antelope. Clemmer also considers the dramatic effect of forest clearance on the piñon and sagebrush plant communities on which the Western Shoshone depended. In summary, Clemmer questions the veracity of Steward's account, offering that

> Global economic forces and the extension of communication and transportation systems that satisfied entrepreneurial dreams of grandeur and nationalistic images

> of manifest destiny were much stronger conditioners of Shoshones' adaptive strategies in the mid-nineteenth century than were the operation of ostensibly pristine environmental processes such as climate, geography, and the occurrence of indigenous flora and fauna [Clemmer 2009:865].

As noted previously, Steward's work and his contributions are not without controversy; however, Clemmer's (2009) critique itself has also been subject to pointed criticism from Great Basin scholars familiar with Steward's work and the environment in which it occurred (Bettinger 2010:28; Thomas 2010). Nevertheless, for our purposes, the most important aspect of Steward's reporting is that he included maps—maps that were the most accurate available for the time and which can be georeferenced to overlay on modern maps and GIS resource layers.

E.3.2 The Case of Nellis AFB, Nevada Test and Training Range

The relevant maps in *Basin-Plateau* (Steward 1938:Figures 9, 11, and 12) do not show any villages located on UTTR lands (see Figures E-2, E-3, and E-4, respectively). Yet SRI's experience in 2004–2005 at the Nellis AFB NTTR found that absence of evidence is not evidence of absence. The lack of ethnographic data in *Basin-Plateau* led us to expect that few or no late prehistoric or historical-period archaeological sites would be located in the 1,275-ac survey area at Black Mountain and Thirsty Canyon, an upland area at the interface of the Mojave Desert and Great Basin. We hypothesized that the "apparent void in Steward's ethnographic data for the area would be reflected in a corresponding lack of archaeological sites dating to the late prehistoric and protohistoric periods" (Altschul et al. 2006:3). In fact, just the opposite occurred, and 46 archaeological sites were recorded during the archaeological survey, including a rock art gallery, extensive habitation areas, and a large number of other sorts of TCPs, including caves containing basketry. From this, Altschul and his colleagues suggested that ethnographic information had not only been overlooked by Steward, but also that his informants may have deliberately withheld information during interviews.

Although the environmental variables of the UTTR differ markedly from those at the NTTR, the comparison between the two here is focused not on environment but on Steward's level of interaction with his informants, the mapped locations of the data he recorded, and the question of whether the resulting maps in *Basin-Plateau* (Steward 1938) are in any way representative of ethnographic resources on the two ranges. In combination with our own experiences, the two sources of potential error noted above lead us to suggest that Steward's maps of village distribution may be an incomplete representation of village locations. As Steward spent so little time in the lands of the Goshute-Western Shoshone, interviewed only two consultants, does not appear to have regularly corroborated his sources, and often did not visit the villages he documented, there is a good probability that *Basin-Plateau* contains an incomplete record of Goshute-Western Shoshone village life and locations. Moreover, Steward's oversight regarding the historical circumstances of the Western Shoshone increases the potential gaps in his data. Fowler and others summarize well our position towards the completeness of Steward's maps of village distribution:

> Although [Steward] clearly failed to explicitly account for the effects of nearly 100 years of contact on the people and their patterns, Steward nonetheless did a

> great service…by recording what he did…the data should not be taken literally as representing precontact conditions, or even 1870s conditions in some instances, and further use of the data in theoretical models for the region should be judicious" [Fowler et al. 1999:59].

From this point we consider to what extent Steward's information can be used to model Goshute-Western Shoshone habitation in the study area.

E.4 MODELING APPROACH

At the outset of this study, we observed that Steward recorded no ethnographic villages on the UTTR in *Basin-Plateau* (Steward 1938). We hypothesized for various reasons discussed above that Steward's record of villages was incomplete. For this reason, we considered that modeling the environmental conditions that were favorable to settled villages that Steward did record within a larger study area would be conducive to predicting favorable zones for those villages that Steward did not record on the UTTR itself. Our aim is to produce a "red-flag model" (Altschul 1990) to predict high-, medium-, and low-probability zones for those culturally significant places unrecorded by Steward. Red-flag models are intended to provide cultural resource managers with a greater degree of awareness of those places that would be costly in terms of time, money, or both. In this case, by modeling those areas that have a high likelihood for containing villages, we hope to support the decision-making capabilities of UTTR's cultural resource managers by flagging highly sensitive zones that could represent a high degree of future investment.

E.4.1 Mapping Village Locations

To establish a sample of village locations suitable for developing a sensitivity model, we examined a study area buffered 50 mi outward from the UTTR main properties—UTTR-North and UTTR-South (see Figure E-1)—deriving village locations from Steward's maps. Based on a cursory examination of his maps, it appeared that Steward possessed and utilized a series of well-surveyed, USGS topographic base maps to produce his own. Nevertheless, Steward's maps introduce uncertainty for village locations due to their small scale and sketchiness. By the same token, our efforts introduced a minute amount of positional error through decisions made during the process of digitization.

Accuracy of the mapped locations was a key consideration. By measuring distances on the three maps that we utilized for this study, we estimated the approximate scale of each map (Table E-1). One can see that the scale of these maps varies roughly from 1:1,463,040 to 1:2,063,259. For reference, the current USGS standards for scale require that "the positions of 90 percent of all points tested must be accurate within 1/50th of an inch (0.05 cm) on the map. At 1:24,000 scale, 1/50th of an inch is 40 feet (12.2 m)" (USGS 1999). Working on the assumption that Steward employed a similar standard for his maps at these scales—which he likely did not—we calculated the best-case-scenario scale error we could hope for village positions on his maps (Table E-2). The accuracy of a USGS 1:24,000 quadrangle map is shown for comparison. These calculations suggest that, at best, the positions of villages on Steward's Figure 12 (see our Figure E-4) can be expected to have an accuracy limit within 1,048 m. His Figure 9 (see our Figure E-2)

Table E-1. Approximate Scale of Maps Consulted in Steward (1938)

Steward (1938) map name	Our Figure Number	Measurement	Approx. Scale
Figure 9	10-2	1 mm ≈ 1.28205 mi	1:2,063,259
Figure 11	10-3	1 mm ≈ 1 mi	1:1,609,344
Figure 12	10-4	1 mm ≈ 0.90909 mi	1:1,463,040

Table E-2. Best Case Scenario Scale Error for Ethnographic Village Positions Derived from Maps in Steward (1938)

Map	Figure number	Scale	1" on map (in ft)	Scale error: 1/50 of 1" on map[1]	Scale error: 1/50 of 1" on map[2]	Size of village symbol[2]	Approx. radius of uncertainty[2]
USGS 1:24k Quad	—	24,000	2,000	40	12	n/a	n/a
Figure 9	10-2	1,609,344	134,112	2682	818	1609	2427
Figure 11	10-3	1,463,040	121,920	2438	743	1463	2206
Figure 12	10-4	2,063,259	171,938	3439	1048	2063	3111

Note: 1 = rounded to nearest foot (ft)
2 = rounded to nearest meter (m)

is slightly better, with village positions accurate within a scale error radius of 817 m, and his Figure 11 (see our Figure E-3) to within 743 m. Moreover, based on calculations of scale, we noted that the 1-mm size of the triangle that Steward used to mark winter village loci would have corresponded to anywhere from 1,463 to 2,063 m in real-world units. This meant that the total radius of uncertainty, or the sum of scale error and symbol size error, could have varied from ± 2,206–3,111 m, had Steward adhered to USGS standards.

Adding on to the positional errors introduced by Steward in his drafting of the maps, there was also a potential source of error introduced by our processes of digitization and georectification. The maps were scanned at 300 dpi at 8-bit grayscale, and the process of georectification took place by matching modern place names on the maps with georeferenced place names available freely via ArcGIS server (USGS 2009). Typically, road or stream intersections would serve as good reference points during the georeferencing process, but these features were absent. Steward's depiction of topography and hydrology is schematic at best. This means that it is difficult to establish georeferenced links between his maps and real-world locations. Each map was georeferenced using a first order polynomial (affine) transformation and a minimum of six control points distributed as evenly as possible over the map. The resulting transformation resulted in a typical root means square error (RMSE) of 0.004, which means that each pixel had a calculated imprecision of four-thousandths of a pixel. Since the average pixel size of a georeferenced map was 130 m across, this meant that the georeferencing process introduced a half-meter of error, a negligible amount when compared with other sources of error.

Once the maps were georectified, the village locations were digitized. Village locations were digitized by drawing a point at each triangle that represented a winter village or at the center of gravity of a labeled cluster of dots representing multiple families in a village. We assigned each

village an SRI provenience designation (PD) as a unique identifier (Table E-3). In order to have the most accurate possible digital locations for these villages, we then adjusted several village

Table E-3. List of Ethnographic Villages in UTTR ELM Study Area (after Steward 1938)

SRI PD No.	Steward (1938) Figure Number	Steward (1938) Figure Label	Village Name	General Location	Population (# families on map)	Population (# persons in text)
1	12	21	Trout Creek	Trout Creek	Unstated	Unstated
2	12	Fish Springs	Unknown	Grouse Creek	Unstated	Unstated
4	12	22	Deep Creek Valley	Deep Creek Valley	Unstated	Unstated
7	12	20	Wanapo'ogwaipi	Indian Spring	Unstated	Unstated
8	12	19	Oŋgwove	Skull Valley	Unstated	Unstated
9	12	18	Suhudaosa	Skull Valley	Unstated	Unstated
10	12	17	Tiava	Skull Valley	Unstated	Unstated
11	12	16	Iowiba	Stansbury Mountains	Unstated	Unstated
12	12	15	Haiyacawiyŋp	Skull Valley	Unstated	Unstated
13	12	12	Utcipa	Sink Valley	Unstated	Unstated
14	12	11	Tutiwunupa	Sink Valley	Unstated	Unstated
15	12	Ogden	Unstated	Ogden River	Unstated	Unstated
17	12	10	Südotsa	Bear River	Unstated	Unstated
18	12	13	Tozava	Skull Valley	Unstated	Unstated
19	12	9	Nagwitüwəp	Blue Creek	Unstated	Unstated
20	12	4	Paduyavavadizop	Dove Creek	3	10
24	12	8	Nanavadzi	Bear River	23	Unstated
25	12	6	Biagamugŋp	Hansels Mountains	15	Unstated
26	12	2	O'o or Podoŋgo'e	Grouse Creek	6	12
27	12	7	Toŋgicavo	Promontory Point	4	Unstated
29	9	None	Unknown	Cherry Creek Mountains	Unstated	Unstated
30	9	18	Wadoya	Antelope Valley	2	Unstated
31	9	17	Toiva	Antelope Valley	4	18-24
32	9	20	Hugapa	Antelope Valley	2	Unstated
34	9	19?	Kwadumba	Kern Mountains	3	Unstated
35	9	22	Bohoba	Kern Mountains	3	Unstated
36	9	1	Tupa	Spring Valley	2	15
37	9	2	Supuva	Spring Valley	3	20
38	9	21?	Suhuva	Kern Mountains	2	Unstated
41	12	1	Tu:said or Aŋgapuni	Grouse Creek	12	7
43	12	3	Kuiya	Grouse Creek Mountains	15	9
50	11	7	Unnamed	Spruce Mountain	5	Unstated
51	11	6	Woŋgogadu	Spruce Mountain	4	Unstated
52	11	10	Biabaduzŋp	Goshute Valley	6	Unstated
54	12	14	Unnamed cave	Skull Valley	Unstated	Unstated

positions using the radius of uncertainty and other information as a guide. Each point was first buffered based on its radius of uncertainty. This circle represents the fuzzy boundary within which the true position of each mapped village location most likely falls. For instance, village points from Steward's Figure 12 (see our Figure E-4) were buffered with a circle whose radius measured 3,111 m. Second, we attempted to reposition villages within this circle, where possible, by comparing the Steward descriptive text, his maps, and USGS 1:24,000 and 1:100,000 topographic data available through ArcGIS Server (USGS 2009).

We preferred to employ visual cues from the map that clearly showed a village adjacent to a (named) water source and were corroborated in the text, e.g., located "along Grouse Creek" (Steward 1938:174). However, only a few places had such clear clues in the text. On most occasions we would rely solely upon the map to determine whether a village was adjacent to a spring or stream. On almost every occasion, we could make a gross determination of whether or not a village lay on a slope or adjacent to it. The one instance in which this could not be determined was a winter village at Fish Springs (see Figure E-4) not described in the text. We judgmentally decided to move the digitized village location off the top of Fish Springs Range to its eastern base, within the radius of uncertainty. This new position put it adjacent to a wetland and several springs. In the instances where there were no clues in the text or map as to a more precise digital location of the village, the digitized point was not moved. The locations of these villages are shown in Figure E-5, labeled with their PDs. The inherent inaccuracy of these villages factored into our consideration of modeling the spatial data. That is, our input data and conclusions are only relevant when considered at a scale and accuracy equivalent to that of Steward's original maps.

On a related note, we attempted to extract population information from *Basin-Plateau* that might highlight village seasonality or central places. Unfortunately, Steward's annotations in the text and on maps of village population proved to be both inconsistent and incomplete (see Table E-3). At times population figures in text and on map contradicted one another. This was compounded by the fact that population tallies represented arbitrary figures projected back to an unspecified date in the past; numbers of families or individuals were generated based on Steward's informants' knowledge. More often than not, population was not mentioned at all. As a result, we omitted population as a variable altogether from this study.

The USGS offers digital elevation models (DEMs) more detailed than any other publicly available, cost-free DEM in the world. Most researchers outside the U.S. use the Shuttle Radar Topography Mission data, collected by the space shuttle Endeavor in February 2000 (USGS 2003), which has a pixel size of 90 m. By contrast, the USGS offers a seamless National Elevation Dataset (NED) DEM covering 95 percent of the continental U.S. and Hawaii. This DEM offers a pixel size down to 10 m per pixel in urban areas, though the majority is covered by a 30 m/pixel DEM (USGS 2011). This incredible level of detail affords equally detailed modeling of contours, slope, aspect, and watersheds. Yet the NED's level of detail is at a scale much too detailed when considering the high level of inaccuracy of Steward's village locations. In order to compensate for this level of detail, we buffered the village locations (digitized as points) to the spatial equivalent of 90 m/pixel.

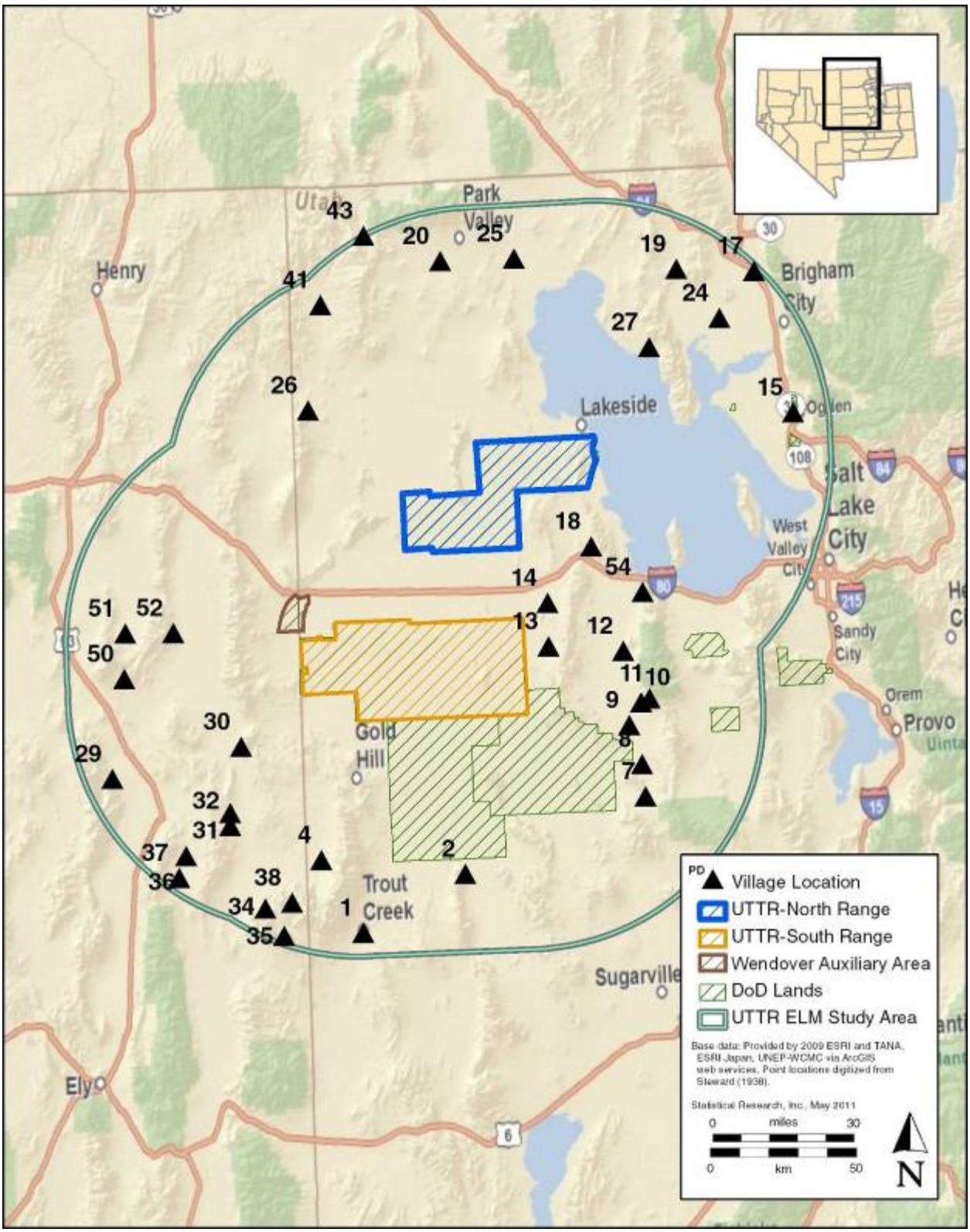

Figure E-5. Mapped village locations relative to UTTR, based upon Steward (1938:Figures 9, 11, 12). Each is labeled with its SRI PD number.

E.4.2 Mapping Environmental Variables

Building upon an understanding of the resources utilized ethnographically within the study area and our previous experiences with *Basin-Plateau* at the NTTR, we developed the parameters for the UTTR ELM. These parameters are based upon the mapped location of each ethnographic village relative to a number of environmental factors—elevation and elevation-derived characteristics (e.g., slope, aspect), geology, distance to water, land use, and distribution of botanical and faunal resources. For vegetation and fauna, we initially focused particularly on those few species that, as documented by the ethnographic record, were vital to the subsistence of the Goshute-Shoshone inhabitants of the region. We also gathered soils and geomorphic data, which are presented in Appendix L.

Steward's characterization of the Shoshone as "gastric" has been examined in detail (Zeanah and Simms 1999), and the extent to which Steward's documentation of the Goshute and Western Shoshone in northwestern Utah represents "pristine aborigines" or "victims of progress" will continue to be a matter of scholarly debate (Bettinger 2010; Clemmer 2009; Thomas 2010). Nevertheless, Clemmer's critique does lend credence to the idea that resources were likely more plentiful before contact in our study area. Detailed spatial data for vegetation, watersheds, and faunal distributions for the early nineteenth century, however, are simply not available. We chose to utilize modern hydrological and land cover data, knowing full well that this information merely approximates the conditions enjoyed by Goshute-Western Shoshone prior to the arrival of Western settlers. In an attempt to balance these concerns, we tried to prioritize those faunal and vegetal resources that appeared to be important to the aboriginal sustenance, emphasizing records predating Steward's study where possible.

E.4.2.1 Geology

UTTR-North has benefited from significant geological study (Hintze 1993:Figures 10 and 25). The Newfoundland Mountains contain deposits from the Cambrian to Quaternary periods. Shales, limestones, and dolomites are in the majority, with smaller amounts of quartz in Jurassic layers. In the Lakeside and Grassy Mountains, formations dating from the Cambrian to the Quaternary periods are present as well. Like the Newfoundlands, sedimentary rocks predominate, though cherts are found in later (late Permian) strata. Miocene to Pliocene valley fill, Quaternary flood deposits, and Lake Bonneville lake deposits cap these earlier layers. In the South Range, Gold Hill and Fish Springs have been studied Hintze 1993, figures 45-46As in the northern mountain ranges, limestone, shale, and quartzite dominate, though older rhyolites, basalts, and granites from the Jurassic era and later are not infrequent.

We consulted the Southwest Region Geology Data website for spatial data relating to the geology of the UTTR ELM project area (SWReGAP 2006), inputting the following layers as 30 m/pixel rasters into the model:

- Shale dominated formations of all ages
- Quaternary age younger alluvium and surficial deposits
- Quaternary age older alluvium and surficial deposits
- Metamorphic or igneous units with a dominantly silicic composition all ages
- Carbonate dominated formations either limestone or dolomites of all ages

E.4.2.2 Water

Water was crucial to the survival of nineteenth- and twentieth-century peoples living in the alkaline flats and arid climate of northwestern Utah. In the UTTR study area, most of the villages appeared to cluster around streams and natural springs, such as Deep Creek, Dove Creek, Fish Springs, Little Bear River, Ogden River, and Trout Creek. By comparison, Steward stated that "[w]inter villages often were located in the upper portion of this [Upper Sonoran zone in the *Artemesia*] belt, against mountain ranges where streams and springs emerged, or along rivers, for example, Owens, Humboldt, and Snake Rivers, which flowed through it" (Steward 1938:17). The Northern Paiute of Owens Valley, by the same token, focused habitation near alluvial fans (Kohler 1988:27). Besides being used for drinking and bathing, water provided beaver and fish, particularly salmon and trout. Wetlands near streams provided an abundance of plant and animal life, which are discussed below. To model water resources (rivers, streams, and springs), we used the National Hydrography Dataset Plus (NHD Plus)(United States Environmental Protection Agency and USGS 2005) to create a 30 m/pixel raster surface for each of the following variables:

- Distance to perennial stream/river
- Distance to perennial lake
- Distance to spring
- Distance to Great Salt Lake

E.4.2.3 Botanical Resources

The UTTR ELM study area is chiefly characterized Great Basin desert scrub community flora (Cronquist et al. 1972). Lindsay and Sargent (1979) and Arkush et al. (1992) consider vegetation zones in the northeastern Great Basin from an archaeological perspective. A more recent review (Bischoff et al. 2000) examines those non-invasive species within floral community zones that were important to humans inhabiting the northeastern Great Basin.

The greasewood-shadscale zone occurs between 4,300 and 4,500 ft AMSL and consists of woody shrubs such as shadscale (*Atriplex confertifolia*), spiny-hop sage (*Grayia spinosa*), and Mormon tea (*Ephedra nevadensis*). As halophytes, greasewood, (*Sarcobatus vermiculatus*), pickleweed (*Allenrolfea occidentalis*), and saltgrass (*Distichlis* sp.) thrive in alkaline playas. These zones occupy much of the Great Salt Desert that stretches amongst the mountain ranges in the study area. During the past two centuries, this zone likely contained few plants important to the Goshute-Western Shoshone. At 4,300 and 4,600 ft AMSL, the mixed grass-shrub zone includes non-native cheatgrass and Russian thistle (*Salsola kali*). The desert scrub-saltbush and grass-cheatgrass zones occurs are found between 4,400 and 4,600 ft AMSL, and these include shadscale and Indian rice grass (*Oryzopsis hymenoides*). The latter was a significant component of native diet (Thomas 1973:161). The Sagebrush zone is found between 5,000 and 5,200 ft AMSL. Yampa (*Carum gairdneri*), greasewood, and big sagebrush (*Artemisia tridentata*) characterize this area. Piñon-juniper is located between 5,200 and 7,000 ft AMSL. Utah juniper (*Juniperus osteosperma*) and single-needle piñon pine (*Pinus monophylla*) have been noted above as integral to the Goshute-Western Shoshone seasonal round.

Despite the relative aridity of the study area, riparian and wetland areas occupy the edges and outlying areas of the Great Salt Lake. Moreover, several springs found on Wendover Auxiliary Area feed a marsh of potentially several thousand acres (Dames and Moore 1996). Riverine areas are characterized by saltgrass, pickleweed, cottonwood (*Populus* sp.), and willow (*Salix* sp.), as these are salt-tolerant species. Salt marshes host marsh rush (*Juncus* sp.), bulrush (*Scirpus* sp.), and cattail (*Typha* sp.). Human use of wetlands in the Great Basin is discussed by Madsen and Janetski (1990) and Hamilton and Auble (1993).

With the UTTR ELM, we initially attempted to prioritize several plant species and two plant families that appeared to be of greater importance in terms of food to the Goshute-Western Shoshone. These species are the piñon pine, the sego lily, the yampa, Indian rice grass, the serviceberry, the Chenopodiaceae family, focusing on goosefoot (*Chenopodia berlandieri*), wild goosefoot (*Chenopodium album*), pickleweed, and blazing star, as well as the Cruciferae family, which includes hedge mustard. However, a visual examination of the histograms of these datasets found that there was often too little variance in distance to individual species for them to be useful variables. In terms of data management, we found it to be more expedient to use publicly available vegetation classes that encompassed the diversity of a vegetation zone. Given the abundance of plant species for food, medicinal, or practical purposes, we ultimately found that it would be counter-productive to account for each plant type individually. To account for botanical resources in our model we obtained land cover spatial data that approximates the diversity of plant life in the UTTR study zone by specifying predominant vegetation classes within zones that approximate those noted above. We consulted the Southwest Regional Gap Analysis Project (SWReGAP 2006) to obtain these land cover classified rasters at 30 m/pixel resolution:

- Great Basin Piñon-Juniper Woodland
- Inter-Mountain Basins Big Sagebrush Shrubland
- Inter-Mountain Basins Playa
- Inter-Mountain Basins Mixed Salt Desert Scrub
- Inter-Mountain Basins Montane Sagebrush Steppe
- Great Basin Xeric Mixed Sagebrush Shrubland

One notable land class excluded from this list is a wetland layer, despite the fact that wetlands are culturally important areas (Janetski 1986, 1990). In past and present, wetlands provided a variety of fish, reptiles, and mammal food sources, as well as extensive vegetal resources and fresh water within a relatively compact space. We initially included this layer in our analysis, but through a visual analysis of the histogram, we found that there was too little variation in distance to wetland that would augment the results. This does not suggest that wetlands were unimportant culturally, but rather that distance to wetlands did not significantly contribute to the correlative model.

E.4.2.4 Faunal Resources

The UTTR study area occupies the northeastern Great Basin and hosts a variety of mammal species. Pronghorn antelope (*Antilocapra americana*) predominate in terms of large mammals and occupy the sagebrush zone. Mule deer (*Odocoileus hemionus*) reside in sagebrush and higher

elevations, whereas mountain sheep (*Ovis canadensis*) move between higher and lower elevations depending on season. Leporids such as jackrabbit (*Lepus* sp.) and cottontail (*Sylvilagus floridanus*) provided skins and sustenance to the Goshute-Western Shoshone. Other small mammals such as pocket gophers (*Geomyidae* spp.), prairie dogs (*Cynomys* spp.), porcupine (*Erethizon dorsatum*), and other rodents can be found in all of the vegetated areas noted above.

The ethnographic record suggests that wild game was relatively rare in the UTTR modeling project area (Chamberlin 1911; Steward 1938), though Clemmer's (2009) critiques of Steward call this assumption somewhat into question. Communal pronghorn antelope and rabbit drives provided much needed sustenance and the prized animal skin (Egan 1917; Simpson 1876; Steward 1938). Reptiles, rodents, and insects, such as grasshoppers and "Mormon crickets," appeared to be have been important contributors to the Goshute-Western Shoshone diet (Steward 1938:33). Commenting on the importance of insects to the diet, Sutton noted that the historical sighting of members of what we know as the Goshute at the Great Salt Lake is significant in that it identifies them in association with the abundant resources that the Lake offered (Sutton 1988:21).

As with vegetation, we consulted the Southwest Regional Gap Analysis Project (SWReGAP 2006) for faunal spatial data at 30 m/pixel resolution:

- Pronghorn antelope (*Antilocapra americana*)
- Northern pocket gopher (*Thomomys talpoides*)
- Common garter snake (*Thamnophis sirtalis*)
- Ring-necked snake (*Diadophis punctatus*)
- Sonoran mountain king snake (*Lampropeltis pyromelana*)
- Night snake (*Hypsiglena torquata*)
- Striped whipsnake (*Masticophis taeniatus*)

Mammal, reptile, and insect resources, though extremely important to the Goshute-Western Shoshone diet, are extremely difficult to model due to their ubiquity across the study area. With the exception of the pocket gopher and pronghorn antelope, the distances to the habitats of almost all of the animal species noted above provided little new information for the model. That is, a visual inspection of the histograms for distance values to many species exhibited little variance. We attempted to compensate for this by introducing several reptile species that did exhibit a greater degree of variance.

E.4.3 Neural Network Classification

The modeling technique used for the UTTR ELM was the multi-layer perception (MLP) neural network classifier using a back propagation algorithm available in the IDRISI software package. Artificial neural network (ANN) derives from attempts to create mathematical representations of biological neural networks and is discussed in more detail earlier in this report (see Figure 5-4 and Section 5.4.1.2; Rust 2010; Gunchinsuren et al. 2011). The modeling approach used to develop the UTTR ELM was very similar to the approach used to refine the Fort Drum surface model, although arbitrary site classes were not developed since the training set consisted of a

single site type: ancestral village locations. As with efforts to refine the Fort Drum surface model, two output activation layer rasters resulting from the ANN classification algorithm were used to create a sensitivity map: one for the fuzzy probability that a cell did not contain a village and one for the fuzzy probability of a cell containing a village. These two class membership rasters were used as input variables to a logistic regression that computed a "final" probability map that a cell contained an ethnographic village.

Although an S Score (Altschul et al. 2004:21) was used to validate statistically-based models at Eglin AFB and Fort Drum, the S Score was not used to validate the UTTR ELM model because of how the training set points were derived for model development. The training points in this case derive not from systematic survey within discrete, bounded areas, but from a combination of fieldwork and interviews with informants that notably represent an incomplete sample of village locations. To successfully apply validation techniques, we would expect to have data on where such sites have not been found. Since village locations are not the result of an intensive pedestrian survey, for instance, we have an incomplete picture of positive information (i.e., where villages are), but not one of negative information (i.e., where villages are not). This limits our ability to statistically verify the sensitivity of our approach. Nonetheless, it does not preclude the UTTR ELM from producing new and valuable information. Thus the model is best used as a heuristic device for purposeful surveys to find TCPs. It is not intended to be used as a tool for military planning (i.e., avoid this area because it may contain a TCP).

E.5 RESULTS

The initial results of the UTTR ELM are promising, in that high- and medium-sensitivity zones account for 31 of the 35 ethnographic village sites (88.6 percent) within our predetermined sensitivity thresholds (Figure E-6). Of those village locations that fall within low-sensitivity zones (n = 4, 11.4 percent), almost all of them would likely have fallen within a medium- or high-sensitivity zone were their mapped locations shifted a pixel or two in any given direction (Table E-4). This can almost certainly be explained by accounting for the large circle of uncertainty for Steward's village locations, discussed previously. For example, PD 52 is technically located on a low-sensitivity pixel, but a zone of high sensitivity is located just 90 m to the north. A village at PD 43 is in a similar situation. By the same token, PD 51 lies in an area of alternating medium and high sensitivity on the northeast side of Spruce Mountain amidst several seasonal drainages.

It is technically within a zone of medium sensitivity, but high-sensitivity pixels are located nearby. To shift the locations of these villages would not significantly alter the model, but merely reflects the inherent limits of digitizing Steward's village locations. By contrast, one village (PD 1) almost certainly was modeled to lie in a low-sensitivity zone, since the nearest medium- and high-sensitivity zones are 1.6 km to the south. The village at PD 2 likewise almost certainly lies with a medium-sensitivity zone, although this may be due to the fact that wetlands were omitted as a variable.

These are the exceptions, as the remainder of the villages lay in the middle of sizable, high- or medium-sensitivity zones. By and large, high-sensitivity zones follow elevations between 4,000 and 6,000 ft, crossing the scrub, sagebrush, and piñon-juniper zones. This makes sense,

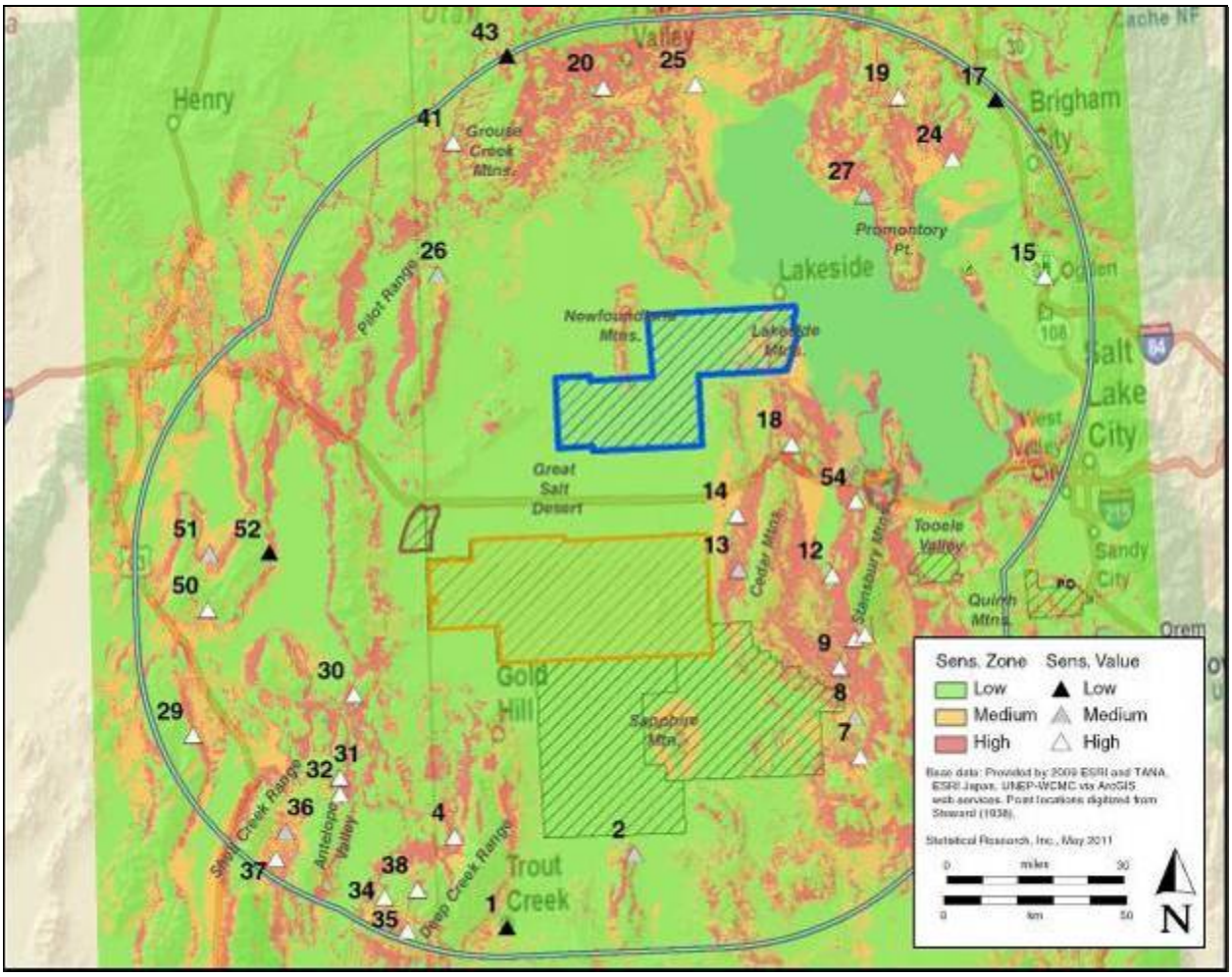

Figure E-6. Ethnographic village locations relative to low-, medium-, and high-sensitivity zones of ELM.

considering that such areas cross-cut the ecological niches of a wide variety of food-producing species, including the piñon pine vital to Goshute-Western Shoshone livelihoods. Starting in the east portion of the UTTR ELM study area, Skull Valley contains a particularly large, high sensitivity zone. This also makes sense, as the area is well-watered, and *Basin-Plateau* mentions this area as the location of seasonal pronghorn antelope drives (Steward 1938:138). The United States Army Dugway Proving Grounds skirt the southern edges of the Sink and Skull Valleys, as well as the Cedar Mountains. Following the northeastern edge of these DoD lands is a swath of medium and high sensitivity areas.

The foothills and valleys on either side of the Cedar, Stansbury, and Quirrh Mountains—particularly Rush Valley and Tooele Valley (see Figure D-6)—were blanketed with high sensitivity area, though only a few villages were recorded in these places (PDs 7−12 and 54) to the west and southwest of the Stansbury Mountains and west and north of the Cedars (PDs 13, 14, and 18). Most telling for the effectiveness and sensitivity of the ELM is that Steward labeled

Table E-4. Sensitivity Zones of Ethnographic Villages Listed by SRI PD Number

SRI PD Number	Sensitivity Zone (by Site)	Sensitivity Zone (by Survey)	Comments on village position relative to sensitivity zones
1	1	1	Highly probable that village is actually in low sensitivity zone, since nearest medium and high sensitivity zones are 1.6 km south
2	2	2	Highly probable that village is actually in medium sensitivity zone, though model may not adequately account for wetlands to east
4	3	3	In middle of high sensitivity zone within watershed of Deep Creek, likely accurate measure
7	3	3	In high sensitivity zone, though positional inaccuracy may put this in high, medium, or low sensitivity
8	2	2	In large medium sensitivity zone, likely accurate measure
9	3	3	In large high sensitivity zone, likely accurate measure
10	3	3	In large high sensitivity zone, likely accurate measure
11	3	3	In large high sensitivity zone, likely accurate measure
12	3	3	In large high sensitivity zone, likely accurate measure
13	1	2	Embedded in large area of high and medium sensitivity, with pockets of low sensitivity. Low sensitivity is likely a result of positional inaccuracy.
14	3	3	In area of mixed sensitivities, could be any one
15	3	3	In small zone of high sensitivity, watershed of Ogden river
17	1	1	Probably misplacement of village point, located 90 m southwest of high sensitivity zone, watershed of Bear River
18	3	3	In large high sensitivity zone, likely accurate measure
19	3	3	In large high sensitivity zone, likely accurate measure
20	3	3	In large high sensitivity zone, likely accurate measure
24	3	3	In large high sensitivity zone, likely accurate measure
25	3	3	In large medium sensitivity zone, likely accurate measure
26	2	2	In small medium sensitivity zone, likely accurate measure
27	3	2	On border between large area of medium and high sensitivity, could be either
29	3	3	On edge of high sensitivity zone adjacent to McDermid Creek, probably accurate measure
30	3	3	On edge of high sensitivity zone, likely accurate measure
31	3	3	On edge of high sensitivity zone, likely accurate measure
32	3	3	In large high sensitivity zone, likely accurate measure
34	3	3	In large high sensitivity zone, likely accurate measure
35	3	3	Embedded in large area of high and medium sensitivity, with pockets of low sensitivity
36	2	2	Embedded in large area of high and medium sensitivity, with pockets of low sensitivity
37	3	3	Embedded in large area of high and medium sensitivity, with pockets of low sensitivity
38	3	3	Embedded in large area of high and medium sensitivity, with pockets of low sensitivity
41	3	3	On edge of high sensitivity zone adjacent to Grouse Creek, probably accurate measure
43	1	1	Probably misplacement of village point, located 210 m to northeast of high sensitivity zone
50	3	3	In large high sensitivity zone, likely accurate measure
51	2	2	Embedded in large area of high and medium sensitivity, with pockets of low sensitivity
52	1	1	Probably misplacement of village point, located 110 m to south of high sensitivity zone
54	3	3	In large high sensitivity zone, likely accurate measure

these valleys on his maps with the names of specific Goshute-Western Shoshone bands (e.g. "Tooele Valley Gosiute") but did not map specific villages. Notable, the Tooele Army Depot, which is DoD property, is situated in the center of two highly sensitive areas in Tooele and Rush Valleys. Moving north of the Great Salt Lake, Promontory Point, Blue Creek (PD 19), and to a lesser extent, Bear River (by PDs 17 and 24) were almost entirely covered with large patches of high and medium sensitivity. The highly sensitive areas around famous Late Prehistoric Promontory Point cave sites (Steward 1937b), though excluded from this study, attest to the residential favorability for this general location.

The largest villages in terms of number of families (as far as Steward noted) in the ELM study area were located in the north near Grouse Creek and Dove Creek (see Figure E-6). Multiple antelope and rabbit locations are mapped near these waterways, as is a piñon forest in the Grouse Creek Mountains. Likely as a result, the villages around Kelton, Matalin, Terrace, and Lucin (see Figure E-4) exhibited large regions of high and medium sensitivity. One can follow the Pilot Range southwestward from Lucin to the Toana Range and Goshute Mountains, and find that high and medium sensitivity zones tend to cluster around 4,000 to 6,000 ft, following waterways and scrub, sagebrush, and piñon-juniper zones. In the southwestern part of the ELM study area is the largest cluster of recorded village locations. These villages and large, contiguous areas of high and medium sensitivity follow the Shell Creek Range (PDs 36 and 37), Deep Creek and the Deep Creek Mountains (PDs 4, 34, 35, and 38), Trout Creek (PD 1), and a large portion of Antelope Valley (PDs 31 and 32). *Basin-Plateau* (Steward 1938:136−137) recorded these areas as rich in piñon forest, rabbit, rodents, such that Deep Creek served as a location for regional festivals.

The largest contiguous area of low sensitivity is the Great Salt Desert. Though the desert alkaline flats supported cultivable species like pickleweed, goosefoot, and blazing star, the ELM classified these areas as less sensitive for villages. This circumstance is due to the absence of other factors which show a higher degree of correlation with habitation elsewhere: small distances to water, piñon and juniper, antelope, and elevations between 4,000 and 6,000 ft. Several "islands" of higher elevation within the Great Salt Desert offer these amenities, such as Sapphire Mountain and the Newfoundland and Silver Island Mountains. Notably Sapphire Mountain, which exhibits areas of high sensitivity on its western, north, and eastern faces, is situated in the center of the Dugway Proving Grounds.

Taking into account the limits of Steward's maps, if we accept the merit of this model as being useful for predicting village locations, we can then begin to consider its usefulness on UTTR lands. For simplicity's sake, we confine our observations to UTTR-North and South (Figures E-7 and E-8). We find the largest high- and medium-sensitivity zones located primarily on the east side of UTTR-North along the foothills of the Lakeside Mountains. The southern tip of the Newfoundland Mountains, which extends into the northern portion of UTTR-North, also has a zone of high and medium sensitivity. Approximately 16.8 sq mi (10,766 ac) of UTTR-North has been classified as highly sensitive, which is about 3 percent of UTTR-North as a whole (Table E-5). By contrast, 0.07 sq mi (~48 ac) of UTTR-South has been deemed to have high sensitivity for villages, which is less than 0.01 percent of UTTR-South. With respect to UTTR-North, about 44 sq mi (28,187 ac), or about 7.9 percent is moderately sensitive for village locations. About

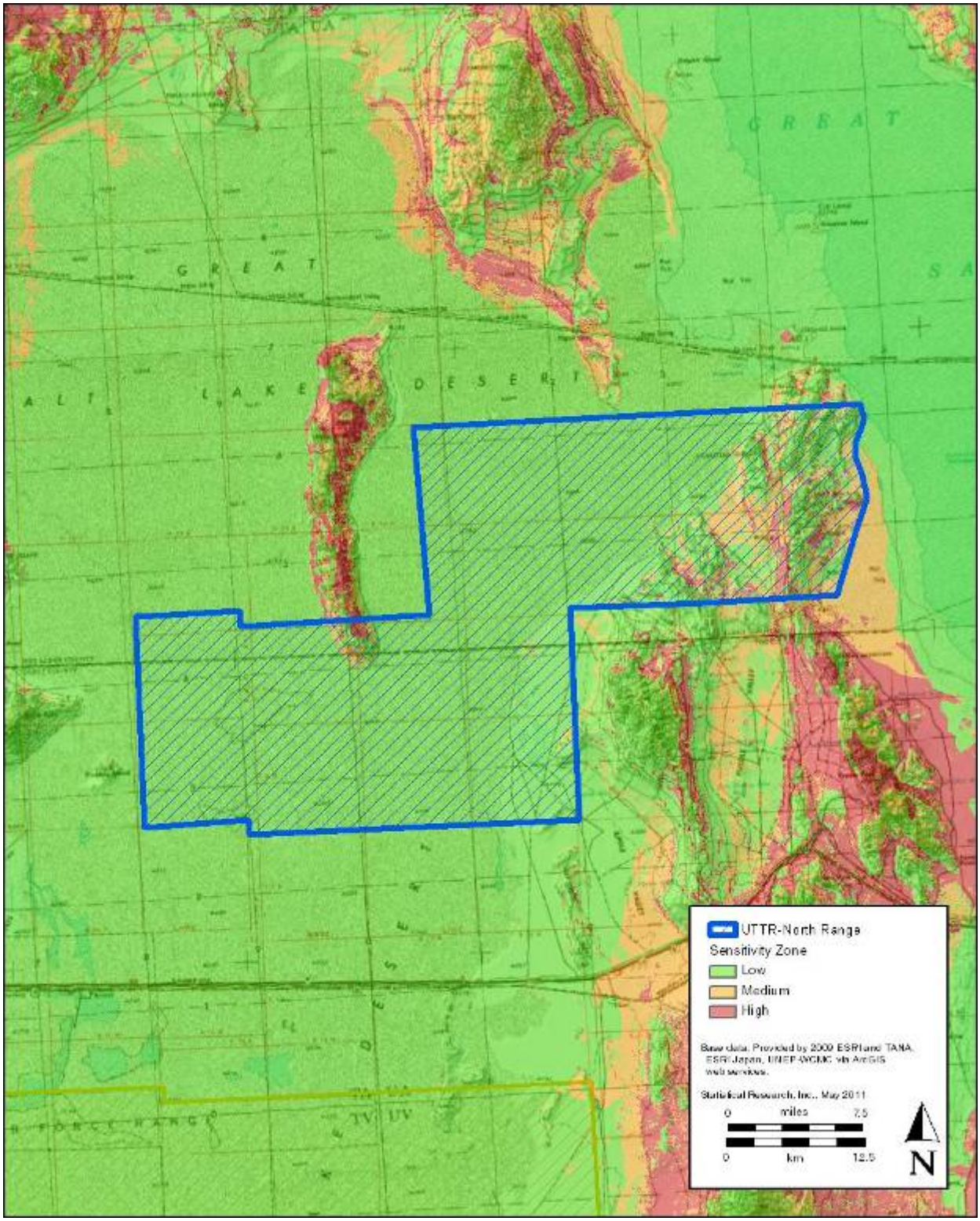

Figure E-7. Detailed view of the UTTR ELM at UTTR-North.

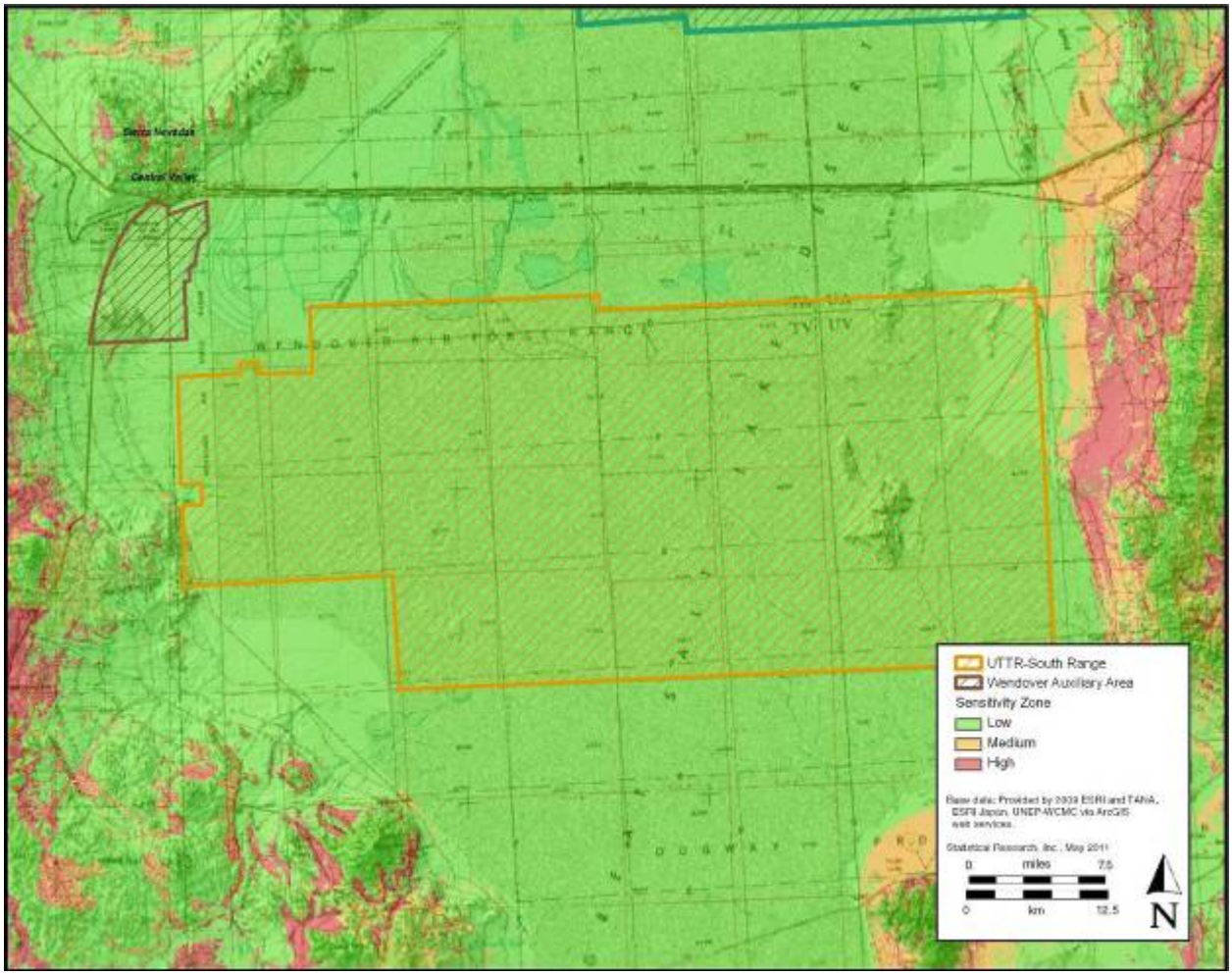

Figure E-8. Detailed view of the UTTR ELM at UTTR-South.

2.5 sq mi (1,618 ac) of UTTR-South is considered moderately sensitive within the model. Taking into account both properties, about 63.5 sq mi (38,954 ac), or less than 5 percent of the UTTR, is either highly or moderately sensitive for unrecorded ethnographic villages.

Table E-5. Tabulation of Areas of Highly and Moderately Sensitive Areas within the UTTR, excluding Wendover Auxiliary Area and Other DoD Lands

Location	Area (sq mi)	Area (sq. mi), High sensitivity	Percent with High sensitivity	Area (sq. mi), Medium sensitivity	Percent with Medium sensitivity	Area (sq. mi) High or Medium sensitivity	Percent with High or Medium sensitivity
UTTR-North	556.1	16.82	3.03%	44.04	7.92%	60.87	10.95%
UTTR-South	885.1	0.08	0.01%	2.53	0.29%	2.60	0.29%
UTTR-North and South	1441.2	16.90	1.17%	46.57	3.23%	63.47	4.40%

Examining and comparing the results of this work with another recent series of predictive models produced for UTTR (Young 2008), Young's "surface sites model" would seem to be the most relevant. The ethnographic villages with which we are concerned are generally too young to have been buried (which excludes Young's "buried sites model"), and they were not placed within rock shelters. One striking difference is that whereas the UTTR ELM shows a higher degree of correlation between higher elevations and upland water sources and vegetal resources, Young's model finds that sites on the surface "are expected on surfaces with relatively young soils with a land cover of Inter-Mountain Basins Mixed Salt Desert Scrub and Inter-Mountain Basins Greasewood Flat" (2008:113). The difference between the two models appears most sharply in UTTR-South. The ELM's sparse areas of medium and high sensitivity follow streams and are focused on elevated areas like Wildcat Mountain. Young's surface sites model, by contrast, presents a large, contiguous area of high and moderate sensitivity on and around Wildcat Mountain and another running east to west about 15 mi long (Young 2008:Figure 44). These contrasts accentuate the different temporal scales yet complementary aims of these two efforts, despite the fact that the two studies use many of the same input layers. Whereas the ELM is focused on locating a subset of villages occupied in the recent past, Young's surface sites model accommodates over ten thousand years of human choices about where to live and work, smoothing over ten millennia of responding to natural dynamics. As Clemmer's critique of Steward suggests, the paucity of resources with which Goshute-Western Shoshone coped may be a recent, Euro-American-induced phenomenon. In this way the ELM represents a deep look at a short period of time, rather than a broad view over millennia. Nevertheless, one major difference that should be noted is that Young's model benefits from fieldwork and more concrete information on where sites are (and are not) located. For its model training set, the ELM works within the limitations of what Steward has recorded. This circumstance could readily be remedied through additional record searches and fieldwork, increasing the predictive power, accuracy, and verisimilitude of the UTTR ELM. Such considerations are raised in the following section.

E.6 SUMMARY AND MANAGEMENT RECOMMENDATIONS

The UTTR ELM represents an important first step in grappling with the limitations of available information to model areas of higher sensitivity to ethnographic villages on UTTR lands. Based on our experiences at Nellis AFB, we argued that Steward's records for ethnographic village locations on the UTTR lands are incomplete. This incompleteness arises due to his research design, methods of mapping, and omission of important historical details surrounding the ethnographic present of the Goshute-Western Shoshone. Still, we propose that it is possible to model village-sensitive zones using village locations provided in Steward's *Basin-Plateau* maps as a training set. Taking into account inaccuracies introduced during Steward's own process of mapping and during the process of digitization, we recorded digital village loci in order to perform a neural network analysis of a 50 mi-wide study area surrounding the UTTR lands. This model incorporated publicly available spatial data, including physical geography and emphasizing faunal and floral resources that were important to the Goshute-Western Shoshone. The resulting sensitivity raster of the UTTR ELM study area presents areas of high, medium, and low sensitivity for potentially unrecorded residential bases. The areas of highest sensitivity were found to cluster around the foothills of mountain ranges, particularly in sage brush and piñon-juniper zones where water, rabbit, pronghorn antelope, piñon pine, juniper berries, and other

resources were plentiful and accessible. Focusing on UTTR proper, UTTR-South exhibits the highest proportion of low sensitivity area, as all but a small portion in the northeast corner lies within the alkaline flats of the Great Salt Desert. UTTR-North, by contrast, holds more promise for locating unknown residential bases in the foothills of the Lakeside Mountains on the east and the Newfoundland Mountains in the north.

Despite these preliminary results, it is important to restate that the UTTR ELM was designed to highlight sensitivity to ethnographically recorded villages, a significant subset of all the sorts of TCPs that might be found on the UTTR. The model was not designed to predict the locations of sacred places or traditional places described in oral histories that did not involve at least seasonal residence. This means that while a mountain peak or natural feature named from afar may have been culturally significant, it may lack those natural characteristics suitable for residence. As a consequence, such places could be marked as areas of low sensitivity within this model.

Caveats aside, the UTTR ELM is designed to be a significant component in the development of a suite of decision-making tools for UTTR's cultural resource managers. As it addresses the issue of ethnographic village locations from the past two centuries, it forms an important complement to the geoarchaeological predictive model recently developed for prehistoric sites (Young 2008). Given that modeling is an iterative, cumulative process, and not an event (Altschul 1988), the UTTR ELM can be augmented by refining of the data available for modeling and expectations of it. The following represents a series of prioritized recommendations on how the model's predictive power could be improved. They are listed in approximate order of increasing investment, though predictive gains generally improve as well.

- Account for wetlands in the UTTR ELM. According to Madsen, "Marshes are the single richest ecosystem yet defined in terms of available energy even when compared with most types of intensive farming…" (Madsen 1980:20, quoted in Sucec 2007:27). This iteration of the ELM originally included wetlands as a land use category, but the value for distance to wetland exhibited too little variance. In order to potentially overcome this issue, the model could selectively experiment with the inclusion of marsh-specific faunal and floral species to observe potential changes in model sensitivity. Such an effort would be relevant, since the bulk of UTTR-South has been found to be of low sensitivity, despite the fact that the total area of wetlands in UTTR-South has been estimated at 22,245 ac (Parsons Engineering Science 1995).

- Integrate higher-resolution and more detailed spatial data, if available. Using better-informed, regional and UTTR-specific spatial data would be preferable to publically available, coarser and less accurate national data. However, higher resolution DEM usage would best be coordinated with acquiring more precise locations of Steward's villages, as one would want to minimize inaccuracy for village positions as much as possible.

- Improve spatial positioning of Steward's known village locations and adding additional, recorded ethnographic villages to the model training set by conducting a records search for sites within the circle of uncertainty for each of Steward's village point. Cross-checking this information with Steward's scant records may enable matches with digitized village points and recorded ethnographic village sites.

- Conduct a ground-based reconnaissance survey within the circle of uncertainty for each village location to relocate it. This may involve surface-based site recording and subsurface testing. This effort would augment the predictive power of the model by providing more precise locations of the villages with respect to natural features.

- Conduct a records search for village locations on the UTTR that Steward did not record. By increasing the size of the model training set, we can increase its predictive power.

- Augment the model to accommodate non-residential TCPs. The ELM focuses on residential bases such as described by Steward, which are a small subset of TCPs as defined overall. Since some TCPs will lack material culture, additional effort could be placed in discovering the location of non-residential places in the vicinity of UTTR. These could include sacred mountains, historic trails, resource procurement areas, or symbolically significant water sources not accounted for in the ELM. Viewshed (Jones 2006) or least-cost-path analyses (Taliferro et al. 2010) that build upon Chamberlin's excellent historical geography (1913), for instance, could refine the ELM to be sensitive to non-residential TCPs as well.

If modeling efforts are to be effective tools for cultural resource management, they must reside within an iterative cycle of questioning, information collection, testing, and refinement. These recommendations provide a generalized road map for enhancing the predictive power of the UTTR ELM over time. Should the UTTR cultural resource managers wish to pursue these recommendations, the ELM can continue to develop as a robust tool within a suite of tools aimed at identification of "red flag" areas that may affect mission success, effective utilization of limited resources, and compliance with National Historic Preservation Act and National Environmental Policy Act regulations.

APPENDIX F: SUBSURFACE SENSITIVITY DETERMINATIONS FOR NATIONAL RESOURCE CONSERVATION SERVICE SOIL TYPES AT EGLIN AFB, OKALOOSA COUNTY, FLORIDA

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
2	Arents, 2 to 8 percent slopes		Entisols		Medium to high
3	Beaches		Not soil		Low to none
4	Chipley and Hurricane soils, 0 to 5 percent slopes	Uplands of the Southern Coastal Plain	Entisols	Thermic, coated Aquic Quartzipsamments	Medium to high
6	Dorovan muck, frequently flooded	Flood plains, hardwood swamps, and depressions in the Southern Coastal Plain	Histosols	Dysic, thermic Typic Haplosaprists	Medium
7	Duckston sand, frequently flooded	Shallow depressions between coastal dunes and on nearly level flats between the dunes and the marshes	Entisols	Siliceous, thermic Typic Psammaquents	Medium
8	Foxworth sand, 0 to 5 percent slopes	Broad uplands and side slopes leading to	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
10	Kureb sand, 0 to 8 percent slopes	Gently sloping to moderately steep soils on Coastal Plain uplands and on side slopes along streams and bays	Entisols	Thermic, uncoated Spodic Quartzipsamments	Medium to high
12	Lakeland sand, 0 to 5 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
13	Lakeland sand, 5 to 12 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
14	Lakeland sand, 12 to 30 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
15	Leon sand	Upland flats, depressions, stream terraces, and tidal areas	Spodosols	Sandy, siliceous, thermic Aeric Alaquods	Medium
16	Lucy loamy sand, 0 to 5 percent slopes	Ridgetops and side slopes on uplands of the Southern Coastal Plain.	Ultisols	Loamy, kaolinitic, thermic Arenic Kandiudults	Low to none
17	Mandarin sand, 0 to 3 percent slopes	Marine terrace	Spodosols	Sandy, siliceous, thermic Oxyaquic Alorthods	Medium
18	Newhan-Corolla complex, rolling	Undulating dunes commonly near beaches and waterways along the coast	Entisols	Thermic, uncoated Typic Quartzipsamments	Medium to high
20	Udorthents, nearly level		Entisols		Medium to high

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
21	Resota sand, 0 to 5 percent slopes	High coastal ridges near the Gulf of Mexico	Entisols	Thermic, coated Spodic Quartzipsamments	Medium to high
22	Rutlege fine sand, depressional	Flats, depressions, flood plains	Inceptisols	Sandy, siliceous, thermic Typic Humaquepts	Medium to high
23	Troup sand, 0 to 5 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
24	Troup sand, 5 to 8 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
25	Troup sand, 8 to 12 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
26	Troup sand, 12 to 25 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
27	Urban land		Not soil		Low to none
34	Albany loamy sand, 0 to 5 percent slopes	Marine terraces and upland flats	Ultisols	Loamy, siliceous, subactive, thermic Aquic Arenic Paleudults	Low to none
35	Angie sandy loam, 2 to 5 percent slopes	Strongly sloping Coastal Plains	Ultisols	Fine, mixed, semiactive, thermic Aquic Paleudults	Low to none
36	Bonifay sand, 0 to 5 percent slopes	Ridges and side slopes in the Southern Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Grossarenic Plinthic Paleudults	Low to none
37	Bonifay sand, 5 to 8 percent slopes	Ridges and side slopes in the Southern Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Grossarenic Plinthic Paleudults	Low to none
38	Dothan loamy sand, 0 to 2 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
39	Dothan loamy sand, 2 to 5 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
40	Dothan loamy sand, 5 to 8 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
41	Fuquay loamy fine sand, 0 to 5 percent slopes	Marine terraces, uplands, flats	Ultisols	Loamy, kaolinitic, thermic Arenic Plinthic Kandiudults	Low to none
42	Fuquay loamy fine sand, 5 to 8 percent slopes	Marine terraces, uplands, flats	Ultisols	Loamy, kaolinitic, thermic Arenic Plinthic Kandiudults	Low to none
43	Kinston, Johnston, and	Flood plains	Inceptisols	Fine-loamy, siliceous,	Medium to

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
	Bibb soils, frequently flooded			semiactive, acid, thermic Fluvaquentic Endoaquepts	high
44	Leefield-Stilson complex, 0 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Arenic Plinthaquic Paleudults	Low to none
45	Orangeburg sandy loam, 0 to 2 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
46	Orangeburg sandy loam, 2 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
47	Orangeburg sandy loam, 5 to 8 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
48	Pickney loamy sand, depressional	Flats, depressions, stream terraces, and flood plains	Inceptisols	Sandy, siliceous, thermic Cumulic Humaquepts	Medium to high
49	Bonifay-Dothan-Angie complex, 5 to 12 percent slopes	Ridges and side slopes in the Southern Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Grossarenic Plinthic Paleudults	Low to none
50	Yemassee, Garcon, and Bigbee soils, occasionally flooded	Terraces and broad flats of the lower Coastal Plain	Ultisols	Fine-loamy, siliceous, semiactive, thermic Aeric Endoaquults	Low to none
51	Troup-Orangeburg-Cowarts complex, 5 to 12 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
52	Escambia fine sandy loam, 0 to 3 percent slopes	Uplands of the Southern Coastal Plain	Ultisols	Coarse-loamy, siliceous, semiactive, thermic Plinthaquic Paleudults	Low to none
53	Notcher gravelly sandy loam, 0 to 2 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, siliceous, subactive, thermic Plinthic Paleudults	Low to none
54	Notcher gravelly sandy loam, 2 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, siliceous, subactive, thermic Plinthic Paleudults	Low to none
55	Pansey sandy loam, depressional	Upland flats and in depressions on interstream divides of the Southern Coastal Plain	Ultisols	Fine-loamy, siliceous, semiactive, thermic Plinthic Paleaquults	Low to none
56	Pansey sandy loam, 1 to 3 percent slopes	Upland flats and in depressions on interstream divides of the Southern Coastal Plain	Ultisols	Fine-loamy, siliceous, semiactive, thermic Plinthic Paleaquults	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
99	Water		Not soil		None
100	Waters of the Gulf of Mexico		Not soil		None

APPENDIX G: SUBSURFACE SENSITIVITY DETERMINATIONS FOR NATIONAL RESOURCE CONSERVATION SERVICE SOIL TYPES AT EGLIN AFB, SANTA ROSA COUNTY, FLORIDA

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
1	Albany loamy sand, 0 to 5 percent slopes	Marine terraces and upland flats	Ultisols	Loamy, siliceous, subactive, thermic Aquic Arenic Paleudults	Low to none
2	Angie variant loam	Strongly sloping Coastal Plains	Ultisols	Fine, mixed, semiactive, thermic Aquic Paleudults	Low to none
3	Bibb-Kinston association	Flood plains of streams in the Coastal Plain	Entisols	Coarse-loamy, siliceous, active, acid, thermic Typic Fluvaquents	Medium to high
4	Bohicket and Handsboro soils	Tidal marshes	Entisols	Fine, mixed, superactive, nonacid, thermic Typic Sulfaquents	Low to none
5	Bonifay loamy sand, 0 to 5 percent slopes	Ridges and side slopes in the Southern Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Grossarenic Plinthic Paleudults	Low to none
6	Chewacla-Wahee-Riverview association	Flood plains	Inceptisols	Fine-loamy, mixed, active, thermic Fluvaquentic Dystrudepts	Medium to high
7	Dorovan-Pamlico association	Flood plains, hardwood swamps, and depressions in the Southern Coastal Plain	Histosols	Dysic, thermic Typic Haplosaprists	Medium
8	Dothan fine sandy loam, 0 to 2 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
9	Dothan fine sandy loam, 2 to 5 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
10	Dothan fine sandy loam, 5 to 8 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
11	Escambia fine sandy loam, 0 to 2 percent slopes	Uplands of the Southern Coastal Plain	Ultisols	Coarse-loamy, siliceous, semiactive, thermic Plinthaquic Paleudults	Low to none
12	Esto loam, 2 to 5 percent slopes	Knolls, short choppy slopes, and ridge crests on gently sloping to steeply sloping landscapes of the	Ultisols	Fine, kaolinitic, thermic Typic Kandiudults	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
		Coastal Plain			
13	Esto loam, 5 to 8 percent slopes	Knolls, short choppy slopes, and ridge crests on gently sloping to steeply sloping landscapes of the Coastal Plain	Ultisols	Fine, kaolinitic, thermic Typic Kandiudults	Low to none
14	Fuquay loamy sand, 0 to 5 percent slopes	Marine terraces, uplands, flats	Ultisols	Loamy, kaolinitic, thermic Arenic Plinthic Kandiudults	Low to none
15	Fuquay loamy sand, 5 to 8 percent slopes	Marine terraces, uplands, flats	Ultisols	Loamy, kaolinitic, thermic Arenic Plinthic Kandiudults	Low to none
16	Garcon loamy fine sand	Broad flats and on river terraces	Ultisols	Loamy, siliceous, active, thermic Aquic Arenic Hapludults	Low to none
17	Gullied land		Not soil		Medium
18	Johns fine sandy loam	Stream terraces	Ultisols	Fine-loamy over sandy or sandy-skeletal, siliceous, semiactive, thermic Aquic Hapludults	Low to none
19	Kalmia loamy fine sand, 2 to 5 percent slopes	Stream terraces	Ultisols	Fine-loamy over sandy or sandy-skeletal, siliceous, semiactive, thermic Typic Hapludults	Low to none
20	Kureb sand, 0 to 8 percent slopes	Gently sloping to moderately steep soils on Coastal Plain uplands and on side slopes along streams and bays	Entisols	Thermic, uncoated Spodic Quartzipsamments	Medium to high
21	Lakeland sand, 0 to 5 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
22	Lakeland sand, 5 to 12 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
23	Lakeland sand, 12 to 30 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
24	Leon sand, 0 to 2 percent slopes	Upland flats, depressions, stream terraces, and tidal areas	Spodosols	Sandy, siliceous, thermic Aeric Alaquods	Medium
25	Lucy loamy sand,	Ridgetops and side slopes on	Ultisols	Loamy, kaolinitic, thermic Arenic	Low to

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
	0 to 5 percent slopes	uplands of the Southern Coastal Plain.		Kandiudults	none
26	Lucy loamy sand, 5 to 8 percent slopes	Ridgetops and side slopes on uplands of the Southern Coastal Plain.	Ultisols	Loamy, kaolinitic, thermic Arenic Kandiudults	Low to none
27	Lynchburg fine sandy loam	Marine terraces, flats	Ultisols	Fine-loamy, siliceous, semiactive, thermic Aeric Paleaquults	Low to none
28	Maxton loamy fine sand, 2 to 5 percent slopes	Low terraces of larger streams and marine terraces at low elevations	Ultisols	Fine-loamy over sandy or sandy-skeletal, siliceous, subactive, thermic Typic Hapludults	Low to none
29	Mulat loamy fine sand	Low-lying areas of the Gulf Coastal flatwoods	Ultisols	Loamy, siliceous, subactive, thermic Arenic Endoaquults	Low to none
30	Orangeburg sandy loam, 0 to 2 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
31	Orangeburg sandy loam, 2 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
32	Orangeburg sandy loam, 5 to 8 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
33	Ortega sand, 0 to 5 percent slopes	Marine terraces	Entisols	Thermic, uncoated Typic Quartzipsamments	Medium to high
34	Pactolus loamy sand, 0 to 5 percent slopes	Stream an marine terraces	Entisols	Thermic, coated Aquic Quartzipsamments	Medium to high
35	Pickney loamy sand	Flats, depressions, stream terraces, and flood plains	Inceptisols	Sandy, siliceous, thermic Cumulic Humaquepts	Medium to high
36	Pits		Not soil		None
37	Rains fine sandy loam	Flats and depressions	Ultisols	Fine-loamy, siliceous, semiactive, thermic Typic Paleaquults	Low to none
38	Red Bay sandy loam, 0 to 2 percent slopes	Broad ridgetops and on side slopes on uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Rhodic Kandiudults	Low to none
39	Red Bay sandy loam, 2 to 5	Broad ridgetops and on side slopes on uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Rhodic Kandiudults	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
	percent slopes				
40	Rutlege loamy sand	Flats, depressions, flood plains	Inceptisols	Sandy, siliceous, thermic Typic Humaquepts	Medium to high
41	Tifton sandy loam, 0 to 2 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
42	Tifton sandy loam, 2 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
43	Tifton sandy loam, 5 to 8 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
44	Troup loamy sand, 0 to 5 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
45	Troup loamy sand, 5 to 8 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
46	Troup loamy sand, 8 to 12 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
47	Troup-Orangeburg-Cowarts complex, 5 to 12 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
48	Urban land		Not soil		Low to none
49	Newhan-Corolla complex, rolling	Undulating dunes commonly near beaches and waterways along the coast	Entisols	Thermic, uncoated Typic Quartzipsamments	Medium to high
50	Beaches		Not soil		Low to none

APPENDIX H: SUBSURFACE SENSITIVITY DETERMINATIONS FOR NATIONAL RESOURCE CONSERVATION SERVICE SOIL TYPES AT EGLIN AFB, WALTON COUNTY, FLORIDA

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
1	Albany-Pactolus loamy sands, 0 to 5 percent slopes	Marine terraces and upland flats	Ultisols	Loamy, siliceous, subactive, thermic Aquic Arenic Paleudults	Low to none
2	Bonifay loamy sand, 0 to 5 percent slopes	Ridges and side slopes in the Southern Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Grossarenic Plinthic Paleudults	Low to none
3	Bonifay loamy sand, 5 to 8 percent slopes	Ridges and side slopes in the Southern Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Grossarenic Plinthic Paleudults	Low to none
4	Chipley sand, 0 to 5 percent slopes	Uplands of the Southern Coastal Plain	Entisols	Thermic, coated Aquic Quartzipsamments	Medium to high
5	Chipley sand, 5 to 8 percent slopes	Uplands of the Southern Coastal Plain	Entisols	Thermic, coated Aquic Quartzipsamments	Medium to high
6	Escambia sandy loam, 2 to 5 percent slopes	Uplands of the Southern Coastal Plain	Ultisols	Coarse-loamy, siliceous, semiactive, thermic Plinthaquic Paleudults	Low to none
8	Dorovan-Pamlico association, frequently flooded	Flood plains, hardwood swamps, and depressions in the Southern Coastal Plain	Histosols	Dysic, thermic Typic Haplosaprists	Medium
9	Dothan loamy sand, 0 to 2 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
10	Dothan loamy sand, 2 to 5 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
11	Dothan loamy sand, 5 to 8 percent slopes	Side slopes and ridge tops of uplands of the Southern Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
12	Foxworth sand, 0 to 5 percent slopes	Broad uplands and side slopes leading to	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
13	Fuquay loamy sand, 0 to 5 percent slopes	Marine terraces, uplands, flats	Ultisols	Loamy, kaolinitic, thermic Arenic Plinthic Kandiudults	Low to none
14	Fuquay loamy sand, 5 to 8 percent slopes	Marine terraces, uplands, flats	Ultisols	Loamy, kaolinitic, thermic Arenic Plinthic Kandiudults	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
15	Kinston-Johnston-Bibb complex, frequently flooded	Flood plains	Inceptisols	Fine-loamy, siliceous, semiactive, acid, thermic Fluvaquentic Endoaquepts	Medium to high
16	Kureb sand, 0 to 8 percent slopes	Gently sloping to moderately steep soils on Coastal Plain uplands and on side slopes along streams and bays	Entisols	Thermic, uncoated Spodic Quartzipsamments	Medium to high
17	Lakeland sand, 0 to 5 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
18	Lakeland sand, 5 to 12 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
19	Lakeland sand, 12 to 30 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
20	Leefield-Stilson loamy sands, 0 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Loamy, siliceous, subactive, thermic Arenic Plinthaquic Paleudults	Low to none
21	Leon sand	Upland flats, depressions, stream terraces, and tidal areas	Spodosols	Sandy, siliceous, thermic Aeric Alaquods	Medium
22	Lucy loamy sand, 0 to 5 percent slopes	Ridgetops and side slopes on uplands of the Southern Coastal Plain.	Ultisols	Loamy, kaolinitic, thermic Arenic Kandiudults	Low to none
23	Lucy loamy sand, 5 to 8 percent slopes	Ridgetops and side slopes on uplands of the Southern Coastal Plain.	Ultisols	Loamy, kaolinitic, thermic Arenic Kandiudults	Low to none
25	Orangeburg sandy loam, 1 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
26	Orangeburg sandy loam, 5 to 8 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
27	Rutlege fine sand	Flats, depressions, flood plains	Inceptisols	Sandy, siliceous, thermic Typic Humaquepts	Medium to high
28	Tifton fine sandy loam, 0 to 2 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
29	Tifton fine sandy loam, 2 to 5 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none
30	Tifton fine sandy loam, 5 to 8 percent slopes	Uplands of the Coastal Plain	Ultisols	Fine-loamy, kaolinitic, thermic Plinthic Kandiudults	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
31	Troup sand, 0 to 5 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
32	Troup sand, 5 to 8 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
33	Troup sand, 8 to 12 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
34	Troup sand, 12 to 25 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
35	Troup-Orangeburg-Cowarts loamy sands, 5 to 12 percent slopes	Steep Coastal Plain uplands and side slopes	Ultisols	Loamy, kaolinitic, thermic Grossarenic Kandiudults	Low to none
36	Pits		Not soil		None
37	Angie sandy loam, 2 to 5 percent slopes	Strongly sloping Coastal Plains	Ultisols	Fine, mixed, semiactive, thermic Aquic Paleudults	Low to none
38	Bonneau-Norfolk-Angie complex, 5 to 12 percent slopes	Marine terraces, uplands	Ultisols	Loamy, siliceous, subactive, thermic Arenic Paleudults	Low to none
39	Pantego loam, depressional	Nearly level and slightly depressional areas of the Southern Coastal Plain and Alantic Coast Flatwoods	Ultisols	Fine-loamy, siliceous, semiactive, thermic Umbric Paleaquults	Low to none
40	Escambia sandy loam, 0 to 2 percent slopes	Uplands of the Southern Coastal Plain	Ultisols	Coarse-loamy, siliceous, semiactive, thermic Plinthaquic Paleudults	Low to none
41	Maurepas muck, frequently flooded	Backswamps	Histosols	Euic, hyperthermic Typic Haplosaprists	Medium
42	Blanton sand, 0 to 5 percent slopes	Uplands and stream terraces of the Coastal Plain	Ultisols	Loamy, siliceous, semiactive, thermic Grossarenic Paleudults	Low to none
43	Kinston-Bibb association, frequently flooded	Flood plains	Inceptisols	Fine-loamy, siliceous, semiactive, acid, thermic Fluvaquentic Endoaquepts	Medium to high
44	Lakeland-Troup-Urban land complex, 0 to 5 percent slopes	Broad uplands in the Lower Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
45	Dirego muck, frequently flooded	Narrow to broad tidal marshes extending from bays into drainage tributaries entering the	Histosols	Sandy or sandy-skeletal, siliceous, euic, thermic Terric Sulfisaprists	Medium

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
		bays			
46	Norfolk loamy sand, 2 to 5 percent slopes	Uplands or marine terraces	Ultisols	Fine-loamy, kaolinitic, thermic Typic Kandiudults	Low to none
47	Bonneau loamy sand, 0 to 5 percent slopes	Marine terraces, uplands	Ultisols	Loamy, siliceous, subactive, thermic Arenic Paleudults	Low to none
48	Yemassee-Garcon-Bigbee complex, occasionally flooded	Terraces and broad flats of the lower Coastal Plain	Ultisols	Fine-loamy, siliceous, semiactive, thermic Aeric Endoaquults	Low to none
49	Eglin sand, 0 to 5 percent slopes	Relatively low elevations within the sand hills commonly near the heads of drainageways.	Spodosols	Sandy, siliceous, thermic Entic Grossarenic Alorthods	Medium
50	Mandarin sand	Marine terrace	Spodosols	Sandy, siliceous, thermic Oxyaquic Alorthods	Medium
51	Bigbee loamy sand, 0 to 5 percent slopes, occasionally flooded	Low terraces along streams in the Southern Coastal Plain	Entisols	Thermic, coated Typic Quartzipsamments	Medium to high
52	Yemassee fine sandy loam, occasionally flooded	Terraces and broad flats of the lower Coastal Plain	Ultisols	Fine-loamy, siliceous, semiactive, thermic Aeric Endoaquults	Low to none

APPENDIX I: SUBSURFACE SENSITIVITY DETERMINATIONS FOR NATIONAL RESOURCE CONSERVATION SERVICE SOIL TYPES AT FORT DRUM, NEW YORK

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
1020	Pits, quarry				
1037A	Endoaquents				
1071A	Bucksport-Pondicherry complex, occasionally flooded	Bogs, primarily in depressions in ground moraines, glaciofluvial deposits, and between shallow till ridges	Histisols	Euic, frigid Typic Haplosaprists	Low to none
1078A	Pondicherry, 0 to 3 percent slopes	Bogs and swamps on outwash plains, lake plains, and till uplands	Histisols	Sandy or sandy-skeletal, mixed, euic, frigid Terric Haplosaprists	Low to none
1079A	Bucksport and Wonsqueak soils, ponded	Bogs, primarily in depressions in ground moraines, glaciofluvial deposits, and between shallow till ridges	Histisols	Euic, frigid Typic Haplosaprists	Low to none
1080A	Wonsqueak and Onjebonge soils, ponded	Depressions in glacial ground moraine, till plains, flood plains, shallow till ridges, outwash plains, and deltas	Histisols	Loamy, mixed, euic, frigid Terric Haplosaprists	Low to none
1081A	Pondicherry and Searsport soils, ponded	Bogs and swamps on outwash plains, lake plains, and till uplands	Histisols	Sandy or sandy-skeletal, mixed, euic, frigid Terric Haplosaprists	Low to none
1088A	Wonsqueak, 0 to 3 percent slopes	Depressions in glacial ground moraine, till plains, flood plains, shallow till ridges, outwash plains, and deltas	Histisols	Loamy, mixed, euic, frigid Terric Haplosaprists	Low to none
1089A	Bucksport, 0 to 3 percent slopes	Bogs, primarily in depressions in ground moraines, glaciofluvial deposits, and between shallow till ridges	Histisols	Euic, frigid Typic Haplosaprists	Low to none
1117A	Rumney, 0 to 3 percent slopes	Floodplains of rivers and streams	Inceptisols	Coarse-loamy, mixed, active, nonacid, frigid Fluvaquentic Endoaquepts	Medium to high

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
1125A	Lovewell, 0 to 3 percent slopes	Floodplains that are commonly in broad depressions	Inceptisols	Coarse-silty, mixed, superactive, frigid Fluvaquentic Dystrudepts	Medium
1126A	Cornish, 0 to 3 percent slopes	Floodplains that are commonly in broad depressions	Inceptisols	Coarse-silty, mixed, superactive, frigid Fluvaquentic Dystrudepts	Medium
1127A	Charles, 0 to 3 percent slopes	Floodplains that are commonly in broad depressions	Entisols	Coarse-silty, mixed, superactive, nonacid, frigid Aeric Fluvaquents	Medium
1128A	Medomak, 0 to 3 percent slopes	Lowest lying position of floodplains	Inceptisols	Coarse-silty, mixed, superactive, nonacid, frigid Fluvaquentic Humaquepts	Low to none
1217A	Wegatchie, 0 to 3 percent slopes	Glacial lake plains that have a plane or concave surface	Inceptisols	Fine-silty, mixed, active, nonacid, frigid Mollic Endoaquepts	Low to none
1235B	Nicholville, 2 to 8 percent slopes	Lake plains and upland till plains that have a mantle of wind or water-deposited silt or very fine sand	Spodisols	Coarse-silty, isotic, frigid Aquic Haplorthods	Low to none
1236A	Roundabout (swp), 0 to 3 percent slopes	Glaciolacustrine or glaciomarine deposits of Wisconsin Age on lake or marine plains	Inceptisols	Coarse-silty, mixed, active, nonacid, frigid Aeric Epiaquepts	Low to none
1237A	Roundabout (p), 0 to 3 percent slopes	Glaciolacustrine or glaciomarine deposits of Wisconsin Age on lake or marine plains	Inceptisols	Coarse-silty, mixed, active, nonacid, frigid Aeric Epiaquepts	Low to none
1238A	Onjebonge, 0 to 3 percent slopes	Depressions on pro-glacial lake plains, glacial outwash plains, deltas, and terraces	Inceptisols	Coarse-silty, mixed, active, nonacid, frigid Histic Humaquepts	Low to none
1329A	Adjidaumo, 0 to 3 percent slopes, rocky	Depressional areas of marine plains or are in depressions in upland basins	Inceptisols	Fine, mixed, active, nonacid, frigid Mollic Endoaquepts	Low to none
1413B	Adams, rocky, 0 to 8 percent slopes	Nearly level to very steep sand plains, kames, moraines, benches, eskers, deltas, and terraces	Spodisols	Sandy, isotic, frigid Typic Haplorthods	Low to none
1413C	Adams, rocky, 8 to 15 percent slopes	Nearly level to very steep sand plains, kames, moraines, benches, eskers, deltas, and terraces	Spodisols	Sandy, isotic, frigid Typic Haplorthods	Low to none
1423B	Adams, 0 to 8 percent slopes	Nearly level to very steep sand plains, kames, moraines, benches, eskers, deltas, and terraces	Spodisols	Sandy, isotic, frigid Typic Haplorthods	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
1423C	Adams, 8 to 15 percent slopes	Nearly level to very steep sand plains, kames, moraines, benches, eskers, deltas, and terraces	Spodisols	Sandy, isotic, frigid Typic Haplorthods	Low to none
1425B	Croghan, 0 to 8 percent slopes	Deltaic or glacial outwash sand deposited in or next to proglacial lake basins	Spodisols	Sandy, isotic, frigid Aquic Haplorthods	Low to none
1426A	Naumburg (swp), 0 to 3 percent slopes	Glaciofluvial or deltaic sands in low-lying areas of sand plains or terraces	Spodisols	Sandy, isotic, frigid Typic Endoaquods	Low to none
1427A	Naumburg (p), 0 to 3 percent slopes	Glaciofluvial or deltaic sands in low-lying areas of sand plains or terraces	Spodisols	Sandy, isotic, frigid Typic Endoaquods	Low to none
1428A	Searsport, 0 to 3 percent slopes	Pockets and depressions on outwash plains, deltas and terraces	Inceptisols	Sandy, mixed, frigid Histic Humaquepts	Low to none
1429B	Naumburg-Lyman complex, 0 to 15 percent slopes, rocky	Glaciofluvial or deltaic sands in low-lying areas of sand plains or terraces	Spodisols	Sandy, isotic, frigid Typic Endoaquods	Low to none
1447A	Deinache, 0 to 3 percent slopes	Glacial lake plains	Entisols	Mixed, frigid Mollic Psammaquents	Low to none
1684B	Kings Falls, 3 to 8 percent slopes, rocky	Bedrock controlled till plains	Inceptisols	Loamy, mixed, active, frigid Lithic Eutrudepts	Low to none
1794D	Nehasne-Kings Falls complex, 15 to 35 percent slopes, very bouldery, very rocky	Till over sandstone, dolomite, limestone or marble bedrock	Inceptisols	Coarse-loamy, mixed, active, frigid Dystric Eutrudepts	Low to none
1874C	Tunbridge-Lyman complex, 3 to 15 percent slopes, very bouldery, very rocky	Till of Wisconsin age on mountain side slopes, mountain tops, mountain ridges, hill tops, and hill slopes	Spodisols	Coarse-loamy, isotic, frigid Typic Haplorthods	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
1874D	Tunbridge-Lyman complex, 15 to 35 percent slopes, very bouldery, very rocky	Till of Wisconsin age on mountain side slopes, mountain tops, mountain ridges, hill tops, and hill slopes	Spodisols	Coarse-loamy, isotic, frigid Typic Haplorthods	Low to none
1874F	Tunbridge-Lyman complex, 35 to 70 percent slopes, very bouldery, very rocky	Till of Wisconsin age on mountain side slopes, mountain tops, mountain ridges, hill tops, and hill slopes	Spodisols	Coarse-loamy, isotic, frigid Typic Haplorthods	Low to none
1884C	Lyman-Abram complex, 3 to 15 percent slopes, very bouldery, very rocky	Thin mantle of till and frost fractured rock fragments on rocky hills, mountains and high plateaus	Spodisols	Loamy, isotic, frigid Lithic Haplorthods	Low to none
1884D	Lyman-Abram complex, 15 to 35 percent slopes, very bouldery, very rocky	Thin mantle of till and frost fractured rock fragments on rocky hills, mountains and high plateaus	Spodisols	Loamy, isotic, frigid Lithic Haplorthods	Low to none
1884F	Abram-Lyman-Rock outcrop complex, 35 to 100 percent slopes, very bouldery	Crests and side slopes of bedrock controlled ridges and mountains	Spodisols	Loamy, isotic, frigid Lithic Haplorthods	Low to none
1894D	Rock outcrop-Abram-Knob Lock complex, 15 to 35 percent slopes, very bouldery	Crests and side slopes of bedrock controlled ridges and mountains	Spodisols	Loamy, isotic, frigid Lithic Haplorthods	Low to none
9023C	Udorthents, disrupted-Insula-Rock outcrop complex, 3 to 15 percent slopes	10-20-inch-thick mantle of till of the Late Wisconsinan glaciation over bedrock	Inceptisols	Loamy, isotic, frigid Lithic Dystrudepts	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
9026A	Endoaquents, disrupted-Hailesboro-Wegatchie complex, 0 to 8 percent slopes	Lacustrine plains and lower valley walls that have a concave or slightly convex surface	Alfisols	Fine-silty, mixed, superactive, frigid Aeric Endoaqualfs	Low to none
9028A	Endoaquents, disrupted-Wonsqueak-Adjidaumo complex, 0 to 3 percent slopes	Depressions in glacial ground moraine, till plains, flood plains, shallow till ridges, outwash plains, and deltas	Histisols	Loamy, mixed, euic, frigid Terric Haplosaprists	Low to none
9078A	Wonsqueak-Adjidaumo association, 0 to 2 percent slopes, frequently ponded	Depressions in glacial ground moraine, till plains, flood plains, shallow till ridges, outwash plains, and deltas	Histisols	Loamy, mixed, euic, frigid Terric Haplosaprists	Low to none
9088A	Wonsqueak-Onjebonge association, 0 to 3 percent slopes, frequently ponded	Depressions in glacial ground moraine, till plains, flood plains, shallow till ridges, outwash plains, and deltas	Histisols	Loamy, mixed, euic, frigid Terric Haplosaprists	Low to none
9088A	Wonsqueak-Onjebonge association, 0 to 3 percent slopes, frequently ponded	Depressions in glacial ground moraine, till plains, flood plains, shallow till ridges, outwash plains, and deltas	Histisols	Loamy, mixed, euic, frigid Terric Haplosaprists	Low to none
9098A	Bucksport-Wonsqueak association, 0 to 2 percent slopes, frequently ponded	Bogs, primarily in depressions in ground moraines, glaciofluvial deposits, and between shallow till ridges	Histisols	Euic, frigid Typic Haplosaprists	Low to none
9197A	Wayland-Teel-Palms association, 0 to 3 percent slopes, frequently flooded	Depressed parts of flood plains of streams receiving runoff from uplands that contain some calcareous drift	Inceptisols	Fine-silty, mixed, active, nonacid, mesic Fluvaquentic Endoaquepts	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
9215B	Heuvelton-Muskellunge-Millsite complex, 0 to 15 percent slopes, very rocky	Lacustrine sediments lake plains and side slopes of dissected ridges	Alfisols	Fine, mixed, active, frigid Aquic Hapludalfs	Low to none
9246A	Hailesboro-Wegatchie-Insula association, 0 to 15 percent slopes, rocky	Lacustrine plains and lower valley walls that have a concave or slightly convex surface	Alfisols	Fine-silty, mixed, superactive, frigid Aeric Endoaqualfs	Low to none
9256A	Roundabout-Onjebonge-Lyman association, 0 to 15 percent slopes, rocky	Glaciolacustrine or glaciomarine deposits of Wisconsin Age on lake or marine plains	Inceptisols	Coarse-silty, mixed, active, nonacid, frigid Aeric Epiaquepts	Low to none
9256A	Roundabout-Onjebonge-Lyman association, 0 to 15 percent slopes, rocky	Glaciolacustrine or glaciomarine deposits of Wisconsin Age on lake or marine plains	Inceptisols	Coarse-silty, mixed, active, nonacid, frigid Aeric Epiaquepts	Low to none
9823C	Insula-Millsite-Quetico-Rock outcrop complex, 3 to 15 percent slopes, very bouldery	10-20-inch-thick mantle of till of the Late Wisconsinan glaciation over bedrock	Inceptisols	Loamy, isotic, frigid Lithic Dystrudepts	Low to none
9833C	Lyman-Abram complex, 3 to 25 percent slopes, very bouldery, very rocky	Thin mantle of till and frost fractured rock fragments on rocky hills, mountains and high plateaus	Spodisols	Loamy, isotic, frigid Lithic Haplorthods	Low to none
9833C	Lyman-Abram complex, 3 to 25 percent slopes, very rocky	Thin mantle of till and frost fractured rock fragments on rocky hills, mountains and high plateaus	Spodisols	Loamy, isotic, frigid Lithic Haplorthods	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
AgA	Agawam fine sandy loam, 0 to 3 percent slopes	Soils on outwash plains, high stream terraces, and terrace escarpments and steep sides of gullies in dissected outwash plains	Inceptisols	Coarse-loamy over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts	Low to none
AgB	Agawam fine sandy loam, 3 to 8 percent slopes	Soils on outwash plains, high stream terraces, and terrace escarpments and steep sides of gullies in dissected outwash plains	Inceptisols	Coarse-loamy over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts	Low to none
Fort Drum 2	Fort Drum 2				
AlB	Alton gravelly loam, 3 to 8 percent slopes	Terraces, terrace faces, beach ridges, alluvial fans, and kames	Inceptisols	Loamy-skeletal, mixed, active, mesic Dystric Eutrudepts	Medium
AlC	Alton gravelly loam, 8 to 15 percent slopes	Terraces, terrace faces, beach ridges, alluvial fans, and kames	Inceptisols	Loamy-skeletal, mixed, active, mesic Dystric Eutrudepts	Medium
AlE	Alton gravelly loam, 25 to 45 percent slopes	Terraces, terrace faces, beach ridges, alluvial fans, and kames	Inceptisols	Loamy-skeletal, mixed, active, mesic Dystric Eutrudepts	Medium
AmA	Amenia loam, 0 to 3 percent slopes	Till plains	Inceptisols	Coarse-loamy, mixed, active, mesic Aquic Eutrudepts	Low to none
AmB	Amenia loam, 3 to 8 percent slopes	Till plains	Inceptisols	Coarse-loamy, mixed, active, mesic Aquic Eutrudepts	Low to none
AnA	Angola silt loam, 0 to 3 percent slopes	Dissected upland plateaus and bedrock-controlled till plains	Alfisols	Fine-loamy, mixed, active, mesic Aeric Endoaqualfs	Low to none
ArB	Arkport fine sandy loam, 3 to 8 percent slopes	Tops and sides of glacial deltas and glacio-fluvial sand plains, and on dunes and beach ridges	Alfisols	Coarse-loamy, mixed, active, mesic Lamellic Hapludalfs	Low to none
ArC	Arkport fine sandy loam, 8 to 15 percent slopes	Tops and sides of glacial deltas and glacio-fluvial sand plains, and on dunes and beach ridges	Alfisols	Coarse-loamy, mixed, active, mesic Lamellic Hapludalfs	Low to none
BfF	Benson channery silt loam, very rocky, 25 to 50 percent slopes	Broad plains and on the tops and side slopes of hills, ridges, knolls, and mounds	Inceptisols	Loamy-skeletal, mixed, active, mesic Lithic Eutrudepts	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
BgB	Benson-Galoo complex, very rocky, 0 to 8 percent slopes	Broad plains and on the tops and side slopes of hills, ridges, knolls, and mounds	Inceptisols	Loamy-skeletal, mixed, active, mesic Lithic Eutrudepts	Low to none
BhB	Bice fine sandy loam, 3 to 8 percent slopes	Hills, ridges and other convex landforms on till uplands	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none
BhC	Bice fine sandy loam, 8 to 15 percent slopes	Hills, ridges and other convex landforms on till uplands	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none
BhD	Bice fine sandy loam, 15 to 25 percent slopes	Hills, ridges and other convex landforms on till uplands	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none
BhF	Bice fine sandy loam, 25 to 50 percent slopes	Hills, ridges and other convex landforms on till uplands	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none
BkC	Bice very stony fine sandy loam, 0 to 15 percent slopes	Hills, ridges and other convex landforms on till uplands	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none
BoA	Bombay loam, 0 to 3 percent slopes	Upland till plains	Alfisols	Coarse-loamy, mixed, active, mesic Oxyaquic Hapludalfs	Low to none
BoB	Bombay loam, 3 to 8 percent slopes	Upland till plains	Alfisols	Coarse-loamy, mixed, active, mesic Oxyaquic Hapludalfs	Low to none
BpB	Bonaparte gravelly loamy fine sand, 0 to 8 percent slopes	Glacial outwash terraces, kames, and eskers	Entisols	Sandy-skeletal, mixed, mesic Typic Udorthents	Low to none
Ca	Canandaigua silt loam	Glacial outwash terraces, kames, and eskers	Entisols	Sandy-skeletal, mixed, mesic Typic Udorthents	Low to none
Cb	Canandaigua mucky silt loam	Lowland lake plains and in depressional areas on glaciated uplands	Inceptisols	Fine-silty, mixed, active, nonacid, mesic Mollic Endoaquepts	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
Cd	Carlisle muck	Lowland lake plains and in depressional areas on glaciated uplands	Inceptisols	Fine-silty, mixed, active, nonacid, mesic Mollic Endoaquepts	Low to none
ChB	Chatfield loam, rocky, 0 to 8 percent slopes	Glaciated plains, hills, and ridges	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Dystrudepts	Low to none
CkC	Chatfield-Rock outcrop complex, rolling	Glaciated plains, hills, and ridges	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Dystrudepts	Low to none
CkE	Chatfield-Rock outcrop complex, steep	Glaciated plains, hills, and ridges	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Dystrudepts	Low to none
ClA	Chaumont silty clay, 0 to 3 percent slopes	Slightly concave landforms where relative thin clayey marine sediments overlie hard bedrock	Alfisols	Very-fine, mixed, active, mesic Aeric Endoaqualfs	Low to none
ClB	Chaumont silty clay, 3 to 8 percent slopes	Slightly concave landforms where relative thin clayey marine sediments overlie hard bedrock	Alfisols	Very-fine, mixed, active, mesic Aeric Endoaqualfs	Low to none
CmA	Claverack loamy fine sand, 0 to 3 percent slopes	Deltas and other sandy deposits associated with glacial lake sediments	Entisols	Sandy over clayey, mixed, superactive, nonacid, mesic Aquic Udorthents	Low to none
CmB	Claverack loamy fine sand, 3 to 8 percent slopes	Deltas and other sandy deposits associated with glacial lake sediments	Entisols	Sandy over clayey, mixed, superactive, nonacid, mesic Aquic Udorthents	Low to none
CnB	Collamer silt loam, 3 to 8 percent slopes	Glacial lake plains and on till plains	Alfisols	Fine-silty, mixed, active, mesic Glossaquic Hapludalfs	Low to none
CnC	Collamer silt loam, 8 to 15 percent slopes	Glacial lake plains and on till plains	Alfisols	Fine-silty, mixed, active, mesic Glossaquic Hapludalfs	Low to none
CnC3	Collamer silt loam, 8 to 15 percent slopes, severely eroded	Glacial lake plains and on till plains	Alfisols	Fine-silty, mixed, active, mesic Glossaquic Hapludalfs	Low to none
CoB	Collamer silt loam, bedrock substratum, 3 to 8	Glacial lake plains and on till plains	Alfisols	Fine-silty, mixed, active, mesic Glossaquic Hapludalfs	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
	percent slopes				
Cp	Covington silty clay	Broad plains and in depressions and drainageways and on toeslopes of swells and knolls	Alfisols	Very-fine, mixed, active, mesic Mollic Endoaqualfs	Low to none
DdB	Darien silt loam, 3 to 8 percent slopes	Wisconsinan age till on till plains, drumlins, and moraines	Alfisols	Fine-loamy, mixed, active, mesic Aeric Endoaqualfs	Low to none
DeB	Deerfield loamy fine sand, 0 to 8 percent slopes	Terraces, deltas, and outwash plains	Entisols	Mixed, mesic Aquic Udipsamments	Medium
Dp	Dumps		Not soil		
ElA	Elmridge fine sandy loam, 0 to 3 percent slopes	Glacial lacustrine and marine terraces, and on lake plains	Inceptisols	Coarse-loamy over clayey, mixed, semiactive, mesic Aquic Dystric Eutrudepts	Low to none
ElB	Elmridge fine sandy loam, 3 to 8 percent slopes	Glacial lacustrine and marine terraces, and on lake plains	Inceptisols	Coarse-loamy over clayey, mixed, semiactive, mesic Aquic Dystric Eutrudepts	Low to none
En	Ensley very stony silt loam	Till on ground moraines, end moraines, and wave cut terraces	Entisols	Coarse-loamy, mixed, active, nonacid, frigid Aeric Endoaquents	Low to none
FaB	Farmington loam, 0 to 8 percent slopes	Glaciated uplands where bedrock is at depths of less than 20 inches	Inceptisols	Loamy, mixed, active, mesic Lithic Eutrudepts	Low to none
Fu	Fluvaquents-Udifluvents complex, frequently flooded		Entisols		Medium
GaA	Galen fine sandy loam, 0 to 3 percent slopes	Sandy deltas and sand mantled till "islands" within lacustrine landscape.	Alfisols	Coarse-loamy, mixed, active, mesic Oxyaquic Hapludalfs	Low to none
GaB	Galen fine sandy loam, 3 to 8 percent slopes	Sandy deltas and sand mantled till "islands" within lacustrine landscape.	Alfisols	Coarse-loamy, mixed, active, mesic Oxyaquic Hapludalfs	Low to none
GbB	Galoo-Rock outcrop complex, 0 to 8 percent	Smooth bedrock controlled landforms that contain both short steep bedrock escarpments and	Entisols	Loamy, mixed, nonacid, mesic Lithic Udorthents	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
	slopes	level areas of exposed bedrock			
GcB	Galoo, acid-Rock outcrop complex, 0 to 8 percent slopes	Smooth bedrock controlled landforms that contain both short steep bedrock escarpments and level areas of exposed bedrock	Entisols	Loamy, mixed, nonacid, mesic Lithic Udorthents	Low to none
GlA	Galway silt loam, 0 to 3 percent slopes	Smooth to step-like landforms which are mantled with till with or without an admixture of silty eolian deposits	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
GlB	Galway silt loam, 3 to 8 percent slopes	Smooth to step-like landforms which are mantled with till with or without an admixture of silty eolian deposits	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
GlC	Galway silt loam, 8 to 15 percent slopes	Smooth to step-like landforms which are mantled with till with or without an admixture of silty eolian deposits	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
GmC	Galway very stony silt loam, 0 to 15 percent slopes	Smooth to step-like landforms which are mantled with till with or without an admixture of silty eolian deposits	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
Gr	Granby mucky loamy fine sand	Outwash plains, lake plains, and glacial drainageways	Mollisols	Sandy, mixed, mesic Typic Endoaquolls	Low to none
GtA	Groton gravelly loam, 0 to 3 percent slopes	Terraces, outwash plains, kames, eskers and moraines	Inceptisols	Sandy-skeletal, mixed, mesic Typic Eutrudepts	Low to none
GtB	Groton gravelly loam, 3 to 8 percent slopes	Terraces, outwash plains, kames, eskers and moraines	Inceptisols	Sandy-skeletal, mixed, mesic Typic Eutrudepts	Low to none
GtE	Groton gravelly loam, 25 to 35 percent slopes	Terraces, outwash plains, kames, eskers and moraines	Inceptisols	Sandy-skeletal, mixed, mesic Typic Eutrudepts	Low to none
GuB	Groton variant gravelly loam, 0 to 8 percent slopes	Terraces, outwash plains, kames, eskers and moraines	Inceptisols	Sandy-skeletal, mixed, mesic Typic Eutrudepts	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
Hb	Halsey mucky loam	Glaciofluvial deposits on level or nearly level terraces and flood plains	Inceptisols	Coarse-loamy over sandy or sandy-skeletal, mixed, active, nonacid, mesic Typic Humaquepts	Low to none
HeB	Heuvelton silt loam, 3 to 8 percent slopes	Lacustrine sediments lake plains and side slopes of dissected ridges	Alfisols	Fine, mixed, active, frigid Aquic Hapludalfs	Low to none
HeC	Heuvelton silt loam, 8 to 15 percent slopes	Lacustrine sediments lake plains and side slopes of dissected ridges	Alfisols	Fine, mixed, active, frigid Aquic Hapludalfs	Low to none
Fort Drum 3	Fort Drum 3				
HmB	Heuvelton-Millsite-Rock outcrop complex, undulating	Lacustrine sediments lake plains and side slopes of dissected ridges	Alfisols	Fine, mixed, active, frigid Aquic Hapludalfs	Low to none
HnB	Hinckley gravelly sandy loam, 0 to 8 percent slopes	Terraces, outwash plains, deltas, kames, and eskers	Entisols	Sandy-skeletal, mixed, mesic Typic Udorthents	Medium
HoB	Hinckley-Hoosic cobbly sandy loams, 0 to 8 percent slopes	Terraces, outwash plains, deltas, kames, and eskers	Entisols	Sandy-skeletal, mixed, mesic Typic Udorthents	Medium
HpB	Hollis-Galoo, acid, complex, rocky, 0 to 8 percent slopes	Bedrock-controlled hills and ridges	Inceptisols	Loamy, mixed, active, mesic Lithic Dystrudepts	Low to none
HrB	Hollis-Rock outcrop complex, 0 to 8 percent slopes	Bedrock-controlled hills and ridges	Inceptisols	Loamy, mixed, active, mesic Lithic Dystrudepts	Low to none
HuB	Hudson silt loam, 3 to 8 percent slopes	Convex lake plains on rolling to hilly moraines and on dissected lower valley side slopes	Alfisols	Fine, illitic, mesic Glossaquic Hapludalfs	Low to none
HuC	Hudson silt loam, 8 to 15 percent slopes	Convex lake plains on rolling to hilly moraines and on dissected lower valley side slopes	Alfisols	Fine, illitic, mesic Glossaquic Hapludalfs	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
HvB	Hudson-Chatfield-Rock outcrop complex, undulating	Convex lake plains on rolling to hilly moraines and on dissected lower valley side slopes	Alfisols	Fine, illitic, mesic Glossaquic Hapludalfs	Low to none
HyE3	Hudson and Vergennes soils, 15 to 35 percent slopes, severely eroded	Convex lake plains on rolling to hilly moraines and on dissected lower valley side slopes	Alfisols	Fine, illitic, mesic Glossaquic Hapludalfs	Low to none
InB	Insula-Quetico complex, rocky, 0 to 8 percent slopes	Till on bedrock controlled uplands	Inceptisols	Loamy, isotic, frigid Lithic Dystrudepts	Low to none
IoB	Insula-Rock outcrop complex, 0 to 8 percent slopes	Till on bedrock controlled uplands	Inceptisols	Loamy, isotic, frigid Lithic Dystrudepts	Low to none
Ju	Junius loamy fine sand	Nearly level lake plains	Entisols	Mixed, mesic Typic Psammaquents	Low to none
KgA	Kingsbury silty clay, 0 to 2 percent slopes	Gently sloping lake plains; calcareous clayey deposits associated with the marine embayments at the end of Wisconsin glaciation	Alfisols	Very-fine, mixed, active, mesic Aeric Endoaqualfs	Low to none
KgB	Kingsbury silty clay, 2 to 6 percent slopes	Gently sloping lake plains; calcareous clayey deposits associated with the marine embayments at the end of Wisconsin glaciation	Alfisols	Very-fine, mixed, active, mesic Aeric Endoaqualfs	Low to none
Kh	Kingsbury-Livingston complex	Gently sloping lake plains; calcareous clayey deposits associated with the marine embayments at the end of Wisconsin glaciation	Alfisols	Very-fine, mixed, active, mesic Aeric Endoaqualfs	Low to none
LaB	Lagross-Haights complex, undulating	Alluvial fans and outwash terraces	Inceptisols	Loamy-skeletal, mixed, active, frigid Typic Dystrudepts	Medium

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
Lb	Lamson fine sandy loam	Glacio-fluvial, glacio-lacustrine and deltaic deposits on glacial lake plains	Inceptisols	Coarse-loamy, mixed, active, nonacid, mesic Aeric Endoaquepts	Low to none
Lc	Livingston mucky silty clay	Calcareous estuarine and glaciolacustrine clays on glacial lake plains	Inceptisols	Very-fine, mixed, active, nonacid, mesic Mollic Endoaquepts	Low to none
Ld	Livingston silty clay loam, frequently flooded	Calcareous estuarine and glaciolacustrine clays on glacial lake plains	Inceptisols	Very-fine, mixed, active, nonacid, mesic Mollic Endoaquepts	Low to none
LoC	Lowville silt loam, 8 to 15 percent slopes	Till mantled with relatively thin loess deposits	Inceptisols	Coarse-loamy, mixed, active, mesic Dystric Eutrudepts	Medium
Ma	Madalin silt loam	Glacial lake sediments of lake plains and depressions in the uplands	Alfisols	Fine, illitic, mesic Mollic Endoaqualfs	Low to none
MdB	Madrid sandy loam, 3 to 8 percent slopes	Moraines and till plains near the margins of or within the areas of glacial lakes	Alfisols	Coarse-loamy, mixed, active, mesic Haplic Glossudalfs	Low to none
MdC	Madrid sandy loam, 8 to 15 percent slopes	Moraines and till plains near the margins of or within the areas of glacial lakes	Alfisols	Coarse-loamy, mixed, active, mesic Haplic Glossudalfs	Low to none
MoA	Massena silt loam, 0 to 3 percent slopes	Till plains	Inceptisols	Coarse-loamy, mixed, active, nonacid, mesic Aeric Endoaquepts	Low to none
MoB	Massena silt loam, 3 to 8 percent slopes	Till plains	Inceptisols	Coarse-loamy, mixed, active, nonacid, mesic Aeric Endoaquepts	Low to none
MtB	Millsite loam, rocky, 0 to 8 percent slopes	Till underlain by crystalline bedrock	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none
MuC	Millsite-Rock outcrop complex, rolling	Till underlain by crystalline bedrock	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none
MuE	Millsite-Rock outcrop complex, steep	Till underlain by crystalline bedrock	Inceptisols	Coarse-loamy, mixed, active, frigid Typic Dystrudepts	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
Mv	Minoa fine sandy loam	Deltas of former glacial lakes	Inceptisols	Coarse-loamy, mixed, active, mesic Aquic Dystric Eutrudepts	Low to none
MwA	Muskellunge silt loam, 0 to 3 percent slopes	Glacial lake plains and uplands mantled with lake sediments	Alfisols	Fine, mixed, active, frigid Aeric Epiaqualfs	Low to none
MwB	Muskellunge silt loam, 3 to 8 percent slopes	Glacial lake plains and uplands mantled with lake sediments	Alfisols	Fine, mixed, active, frigid Aeric Epiaqualfs	Low to none
NlA	Nellis loam, 0 to 3 percent slopes	Upland ridges, knolls, and hillsides of calcareous till	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
NlB	Nellis loam, 3 to 8 percent slopes	Upland ridges, knolls, and hillsides of calcareous till	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
NlC	Nellis loam, 8 to 15 percent slopes	Upland ridges, knolls, and hillsides of calcareous till	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
NlD	Nellis loam, 15 to 25 percent slopes	Upland ridges, knolls, and hillsides of calcareous till	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
NmF	Nellis and Madrid soils, steep	Upland ridges, knolls, and hillsides of calcareous till	Inceptisols	Coarse-loamy, mixed, superactive, mesic Typic Eutrudepts	Low to none
Nn	Newstead silt loam	Low areas or depressions on till plains	Inceptisols	Coarse-loamy, mixed, active, nonacid, mesic Aeric Endoaquepts	Low to none
NoA	Niagara silt loam, 0 to 3 percent slopes	Glacio-lacustrine deposits in level to slightly concave areas on lake plains and in valleys	Alfisols	Fine-silty, mixed, active, mesic Aeric Endoaqualfs	Low to none
NoB	Niagara silt loam, 3 to 8 percent slopes	Glacio-lacustrine deposits in level to slightly concave areas on lake plains and in valleys	Alfisols	Fine-silty, mixed, active, mesic Aeric Endoaqualfs	Low to none
NpB	Niagara silt loam, bedrock substratum, 2 to 6 percent slopes	Glacio-lacustrine deposits in level to slightly concave areas on lake plains and in valleys	Alfisols	Fine-silty, mixed, active, mesic Aeric Endoaqualfs	Low to none
Pa	Palms muck	Closed depressions on moraines, lake plains, till plains, outwash plains, and hillside seep areas, and on backswamps of flood plains	Histisols	Loamy, mixed, euic, mesic Terric Haplosaprists	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
PhA	Phelps gravelly loam, 0 to 3 percent slopes	Glacial outwash terraces	Alfisols	Fine-loamy over sandy or sandy-skeletal, mixed, active, mesic Glossaquic Hapludalfs	Low to none
PhB	Phelps gravelly loam, 3 to 8 percent slopes	Glacial outwash terraces	Alfisols	Fine-loamy over sandy or sandy-skeletal, mixed, active, mesic Glossaquic Hapludalfs	Low to none
Pm	Pits, quarry		not soil		None
Pn	Pits, sand and gravel		not soil		None
PoB	Plainfield sand, 0 to 8 percent slopes	Sandy drift on outwash plains, valley trains, glacial lake basins, stream terraces, and moraines and other upland areas	Entisols	Mixed, mesic Typic Udipsamments	Low to none
PoC	Plainfield sand, rolling	Sandy drift on outwash plains, valley trains, glacial lake basins, stream terraces, and moraines and other upland areas	Entisols	Mixed, mesic Typic Udipsamments	Low to none
PpD	Plainfield and Windsor soils, hilly	Sandy drift on outwash plains, valley trains, glacial lake basins, stream terraces, and moraines and other upland areas	Entisols	Mixed, mesic Typic Udipsamments	Low to none
PrB	Plainfield sand, altered surface, 0 to 8 percent slopes	Sandy drift on outwash plains, valley trains, glacial lake basins, stream terraces, and moraines and other upland areas	Entisols	Mixed, mesic Typic Udipsamments	Low to none
PrC	Plainfield sand, altered surface, rolling	Sandy drift on outwash plains, valley trains, glacial lake basins, stream terraces, and moraines and other upland areas	Entisols	Mixed, mesic Typic Udipsamments	Low to none
Ps	Pootatuck fine sandy loam	Floodplains subject to common flooding	Inceptisols	Coarse-loamy, mixed, active, mesic Fluvaquentic Dystrudepts	Medium to high
QeB	Quetico-Rock outcrop complex, 2 to 8 percent slopes	Glacial drift on uplands with relief controlled by the underlying bedrock	Entisols	Loamy, isotic, acid, frigid Lithic Udorthents	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
RhA	Rhinebeck silt loam, 0 to 3 percent slopes	Glacial lake plains and uplands mantled with lake sediments	Alfisols	Fine, illitic, mesic Aeric Endoaqualfs	Low to none
RhB	Rhinebeck silt loam, 3 to 8 percent slopes	Glacial lake plains and uplands mantled with lake sediments	Alfisols	Fine, illitic, mesic Aeric Endoaqualfs	Low to none
RkC	Rhinebeck-Chatfield-Rock outcrop complex, rolling	Glacial lake plains and uplands mantled with lake sediments	Alfisols	Fine, illitic, mesic Aeric Endoaqualfs	Low to none
Ru	Ruse gravelly loam, rocky	Till material underlain by limestone bedrock	Mollisols	Loamy, mixed, active, frigid Lithic Endoaquolls	Low to none
Sa	Saprists and Aquents, ponded		Histisols/Entisols		Low to none
Fort Drum 4	Fort Drum 4				
Sc	Scarboro mucky loamy fine sand	Glaciofluvial deposits on outwash plains, deltas, and terraces	Inceptisols	Sandy, mixed, mesic Histic Humaquepts	Low to none
Sh	Shaker fine sandy loam	Low-lying positions on glaciolacustrine and marine terraces	Inceptisols	Coarse-loamy over clayey, mixed, semiactive, nonacid, mesic Aeric Epiaquepts	Low to none
Su	Sun silt loam	Low areas or depressions on till plains	Inceptisols	Coarse-loamy, mixed, active, nonacid, mesic Aeric Epiaquepts	Low to none
Sv	Sun very stony silt loam	Low areas or depressions on till plains	Inceptisols	Coarse-loamy, mixed, active, nonacid, mesic Aeric Epiaquepts	Low to none
Te	Teel silt loam	Floodplains along streams and low gradient alluvial fans	Inceptisols	Coarse-silty, mixed, active, mesic Fluvaquentic Eutrudepts	Medium to high
ToA	Tonowanda silt loam, 0 to 3 percent slopes	Estuarine or glaciolacustrine deposits on glacial lake plains and terraces	Inceptisols	Coarse-silty, mixed, active, nonacid, mesic Aeric Endoaquepts	Low to none
Ua	Udorthents, refuse substratum		Entisols		Low to none
Ub	Udorthents, smoothed		Entisols		Medium
Ur	Urban land				

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
Us	Unsurveyed stony site				Low to none
VeB	Vergennes silty clay loam, 3 to 8 percent slopes	Broad plains and on the tops and side slopes of hills ridges and knolls on glacial lake plains	Alfisols	Very-fine, mixed, active, mesic Glossaquic Hapludalfs	Low to none
VeC	Vergennes silty clay loam 8 to 15 percent slopes	Broad plains and on the tops and side slopes of hills ridges and knolls on glacial lake plains	Alfisols	Very-fine, mixed, active, mesic Glossaquic Hapludalfs	Low to none
W	Water		Not soil		None
Wa	Wareham loamy fine sand	Glaciofluvial outwash on plains, deltas, and terraces	Entisols	Mixed, mesic Humaqueptic Psammaquents	Low to none
We	Wayland silt loam	Low areas or slackwater areas on flood plains	Inceptisols	Fine-silty, mixed, active, nonacid, mesic Fluvaquentic Endoaquepts	Low to none
Wh	Whately fine sandy loam	Outwash materials over clayey marine or lacustrine deposits in depressional areas of glaciolacustrine, marine or outwash plains and deltas	Inceptisols	Coarse-loamy over clayey, mixed over illitic, superactive, nonacid, frigid Mollic Epiaquepts	Low to none
Wk	Willette muck	Depressions on lake plains, ground moraines and end moraines	Histisols	Clayey, illitic, euic, mesic Terric Haplosaprists	Low to none
WmB	Williamson silt loam, 3 to 8 percent slopes	Lake plains and uplands mantled by wind or water-deposited silt and very fine sand	Inceptisols	Coarse-silty, mixed, active, mesic Typic Fragiudepts	Low to none
WnB	Wilpoint silty clay loam, 3 to 8 percent slopes	Convex landscapes where relatively thin clayey marine sediments overlie hard bedrock	Alfisols	Very-fine, mixed, mesic Aquic Hapludalfs	Low to none
WnC	Wilpoint silty clay loam 8 to 15 percent slopes	Convex landscapes where relatively thin clayey marine sediments overlie hard bedrock	Alfisols	Very-fine, mixed, mesic Aquic Hapludalfs	Low to none
WoB	Windsor loamy fine sand, 0 to 8 percent slopes	Terrace escarpments on glaciofluvial landforms	Entisols	Mixed, mesic Typic Udipsamments	Low to none
WoC	Windsor loamy fine sand, 8 to 15 percent slopes	Terrace escarpments on glaciofluvial landforms	Entisols	Mixed, mesic Typic Udipsamments	Low to none

APPENDIX J: SUBSURFACE SENSITIVITY DETERMINATIONS FOR NATIONAL RESOURCE CONSERVATION SERVICE SOIL TYPES AT SAYLOR CREEK RANGE, ELMORE COUNTY, IDAHO

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
1	Abgese loamy sand, 2 to 8 percent slopes	Alluvium and colluvium on alluvial fans, terraces, fan piedmont remnants and low hills	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
2	Abgese loamy sand, 8 to 40 percent slopes	Alluvium and colluvium on alluvial fans, terraces, fan piedmont remnants and low hills	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
3	Abgese sandy loam, 0 to 4 percent slopes	Alluvium and colluvium on alluvial fans, terraces, fan piedmont remnants and low hills	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
4	Arbidge fine sandy loam, 1 to 4 percent slopes	Stream and lacustrine terraces, fan terraces, plug domes, calderas, tablelands, and alluvial plains	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Argidurids	Low to none
5	Arbidge-Buko complex, 1 to 8 percent slopes	Stream and lacustrine terraces, fan terraces, plug domes, calderas, tablelands, and alluvial plains	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Argidurids	Low to none
7	Bahem silt loam, 0 to 4 percent slopes	Loess or silty alluvium on terraces, basalt plains, buttes, and hillsides	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplocalcids	Low to none
8	Bahem silt loam, 4 to 8 percent slopes	Loess or silty alluvium on terraces, basalt plains, buttes, and hillsides	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplocalcids	Low to none
9	Bahem-Minidoka-Trevino complex, 0 to 4 percent slopes	Loess or silty alluvium on terraces, basalt plains, buttes, and hillsides	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplocalcids	Low to none
10	Baldock loam, 0 to 2 percent slopes	Alluvial fans, floodplains, lake basins, and low terraces	Mollisols	Fine-loamy, mixed, superactive, mesic Typic Calciaquolls	Low to none
11	Bram silt loam, 0 to 2 percent slopes	Low terraces, alluvial fans, and some lacustrine plains	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplocalcids	Low to none
12	Bramwell silty clay loam, 0 to 1 percent slopes	low stream or lacustrine terraces and floodplains	Aridisols	Fine-silty, mixed, superactive, mesic Aquic Haplocalcids	Low to none
20	Bruncan-Troughs complex, 0 to 5 percent slopes	Nearly level to rolling on tablelands, calderas, structural benches, plains and buttes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
21	Buko fine sandy loam, 1 to 4 percent slopes	Alluvial terraces	Aridisols	Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Durinodic Xeric Haplocalcids	Low to none
22	Buko fine sandy loam, 4 to 12 percent slopes	Alluvial terraces	Aridisols	Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Durinodic Xeric Haplocalcids	Low to none
23	Chardoton silt loam, 0 to 4 percent slopes	Silty alluvium from loess and weathered volcanic ash over loamy alluvium from basalt and volcanic ash on lava flow troughs on shield volcanoes and lava plains	Aridisols	Fine, smectitic, mesic Xeric Paleargids	Low to none
27	Chilcott-Elijah silt loams, 0 to 12 percent slopes	Thin mantle of loess over silty alluvium from loess and weathered volcanic ash over loamy or sandy and gravelly alluvium from igneous materials on high terraces, mesas, calderas, shield volcanos and basalt plains	Aridisols	Fine, smectitic, mesic Abruptic Xeric Argidurids	Low to none
31	Colthorp stony silt loam, 0 to 8 percent slopes	Silty alluvium from loess and weathered volcanic on basalt plains, terraces and on plug domes and lava flow lobes on lava plains and shield volcanoes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
32	Colthorp-Chilcott silt loams, 0 to 8 percent slopes	Silty alluvium from loess and weathered volcanic on basalt plains, terraces and on plug domes and lava flow lobes on lava plains and shield volcanoes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
33	Colthorp-Kunaton complex, 0 to 8 percent slopes	Silty alluvium from loess and weathered volcanic on basalt plains, terraces and on plug domes and lava flow lobes on lava plains and shield volcanoes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
35	Colthorp-Minveno stony silt loams, 0 to 8 percent slopes	Silty alluvium from loess and weathered volcanic on basalt plains, terraces and on plug domes and lava flow lobes on lava plains and shield volcanoes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
36	Colthorp-Rock outcrop complex, 4 to 20 percent slopes	Silty alluvium from loess and weathered volcanic on basalt plains, terraces and on plug domes and lava flow lobes on lava plains and shield volcanoes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
39	Cottle-Trevino-Rock outcrop complex, 8 to 30 percent slopes	Residuum and colluvium from welded rhyolitic on summits, shoulders, and backslopes of foothills	Aridisols	Loamy-skeletal, mixed, superactive, mesic Lithic Xeric Haplargids	Low to none
40	Cottle-Willhill complex, 2 to 25 percent slopes	Residuum and colluvium from welded rhyolitic on summits, shoulders, and backslopes of foothills	Aridisols	Loamy-skeletal, mixed, superactive, mesic Lithic Xeric Haplargids	Low to none
44	Davey loamy sand, 4 to 12 percent slopes	Alluvium on sand sheets, lagoons, alluvial fans, basin-floor remnants, and fan skirts	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
45	Davey loamy fine sand, 0 to 4 percent slopes	Alluvium on sand sheets, lagoons, alluvial fans, basin-floor remnants, and fan skirts	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
46	Davey-Buko complex, 1 to 12 percent slopes	Alluvium on sand sheets, lagoons, alluvial fans, basin-floor remnants, and fan skirts	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
47	Davey-Mazuma complex, 12 to 40 percent slopes	Alluvium on sand sheets, lagoons, alluvial fans, basin-floor remnants, and fan skirts	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
48	Davey-Quincy complex, 1 to 12 percent slopes	Alluvium on sand sheets, lagoons, alluvial fans, basin-floor remnants, and fan skirts	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
49	Davey-Vanderhoff complex, 1 to 4 percent slopes	Alluvium on sand sheets, lagoons, alluvial fans, basin-floor remnants, and fan skirts	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
50	Dors fine sandy loam, 0 to 4 percent slopes	Fan terraces	Aridisols	Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Typic Haplocalcids mesic, Typic Calciorthids	Low to none
51	Dors gravelly fine sandy loam, 4 to 12 percent slopes	Fan terraces	Aridisols	Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Typic Haplocalcids mesic, Typic Calciorthids	Low to none
52	Dors-Loray complex, 0 to 4 percent slopes	Fan terraces	Aridisols	Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Typic Haplocalcids mesic, Typic Calciorthids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
53	Dune land				Medium
54	Elijah silt loam, 0 to 4 percent slopes	Loess or silty alluvium from loess and weathered volcanic ash over medium to coarse textured alluvium or lacustrine sediments on dissected high terraces in valleys and on plug domes (buttes), lava flow lobes and troughs on shield volcanoes and lava plains	Aridisols	Fine-silty, mixed, superactive, mesic Xeric Argidurids	Low to none
56	Elijah-Purdam silt loams, 0 to 8 percent slopes	Loess or silty alluvium from loess and weathered volcanic ash over medium to coarse textured alluvium or lacustrine sediments on dissected high terraces in valleys and on plug domes (buttes), lava flow lobes and troughs on shield volcanoes and lava plains	Aridisols	Fine-silty, mixed, superactive, mesic Xeric Argidurids	Low to none
60	Fluvaquents, channeled		Entisols		Medium
65	Garbutt silt loam, 0 to 4 percent slopes	Alluvial fans, low terraces, and basalt plains	Entisols	Coarse-silty, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
66	Garbutt silt loam, 4 to 8 percent slopes	Alluvial fans, low terraces, and basalt plains	Entisols	Coarse-silty, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
67	Garbutt-Weso complex, 0 to 2 percent slopes	Alluvial fans, low terraces, and basalt plains	Entisols	Coarse-silty, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
70	Grandview loam, 0 to 4 percent slopes	Concave parts of alluvial fans, stream terraces and floodplains	Aridisols	Fine-loamy, mixed, superactive, mesic Sodic Haplocalcids	Low to none
71	Grandview, drained-Garbutt silt loams, 0 to 4 percent slopes	Concave parts of alluvial fans, stream terraces and floodplains	Aridisols	Fine-loamy, mixed, superactive, mesic Sodic Haplocalcids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
73	Greenleaf very fine sandy loam, 0 to 4 percent slopes	Laminated, silty lacustrine deposits or old alluvium, though the upper part may be influenced by loess, on dissected, low and medium terraces	Aridisols	Fine-silty, mixed, superactive, mesic Xeric Calciargids	Low to none
74	Greenleaf-Shano complex, 4 to 12 percent slopes	Laminated, silty lacustrine deposits or old alluvium, though the upper part may be influenced by loess, on dissected, low and medium terraces	Aridisols	Fine-silty, mixed, superactive, mesic Xeric Calciargids	Low to none
79	Hawsley loamy sand, 0 to 12 percent slopes	Alluvium and water reworked eolian sand of sand sheets	Entisols	Mixed, mesic Typic Torripsamments	Medium
80	Hotcreek-Troughs association, 1 to 15 percent slopes	Residuum and local alluvium on undulating and rolling on foothills	Aridisols	Loamy-skeletal, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
84	Jacquith loamy sand, 4 to 12 percent slopes	Aeolian or alluvial deposits slightly dissected, medium and high terraces	Aridisols	Sandy, mixed, mesic Xereptic Haplodurids	Low to none
85	Jacquith loamy fine sand, 1 to 8 percent slopes	Aeolian or alluvial deposits slightly dissected, medium and high terraces	Aridisols	Sandy, mixed, mesic Xereptic Haplodurids	Low to none
86	Jacquith-Quincy loamy sands, 0 to 12 percent slopes	Aeolian or alluvial deposits slightly dissected, medium and high terraces	Aridisols	Sandy, mixed, mesic Xereptic Haplodurids	Low to none
90	Lankbush sandy loam, 0 to 4 percent slopes	Alluvial fans, fan skirts, old dissected terraces, footslopes, and dissected uplands	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
91	Lankbush-Lanktree complex, 4 to 30 percent slopes	Alluvial fans, fan skirts, old dissected terraces, footslopes, and dissected uplands	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
92	Lankbush-Jenness association, 0 to 4 percent slopes	Alluvial fans, fan skirts, old dissected terraces, footslopes, and dissected uplands	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
95	Letha fine sandy loam, drained, 0 to 4 percent slopes	Low terraces	Inceptisols	Coarse-loamy, mixed, superactive, calcareous, mesic Aeric Halaquepts	Medium to high

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
96	Letha loam, 0 to 2 percent slopes	Low terraces	Inceptisols	Coarse-loamy, mixed, superactive, calcareous, mesic Aeric Halaquepts	Medium to high
97	Letha-Baldock loams, 0 to 2 percent slopes	Low terraces	Inceptisols	Coarse-loamy, mixed, superactive, calcareous, mesic Aeric Halaquepts	Medium to high
98	Loray gravelly fine sandy loam, 0 to 12 percent slopes	Beach plains, offshore bars and fan skirts	Aridisols	Sandy-skeletal, mixed, mesic Typic Haplocalcids	Low to none
99	Loray-Dors complex, 8 to 20 percent slopes	Beach plains, offshore bars and fan skirts	Aridisols	Sandy-skeletal, mixed, mesic Typic Haplocalcids	Low to none
100	Mazuma fine sandy loam, 0 to 4 percent slopes	Alluvium and lacustrine deposits on basin floor remnants, lagoons, beach plains, alluvial flats, fan skirts, and stream terraces	Entisols	Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
101	Mazuma-Hawsley complex, 0 to 12 percent slopes	Alluvium and lacustrine deposits on basin floor remnants, lagoons, beach plains, alluvial flats, fan skirts, and stream terraces	Entisols	Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
102	McKeeth gravelly loam, 2 to 12 percent slopes	Fan piedmonts and fan terraces	Aridisols	Fine-loamy, mixed, superactive, mesic Durinodic Calciargids	Low to none
103	Minidoka-Minveno silt loams, 0 to 4 percent slopes	Loess and alluvium on terraces and basalt plains	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplodurids	Medium
105	Minveno silt loam, 0 to 4 percent slopes	Silty alluvium from loess and weathered volcanic ash on hills, buttes, pressure ridges, tumuli, plus domes (bettes), lava flow lobes and structural benches on lava plains and shield volcanoes, calderas, structural benches, and terraces	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Haplodurids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
106	Minveno silt loam, 4 to 8 percent slopes	Silty alluvium from loess and weathered volcanic ash on hills, buttes, pressure ridges, tumuli, plus domes (bettes), lava flow lobes and structural benches on lava plains and shield volcanoes, calderas, structural benches, and terraces	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Haplodurids	Low to none
107	Minveno-Minidoka stony silt loams, 0 to 8 percent slopes	Silty alluvium from loess and weathered volcanic ash on hills, buttes, pressure ridges, tumuli, plus domes (bettes), lava flow lobes and structural benches on lava plains and shield volcanoes, calderas, structural benches, and terraces	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Haplodurids	Low to none
108	Monroe-Jenness complex, 0 to 2 percent slopes	Alluvial fans, flood plains, and low stream terraces	Mollisols	Fine-loamy, mixed, superactive, mesic Cumulic Haploxerolls	Medium to high
109	Monroe-Goose Creek association, 0 to 2 percent slopes	Alluvial fans, flood plains, and low stream terraces	Mollisols	Fine-loamy, mixed, superactive, mesic Cumulic Haploxerolls	Medium to high
110	Moran-Teewinot-Coski complex, 10 to 50 percent slopes	Alluvium or colluvium on mountain slopes, mesa summits, and footslopes	Inceptisols	Loamy-skeletal, mixed, superactive Typic Humicryepts	Low to none
112	Ornea gravelly loam, 2 to 8 percent slopes	Alluvium from lacustrine deposits and volcaniclastic materials on fan terraces, pediments, and valleysides	Aridisols	Fine-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Typic Haplargids	Low to none
113	Owsel-Purdam complex, 1 to 12 percent slopes	Alluvium and loess on calderas, terraces, and terrace sideslopes	Aridisols	Fine-silty, mixed, superactive, mesic Durinodic Xeric Haplargids	Low to none
114	Perazzo-Ornea-Abgese complex, 12 to 40 percent slopes	Fan piedmonts	Aridisols	Loamy-skeletal, mixed, superactive, mesic Typic Haplargids	Low to none
115	Pits, gravel				None

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
116	Power silt loam, 1 to 4 percent slopes	Silty alluvium from loess and weathered volcanic ash over loamy alluvium from igneous material son lava flow troughs and buttes on lava plains and shield volcanoes and old stream terraces in valleys	Aridisols	Fine-silty, mixed, superactive, mesic Xeric Calciargids	Low to none
119	Power-Purdam silt loams, 0 to 1 percent slopes	Silty alluvium from loess and weathered volcanic ash over loamy alluvium from igneous material son lava flow troughs and buttes on lava plains and shield volcanoes and old stream terraces in valleys	Aridisols	Fine-silty, mixed, superactive, mesic Xeric Calciargids	Low to none
120	Purdam silt loam, 0 to 4 percent slopes	Silty alluvium from loess and weathered volcanic ash over medium or moderately coarse-textured alluvium from igneous materials on plug domes (buttes), lava flow lobes and troughs on lava plains and shield volcanoes and on dissected terraces in valleys	Aridisols	Fine-silty, mixed, superactive, mesic Haploxeralfic Argidurids	Low to none
121	Purdam silt loam, 4 to 8 percent slopes	Silty alluvium from loess and weathered volcanic ash over medium or moderately coarse-textured alluvium from igneous materials on plug domes (buttes), lava flow lobes and troughs on lava plains and shield volcanoes and on dissected terraces in valleys	Aridisols	Fine-silty, mixed, superactive, mesic Haploxeralfic Argidurids	Low to none
122	Purdam-Sebree-Owsel complex, 0 to 8 percent slopes	Silty alluvium from loess and weathered volcanic ash over medium or moderately coarse-textured alluvium from igneous materials on plug domes (buttes), lava flow lobes and troughs on lava plains and shield volcanoes and on dissected terraces in valleys	Aridisols	Fine-silty, mixed, superactive, mesic Haploxeralfic Argidurids	Low to none
124	Quincy fine sand, 0 to 12 percent slopes	Uplands, fan piedmonts and terraces, some having a ridged, hummocky, or dune microrelief.	Entisols	Mixed, mesic Xeric Torripsamments	Medium

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
125	Quincy loamy fine sand, 12 to 30 percent slopes	Uplands, fan piedmonts and terraces, some having a ridged, hummocky, or dune microrelief.	Entisols	Mixed, mesic Xeric Torripsamments	Medium
132	Rock outcrop-Rubble land association				None
133	Royal fine sandy loam, 0 to 4 percent slopes	Alluvium and wind modified glaciofluvial sediments on footslopes and terraces	Aridisols	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	Low to none
134	Royal fine sandy loam, 4 to 12 percent slopes	Alluvium and wind modified glaciofluvial sediments on footslopes and terraces	Aridisols	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	Low to none
135	Royal-Davey complex, 0 to 12 percent slopes	Alluvium and wind modified glaciofluvial sediments on footslopes and terraces	Aridisols	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	Low to none
136	Royal-Davey complex, 12 to 40 percent slopes	Alluvium and wind modified glaciofluvial sediments on footslopes and terraces	Aridisols	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	Low to none
137	Royal-Shano-Rock outcrop complex, 0 to 20 percent slopes	Alluvium and wind modified glaciofluvial sediments on footslopes and terraces	Aridisols	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	Low to none
138	Royal-Truesdale fine sandy loams, 0 to 4 percent slopes	Alluvium and wind modified glaciofluvial sediments on footslopes and terraces	Aridisols	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	Low to none
140	Schoolhouse-Rock outcrop complex, 40 to 90 percent slopes	Mountain sideslopes and ridges	Entisols	Sandy-skeletal, mixed, mesic Lithic Xerorthents	Low to none
141	Scism silt loam, 0 to 4 percent slopes	Loess and weathered volcanic ash over loamy on lava plains, shield volcanoes, calderas, terraces, draws, and tablelands	Aridisols	Coarse-silty, mixed, superactive, mesic Xereptic Haplodurids	Low to none
142	Scoon very fine sandy loam, 0 to 4 percent slopes	Loess and silty alluvium mantling a duripan on uplands and terraces	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Haplodurids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
143	Shano loam, 1 to 12 percent slopes	Loess on terraces, uplands, plateaus, and hills	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplocambids	Low to none
144	Shano-Owsel complex, 0 to 12 percent slopes	Loess on terraces, uplands, plateaus, and hills	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplocambids	Low to none
145	Shano-Truesdale fine sandy loams, 0 to 12 percent slopes	Loess on terraces, uplands, plateaus, and hills	Aridisols	Coarse-silty, mixed, superactive, mesic Xeric Haplocambids	Low to none
146	Shoofly loam, 0 to 4 percent slopes	Piedmont fans and lower dissected fans	Aridisols	Loamy, mixed, superactive, mesic, shallow Typic Argidurids	Low to none
147	Shoofly-Ornea complex, 2 to 12 percent slopes	Piedmont fans and lower dissected fans	Aridisols	Loamy, mixed, superactive, mesic, shallow Typic Argidurids	Low to none
148	Sidlake-Bruncan complex, 1 to 8 percent slopes	Aeolian material on basalt or rhyolite plains and terraces	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
154	Timmerman loamy sand, 2 to 20 percent slopes, extremely bouldery	Glacial outwash and alluvium mixed with loess in the upper part on terraces and glacial outwash plains	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
155	Timmerman sandy loam, 0 to 4 percent slopes	Glacial outwash and alluvium mixed with loess in the upper part on terraces and glacial outwash plains	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
156	Timmerman sandy loam, 4 to 12 percent slopes	Glacial outwash and alluvium mixed with loess in the upper part on terraces and glacial outwash plains	Aridisols	Sandy, mixed, mesic Xeric Haplocambids	Low to none
157	Trevino-Garbutt-Weso complex, 2 to 8 percent slopes	Loess and weathered volcanic ash mixed with alluvium and colluvium on basalt plains, buttes, terraces, and terrace side slopes and plug domes, lava flow lobes, pressure ridges and tumuli on shield volcanoes and lava plains	Aridisols	Loamy, mixed, superactive, mesic Lithic Xeric Haplocambids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
158	Trevino-Minidoka complex, 8 to 30 percent slopes	Loess and weathered volcanic ash mixed with alluvium and colluvium on basalt plains, buttes, terraces, and terrace side slopes and plug domes, lava flow lobes, pressure ridges and tumuli on shield volcanoes and lava plains	Aridisols	Loamy, mixed, superactive, mesic Lithic Xeric Haplocambids	Low to none
159	Trevino-Rock outcrop complex, 0 to 8 percent slopes	Loess and weathered volcanic ash mixed with alluvium and colluvium on basalt plains, buttes, terraces, and terrace side slopes and plug domes, lava flow lobes, pressure ridges and tumuli on shield volcanoes and lava plains	Aridisols	Loamy, mixed, superactive, mesic Lithic Xeric Haplocambids	Low to none
161	Truesdale fine sandy loam, 0 to 4 percent slopes	Alluvium or lacustrine sediments on high terraces and basalt plains	Aridisols	Coarse-loamy, mixed, superactive, mesic Xereptic Haplodurids	Low to none
162	Truesdale fine sandy loam, 4 to 12 percent slopes	Alluvium or lacustrine sediments on high terraces and basalt plains	Aridisols	Coarse-loamy, mixed, superactive, mesic Xereptic Haplodurids	Low to none
163	Typic Torriorthents, 4 to 20 percent slopes		Entisols		Low to none
164	Typic Torriorthents-Badland complex, 20 to 70 percent slopes		Entisols		Low to none
165	Typic Torriorthents-Rubble land complex, 20 to 70 percent slopes		Entisols		Low to none
167	Vanderhoff fine sandy loam, 0 to 4 percent slopes	Residuum and colluvium from consolidated siltstone or tuff of the Payette or related Tertiary formations on dissected lacustrine terraces	Entisols	Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
168	Vanderhoff fine sandy loam, 4 to 12 percent slopes	Residuum and colluvium from consolidated siltstone or tuff of the Payette or related Tertiary formations on dissected lacustrine terraces	Entisols	Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents	Low to none
169	Vanderhoff-Buko-Loray complex, 2 to 20 percent slopes	Residuum and colluvium from consolidated siltstone or tuff of the Payette or related Tertiary formations on dissected lacustrine terraces	Entisols	Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents	Low to none
170	Vining very stony fine sandy loam, 0 to 8 percent slopes	Aeolian and alluvial material of mixed origin on hilly basalt plains and terraces	Aridisols	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids	Low to none
171	Willhill-Cottle association, 2 to 25 percent slopes	Slope alluvium and residuum derived from welded rhyolitic tuff on hills and plateaus	Aridisols	Loamy-skeletal, mixed, superactive, mesic Durinodic Xeric Calciargids	Low to none
172	Xeric Torriorthents and Xerollic Camborthids, 8 to 20 percent slopes		Entisols		Low to none
173	Xeric Torriorthents-Xerollic Camborthids complex, 20 to 70 percent slopes		Entisols		Low to none
175	Water				None

APPENDIX K: SUBSURFACE SENSITIVITY DETERMINATIONS FOR NATIONAL RESOURCE CONSERVATION SERVICE SOIL TYPES AT SAYLOR CREEK RANGE, OWYHEE COUNTY, IDAHO

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
8	Arbidge-Laped-Slickspots complex, 0 to 8 percent slopes	Stream and lacustrine terraces, fan terraces, plug domes, calderas, tablelands, and alluvial plains	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Argidurids	Low to none
13	Badland-Typic Torriorthents-Xeric Torriorthents complex, very steep		Entisols		
28	Bruncan-Jenor-Troughs association, 1 to 10 percent slopes	Nearly level to rolling on tablelands, calderas, structural benches, plains and buttes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
30	Bruncan-Minveno complex, 2 to 15 percent slopes	Nearly level to rolling on tablelands, calderas, structural benches, plains and buttes	Aridisols	Loamy, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
43	Cottle-Willhill complex, 3 to 25 percent slopes	Summits, shoulders, and backslopes of foothills	Aridisols	Loamy-skeletal, mixed, superactive, mesic Lithic Xeric Haplargids	Low to none
69	Hardtrigger-Briabbit-Tindahay complex, 1 to 15 percent slopes	Fan terraces, calderas and structural benches	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
74	Hardtrigger-Scism complex, 1 to 5 percent slopes	Fan terraces, calderas and structural benches	Aridisols	Fine-loamy, mixed, superactive, mesic Xeric Haplargids	Low to none
84	Hotcreek-Troughs association 1 to 15 percent slopes	Undulating and rolling on foothills	Aridisols	Loamy-skeletal, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
100	McKeeth-Veta gravelly loams, 2 to 15 percent slopes	Fan piedmonts and fan terraces	Aridisols	Fine-loamy, mixed, superactive, mesic Durinodic Calciargids	Low to none
117	Orovada-Roseworth-Wholan complex, 1 to 5 percent slopes	Loess high in volcanic ash over alluvium on fan skirts, fan remnants, fan aprons, inset fans, calderas, and draws	Aridisols	Coarse-loamy, mixed, superactive, mesic Durinodic Xeric Haplocambids	Low to none

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
118	Owsel-Coonskin-Orovada complex, 1 to 5 percent slopes	Alluvium and loess on calderas, terraces, and terrace sideslopes	Aridisols	Fine-silty, mixed, superactive, mesic Durinodic Xeric Haplargids	Low to none
130	Pits, gravel		Not soil		None
133	Playas-Duric Natrargids association, nearly level		Aridisols		Low to none
134	Plush-Rubble land-Rock outcrop association, 25 to 50 percent slopes	Colluvium and slope alluvium on sideslopes of foothills, commonly below cliffs, and on landslide deposits	Aridisols	Loamy-skeletal, mixed, superactive, mesic Xeric Haplargids	Low to none
143	Rock outcrop-Xerollic Haplargids complex, very steep		Aridisols		Low to none
147	Scism silt loam, 5 to 20 percent slopes	Loess and weathered volcanic ash on lava plains, shield volcanoes, calderas, terraces, draws, and tablelands	Aridisols	Coarse-silty, mixed, superactive, mesic Xereptic Haplodurids	Low to none
167	Sugarcreek gravelly loam, 3 to 30 percent slopes	Residuum and colluvium on undulating to hilly summits and sideslopes of hills and structural benches	Aridisols	Loamy-skeletal, mixed, superactive, mesic Durinodic Xeric Haplocalcids	Low to none
180	Troughs-Jenor-Laped association, 1 to 10 percent slopes	Alluvium and loess on calderas, structural benches, and plateaus	Aridisols	Loamy-skeletal, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
182	Troughs-Sugarcreek association, 2 to 15 percent slopes	Alluvium and loess on calderas, structural benches, and plateaus	Aridisols	Loamy-skeletal, mixed, superactive, mesic, shallow Xeric Argidurids	Low to none
210	Willhill-Cottle association, 3 to 35 percent slopes	Slope alluvium and residuum on hills and plateaus	Aridisols	Loamy-skeletal, mixed, superactive, mesic Durinodic Xeric Calciargids	Low to none
213	Xerollic Haplargids-Xerollic Paleargids-Rubble land complex, steep		Aridisols		Low to none

APPENDIX L: SUBSURFACE SENSITIVITY DETERMINATIONS FOR NATIONAL RESOURCE CONSERVATION SERVICE SOIL TYPES AT UTAH TEST AND TRAINING RANGE

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
3	Amtoft, dry-rock outcrop complex, 30 to 70 percent slopes	Crests and backslopes of hills, mountains and ridges	Aridisols	Loamy-skeletal, carbonatic, mesic Lithic Xeric Haplocalcids	Low to none
4	Amtoft-rock outcrop complex, 30 to 70 percent slopes	Crests and backslopes of hills, mountains and ridges	Aridisols	Loamy-skeletal, carbonatic, mesic Lithic Xeric Haplocalcids	Low to none
11	Checkett-rock outcrop complex, 10 to 40 percent slopes	Mountains, hills and ridgetops	Aridisols	Loamy-skeletal, mixed, superactive, mesic Lithic Xeric Haplargids	Low to none
12	Cliffdown gravelly sandy loam, 2 to 15 percent slopes	Fan remnants, fan aprons, fan skirts, inset fans, and beach plains	Entisols	Loamy-skeletal, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
16	Dune land				
17	Dynal sand, 2 to 15 percent slopes	Slightly elevated beach ridges and stable dunes along the edge of the Great Salt Lake, with mainly oolitic sand	Entisols	Carbonatic, mesic Typic Torripsamments	Medium to high
18	Dynal-Tooele, saline, complex, 0 TO 15 percent slope	Slightly elevated beach ridges and stable dunes along the edge of the Great Salt Lake, with mainly oolitic sand	Entisols	Carbonatic, mesic Typic Torripsamments	Medium to high
19	Erda silt loam, 1 to 5 percent slope	Nearly level to gently sloping lake terraces, alluvial flats and fan terraces	Mollisols	Fine-silty, mixed, superactive, mesic Typic Calcixerolls	Medium
21	Hiko Peak gravelly loam, 2 to 15 percent slope	Alluvium and colluvium on alluvial fans, fan remnants, and hills	Aridisols	Loamy-skeletal, mixed, active, mesic Xeric Haplocalcids	Medium

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
27	Izamatch-Cliffdown, alkali, complex, 2 to 8 percent slope	Re-worked mixed alluvium influenced by calcareous loess on beach plains, fan skirts, and dissected lake plains	Entisols	Sandy-skeletal, mixed, mesic Typic Torriorthents	Medium to high
32	Kanosh-Saltair-Logan complex, 0 to 2 percent slope	Lacustrine deposits and alluvium on low lake terraces, deltas, and flood plains.	Aridisols	Coarse-loamy, mixed, active, mesic Xeric Calcigypsids	Medium to high
44	Pits				
45	Playas				
46	Playas-Saltair complex, 0 to 1 percent slope	Lacustrine deposits and some alluvium on lake plains and basin floors	Aridisols	Fine-silty, mixed, superactive, mesic Typic Aquisalids	Low to none
52	Salt flats				
53	Saltair-playas complex, 0 to 1 percent slope	Lacustrine deposits and some alluvium on lake plains and basin floors	Aridisols	Fine-silty, mixed, superactive, mesic Typic Aquisalids	Low to none
56	Skumpah silt loam, 0 to 2 percent slope	Alluvial flats, lake plains, and fan skirts	Aridisols	Fine-silty, mixed, active, mesic Typic Natrargids	Low to none
57	Skumpah silt loam, wet substratum, 0 to 1 percent slope	Alluvial flats, lake plains, and fan skirts	Aridisols	Fine-silty, mixed, active, mesic Typic Natrargids	Low to none
58	Skumpah silt loam, wet substratum, saline, 0 to 1 percent slope	Alluvial flats, lake plains, and fan skirts	Aridisols	Fine-silty, mixed, active, mesic Typic Natrargids	Low to none
59	Skumpah silt loam, saline, 0 to 2 percent slope	Alluvial flats, lake plains, and fan skirts	Aridisols	Fine-silty, mixed, active, mesic Typic Natrargids	Low to none
60	Skumpah-Yenrab complex, saline, 0 to 15 percent slope	Alluvial flats, lake plains, and fan skirts	Aridisols	Fine-silty, mixed, active, mesic Typic Natrargids	Low to none
66	Timpie silt loam, 0 to 3 percent slope	Alluvium and lacustrine sediments of alluvial flats, lake terraces, fan remnants, inset fans and dissected lake plains	Entisols	Fine-silty, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
67	Timpie silt loam, saline, 0 to 4 percent slope	Alluvium and lacustrine sediments of alluvial flats, lake terraces, fan remnants, inset fans and dissected lake plains	Entisols	Fine-silty, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
68	Timpie-Tooele complex, saline, 0 to 5 percent slope	Alluvium and lacustrine sediments of alluvial flats, lake terraces, fan remnants, inset fans and dissected lake plains	Entisols	Fine-silty, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
69	TOOELE FINE SANDY LOAM, 0 TO 5 percent slope	Alluvium, lacustrine sediments and aeolian material on fan skirts, fan terraces, lake plains, and lake terraces	Entisols	Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
70	Tooele fine sandy loam, saline, 0 to 5 percent slope	Alluvium, lacustrine sediments and aeolian material on fan skirts, fan terraces, lake plains, and lake terraces	Entisols	Coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents	Medium
73	Yenrab fine sand, 2 to 15 percent slope	Fan terraces, lake terraces, basin floors, lake plains, and beach bars, and are usually on stabilized dunes that occur on these landforms	Entisols	Mixed, mesic Typic Torripsamments	Medium to high
74	Yenrab-badlands complex, 2 to 15 percent slope	Fan terraces, lake terraces, basin floors, lake plains, and beach bars, and are usually on stabilized dunes that occur on these landforms	Entisols	Mixed, mesic Typic Torripsamments	Medium to high
75	Yenrab-Tooele complex, saline, 0 to 15 percent slope	Fan terraces, lake terraces, basin floors, lake plains, and beach bars, and are usually on stabilized dunes that occur on these landforms	Entisols	Mixed, mesic Typic Torripsamments	Medium to high

Map Unit Symbol	Map Unit Name	Landform/Geographic Setting	Soil Order	Soil Family	Buried Site Potential
65A	Theriot-rock outcrop complex, 15 to 70 percent slope	Residuum and colluvium on mountains, hills, ridges, and pediments	Entisols	Loamy-skeletal, carbonatic, mesic Lithic Torriorthents	Low to none
W	Water				None