851-17

SUSTAINABILITY AND
ENVIRONMENTAL GROUP

# CULTURAL RESOURCE PREDICTIVE MODELING

ABERDEEN TEST CENTER
DUGWAY PROVING GROUND
REAGAN TEST SITE
REDSTONE TEST CENTER
WHITE SANDS MISSILE RANGE
YUMA PROVING GROUND

NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY

30TH SPACE WING
45TH SPACE WING
96TH TEST WING
412TH TEST WING
ARNOLD ENGINEERING DEVELOPMENT COMPLEX

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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# DOCUMENT 851-17

# CULTURAL RESOURCE PREDICTIVE MODELING

October 2017

Prepared by


Sustainability and Environmental Group
Range Commanders Council


Published by


Secretariat
Range Commanders Council
U.S. Army White Sands Missile Range
New Mexico 88002-5110

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# Preface

This document was prepared by the Sustainability and Environmental Group under the Range Commanders Council. All member ranges are in different stages of having or using Cultural Resource Predictive Modeling. This document surveyed the range members to determine what level was being used. The ultimate goal is to have a compliant cultural resource program and provide support to the test ranges for their missions. This document will provide information such as lessons learned, points of contact, and resources to the range cultural resource managers.

Objective/Scope: Identify existing cultural resource predictive models and lessons learned from predictive modeling. Provide a list of points of contact.

Deliverable: Report outlining what cultural resource predictive modeling is, including benefits and limitations; list of models that currently exist, including benefits and limitations; lessons learned from previous predictive modeling efforts; and subject matter experts at member ranges.

Benefit: Virtually every member range has cultural resources (CRs) on the range. Predicting the location of CRs would benefit the range user when planning future test programs. Cultural resource predictive modeling is rather complex. When faced with the challenges, this document would accelerate the timeline for member ranges.

Please direct any questions about this document to the RCC Secretariat.

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# Acronyms

| | |
|---|---|
| AFB | Air Force Base |
| ACDC | Archaeological Cultural Database Compilation |
| AUTEC | Atlantic Underwater Test and Evaluation Center |
| BMGR-E | Barry M. Goldwater Range East |
| CR | cultural resource |
| CRM | cultural resource management |
| CRPM | Cultural Resource Predictive Modeling |
| DoD | Department of Defense |
| ESTCP | Environmental Security Technology Certification Program |
| GIS | geographic information system |
| MRTFB | Major Range and Test Facility Base |
| NAVAIR | Naval Air Warfare Center |
| NEPA | National Environmental Policy Act |
| NHPA | National Historic Preservation Act |
| PA | Programmatic Agreement |
| POC | point of contact |
| RCC | Range Commanders Council |
| SEG | Sustainability and Environmental Group |
| SHPO | State Historic Preservation Office |
| SSU | sample survey unit |
| THPO | Tribal Historic Preservation Office |

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# CHAPTER 1

# Background

## 1.1 Range Commanders Council Sustainability and Environmental Group

The mission of the Range Commanders Council (RCC) is to serve "the technical and operational needs of the United States (U.S.) test, training, and operational ranges." The Sustainability and Environmental Group (SEG), one of many RCC working groups, was formed in 2012 when the Sustainability Group and Range Environmental Group were merged. The SEG's goal is to monitor and address sustainability, encroachment, environmental, and community outreach issues affecting the test, training, and operational ranges.

The SEG meets twice a year to review and discuss the latest issues affecting the ability of member ranges to sustain their missions and shares tools for proactively addressing those concerns. The SEG focuses on environmental management and compliance, land use, outreach, air and sea space encroachment, and other sustainability areas. The SEG shares trends and approaches used to protect the military mission and recommends solutions to commanders.

Meetings are interactive and open to ranges and installations throughout the U.S. and are not limited to Major Range and Test Facility Base (MRTFB) installations. Entities both inside and outside the Department of Defense (DoD) with common interests in environmental, sustainability, encroachment, and community outreach solutions are welcome to attend.

## 1.2 Introduction

The DoD is obligated under Sections 106 and 110 of the National Historic Preservation Act (NHPA) of 1966, as amended[1], to identify cultural resources (CRs) significant to our national heritage and to take appropriate steps toward preserving and protecting those resources. Under the National Environmental Policy Act (NEPA)[2], the DoD is also required to involve stakeholders in environmental planning processes.

These obligations are met by evaluating the environmental impacts of potential undertakings, proposing project alternatives, soliciting input from stakeholders through an open and transparent consultation process, and, if necessary, mitigating any adverse effects an undertaking would have on historic properties.

To fulfill cultural resource management (CRM) legal obligations under NEPA and the NHPA, military installations need to demonstrate that CRM decisions are based on objective and replicable information on the distribution and significance of archaeological sites under their jurisdiction.

The DoD has long taken a conservative approach to these legal mandates, with the agency's stated goal being to inventory all military holdings and evaluate all discovered archaeological sites. However laudable, these goals are unrealistic with current and future funding/staffing levels.

[1] National Historic Preservation Act of 1966, as amended, 16 U.S.C. § 470 et. seq. (last amended 2014).
[2] National Environmental Policy Act as amended. 42 U.S.C. 4321 et seq.

## 1.3 What is Cultural Resource Predictive Modeling (CRPM)?

Archaeological predictive models use prior knowledge to predict the expected nature and distribution of the archaeological record.

There is no one kind of predictive model, although the military has many models designed to predict the location of sites discovered through conventional survey techniques. Note: models are built for areas needed, topographical considerations, and type of CR.

In addition to predicting site location, models can be constructed to predict archaeological data quality, significance, the potential of encountering buried sites, and other features important to the management of CRs on military lands.

The CRPM process relies on using prior knowledge already gained about the archaeological record.

Verification of models through ground survey needs to be part of the process to ensure accuracy of the predictive modeling.

The Environmental Security Technology Certification Program (ESTCP) project illustrated that there is no single kind of model that each installation needs (i.e., a locational model for all sites discovered through conventional survey methods) but that modeling should suit current and anticipated management needs in a flexible manner (Green et al., 2012).[3]

## 1.4 Lessons Learned from Strategic Environmental Research and Development Program/ESTCP CRPM Projects

The completion of this task assignment (RCC SEG-002) required identifying existing DoD cultural resource predictive models and the lessons learned from the development and use of these various models across a variety of military installations.

A goal of this assessment was to identify the benefits and limitations of existing DoD models through a questionnaire survey of CR subject matter experts and what has been learned from previous efforts. The survey results showed that an assortment of different models of varying complexity is used by the nine ranges that have predictive models, and that further refinement and development of them is required. Additionally, it should be noted that the survey did not elicit clear-enough responses from the member ranges on which the RCC would be able to draw any definitive conclusions about predictive modeling.

Over the course of this task assignment, research discovered that a number of attempts at CRPM have been conducted over the years at various DoD installations that indicate a core set of issues related to the usefulness of these models and the inherent difficulties in their development. The study by Green, et al., entitled *Integrating Archaeological Modeling in DoD Cultural Resource Compliance*, illustrates this point. This extensive five-year research effort into the utility of predictive modeling was conducted by the ESTCP and was built off of seven years of legacy-funded work that "was designed to validate models and demonstrate their potential for streamlining and economizing compliance and improving asset management" (Green et al.,

[3] Green, Paul R. et al. *Integrating Archaeological Modeling in DoD Cultural Resource Compliance*. Project RC-200720. Version 3.0. 26 October 2012. May be superseded by update. Retrieved 4 May 2017. Available at http://www.dtic.mil/dtic/tr/fulltext/u2/a571270.pdf.

2012). This project was sponsored by the US Air Force Civil Engineering Center and the US Army Corp of Engineers.

As Green et al. revealed, and which the RCC questionnaire survey and our research corroborates, the core issues related to predictive modeling are relatively consistent across the board; however, each installation's situation in creating predictive models is unique due to the archaeological and geographical distinctiveness of each range. As the report states:

> 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 (Green et al. 2012, xiii).
>
> Developing predictive models requires a large quantity of CRM and environmental data. Although many installations have compiled some of this data, they often are not readily available in a digital format. 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 (Green et al. 2012, 180).

A common presumption is that predictive models can lessen costs of environmental and CR compliance by eliminating the need to conduct archaeological surveys. While in theory this perspective may appear cost-effective, the reality may be that the up-front costs and time necessary to develop a usable predictive model that could elicit concurrence from state and tribal historic preservation officers and other stakeholders could be more problematic. As the cited study shows, it was a five-year research program based on seven years of legacy data. Development of predictive models requires a long-term commitment in both time and funding in order to create models that are reliable, replicable, and can be improved over time. This is not to say that developing predictive models at RCC member ranges is not feasible, but only to point out that it is a process that entails a great deal of collaboration and consultation with stakeholders to ensure that all concerns are addressed so that Programmatic Agreements (PAs) may be instituted that can streamline Sections 106 and 110 procedures of the NHPA, as well as the requirements of the NEPA.

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 a geographic information system (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 [SHPO] staff, Native American groups, and other interested parties) from the beginning of the modeling process and maintain regular contact. Consulting parties will need assurance to maintain 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 improve with more data, allowing the DoD to meet its stewardship and mission goals more efficiently and with better results (Green et al. 2012).

# CHAPTER 2

# Survey

## 2.1 Survey Questions

Appendix A is a copy of a blank survey questionnaire while Appendix B has copies of the completed surveys. A questionnaire went to all member and associate member ranges on the SEG. There are 18 member ranges and 17 associate members. Because associate members may not be affiliated with an installation that has a range, it is reasonable to not expect all 17 to reply. Fourteen survey questionnaires were returned with five of them as a negative, i.e., no CRPM system used. Below is the breakdown of the ranges that responded.

- Cape Canaveral
- Eglin Air Force Base (AFB) (96th Test Wing)
- Vandenberg AFB (30th Space Wing)
- Naval Undersea Warfare Center Division Newport Atlantic Undersea Test and Evaluation Center (AUTEC) - Negative
- Barry M. Goldwater Range (BMGR)
- NASA Wallops Island
- Aberdeen Test Center
- Naval Air Warfare Center (NAVAIR) Patuxent River (PR)
- Edwards AFB (412th Test Wing)
- White Sands Missile Range
- Pacific Missile Range Facility - Negative
- Naval Undersea Warfare Center Division Keyport - Negative
- NAVAIR China Lake – Negative
- NAVAIR Point Mugu - Negative

## 2.2 Details of Responses

### 2.2.1 Cape Canaveral Air Force Station/Patrick AFB (45th Space Wing)

Point of contact (POC) Thomas Penders, 45th Space Wing Cultural Resources Manager, thomas.penders@us.af.mil, DSN 467-0886.

Cape Canaveral does have a CRPM system; however, it is based on current knowledge supported by previous surveys. There are deficiencies in these previous surveys. The model in use is not a computerized program. Cape Canaveral is currently programming a series of archaeological surveys to correct the predictive model over the next six years that includes systematic Phase I testing.

The GIS layers to incorporate are:

- Topographic – Relic dune ridges;
- Soil – Well to excessively drained sandy soils;
- Water – Freshwater swales, freshwater marshes, freshwater lakes/ponds;
- Vegetation – maritime hammocks, oak hammocks, Australian pines and exotics decorative plants for historic sites;
- Social – within 100m of water sources.

The CRPM system has not been validated but is a part of their Integrated Cultural Resource Management Plan (ICRMP), which SHPO has accepted. Cape Canaveral has a good relationship with their SHPO. Only 25% of the installation has been surveyed and the CRPM system includes subsurface testing, geomorphology, and historic models.

Lessons Learned: Predictive models based on surveys at Cape Canaveral from the 1980s and 1990s are inaccurate and were redundant. They only tested where they "KNEW" sites would be located partly from data from the 1960s and earlier. The surveys did not test all the ecosystems and missed a significant freshwater feature on Cape Canaveral (large freshwater lake). Since 2006 various environmental studies have found maritime hammocks that contain prehistoric sites. Previous surveys declared these areas as low-probability zones. While predictive modeling assists in identifying impacts and possible sites, it is only a tool that should be used in any preliminary study and should NEVER replace field studies. Kennedy Space Center is finding this out with previously unrecorded sites being found recently.

### 2.2.2 Eglin AFB (96th Test Wing)

POC Rhena Lynn Shreve, rhena.shreve.1@us.af.mil, 850-883-2102.

Eglin does have a CRPM system and uses it almost daily. It is GIS-based and was established initially in 1995, then validated in 2012. Eglin has significant layers under topographic, soil, water, and vegetation.

**Table 2-1. Eglin AFB Model Predictors**

| Resource | Variable |
|---|---|
| Topographic | % slope |
| Soils | Distance to soil facies with thick A horizon. |
| Water | 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 coast. |
| Vegetation | 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. |

Eglin has 57% of their installation surveyed with 98% of the high-probability areas surveyed, has a PA with SHPO, and has a very good working relationship with them. The model includes subsurface investigation, geomorphology, and historic information.

Lessons Learned: The original model was focused on the identification of prehistoric resources. This shortfall was remedied in the second version, which included data from historic resources such as US Forest Service maps and documents, General Land Office records, early aerial photographs, maps, and local histories to identify early homesteads and industrial sites. The predictive model should not be a stagnate tool, but one that evolves and is improved as technology changes and new information comes to light. These improvements increase the validity of the predictive model as a planning tool for the coordination of mission activities.

### 2.2.3 Vandenberg AFB (30th Space Wing)

POC Christopher Ryan, christopher.ryan.7@us.af.mil, 805-605-0748.

The following is the response provided by Vandenberg's POC. "Vandenberg does not have a CRPM system but uses predictive modeling informally. For example, there is no probability for buried archaeological deposits on the Burton Mesa, but there is high probability for buried deposits in river valleys. That is something I understand based on my professional knowledge about geology, geomorphology, and geoarchaeology, as well as my experience with excavations on the various regions of the base. I don't have one because I have never asked for funding for one, because I don't really need one. We have a base-wide survey, so we know where the surface sites are, and I intuitively understand where the subsurface sites will likely exist."

### 2.2.4 Naval Undersea Warfare Center Detachment AUTEC

POC Marc Ciminello, marc.ciminello@autec.navy.mil, 561-671-2612.

There are minor Bahamian archaeological resources at AUTEC site 4 on Golding Cay. The Bahamian archeological resources have been surveyed and an inventory has been provided to the appropriate Bahamian Ministry; therefore, there is no need for a CRPM system.

### 2.2.5 Barry M. Goldwater Range-East (BMGR-E)

POC Adrianne Rankin, adrianne.rankin@us.af.mil, 623-856-8410.

The BMGR-E range does not have a CRPM system but is exploring how they can use the data collected during the Section 110 work to develop a comprehensive and representative understanding of the archaeology of the BMGR-E. The software they will be using is ArcGIS 10.3; R statistical package 3.2.3; Archaeological Cultural Database Compilation (ACDC) v2 database; Microsoft Access 2007; Environmental Systems Research Institute; and Statistical Research, Inc. The strategy is to use ACDC v2 to organize sites into types according to function, chronology, and condition. The Luke AFB Range Management Office GIS data will be used along with environmental strata to develop model training and test samples, according to site type and modeling unit. Survey has recently been completed in upland areas of the BMGR-E, providing important data in underrepresented environmental zones. A healthy list of model predictors will be used, as shown in Table 2-2.

| Table 2-2. BMGR-E Model Predictors | |
|---|---|
| Resource | Variable |
| Topographic | Shelter, relief, surface roughness/texture, aspect, slope/slope length, elevation-standardized height/height above channel. |
| Soil | Soil texture, depth to restrictive layer, CaCO3 content, organic matter content/ A Horizon thickness, erosion potential (k factor, Erosion/Deposition Model), available water capacity. |
| Water | Cost distance to drainage (major and minor), cost distance to Gila river, cost distance to Adair Bay, cost distance to springs/tinajas, flow accumulation historic rainfall averages. |
| Vegetation | Vegetation diversity within 1 km, vegetation type, surface visibility. |
| Social | Shell trade routes, cost distance to lithic source materials (e.g., obsidian), least cost paths among major sites and resource zones. |

The BMGR-E range has about 18% of the range surveyed and has a good relationship with SHPO. They are using the report *Pathways to Preservation: A Research Design and Heritage Management Plan for the Barry M. Goldwater Range, East* to implement CRPM since they are just starting this process.

Lessons Learned: The contractor in developing these tools, SRI, has learned that sampling areas that are not directly affected by training or development can be very important to building effective models. Moreover, performing subsurface testing and data recovery is important to understanding and modeling site condition, significance, and integrity. When developing programmatic approaches to site and landscape management, CRPM is an important component, and the 56 RMO/ESM is moving toward a programmatic approach.

### 2.2.6 NASA Wallops Flight Facility

POC Shari Miller and Randy Stanley, shari.a.miller@nasa.gov and randall.m.stanley@nasa.gov. 757-824-2327 and 757-824-1309 respectively.

Wallops does have cultural properties to manage and does have a CRPM system but has only used it once. Wallops has based it off of the document *Final Cultural Resource Assessment of Wallops Flight Facility, Accomack County Virginia*.[4] They have established a PA with the Virginia SHPO and the Advisory Council on Historic Preservation that incorporates verifying the model through a Phase I assessment.

Model predictors are as follows (URS and EG&G 2003 p. 5-48).

> The above model describes areas of moderate and high sensitivity for prehistoric archaeological resources. Low archaeological sensitivity areas include any of the following characteristics: poorly-drained soils (during prehistory); slopes greater than 10 percent; distances greater than 160 meters (500 feet) from water; and severe disturbance from modern activities, such as

[4] URS Group and EG&G Technical Services, Inc. *Final Cultural Resource Assessment of Wallops Flight Facility, Accomack County Virginia*. November 2003. Retrieved 30 August 2017. Available at https://sites.wff.nasa.gov/code250/docs/Cultural%20Resources%20Assessment.pdf.

construction and earth-moving. The predictive model for prehistoric site locations within the current project area is summarized in Table 5-2.

Table 5-2. Prehistoric Site Predictive Model for the Project Area

| Sensitivity | Landform | Soil Drainage Type | Slope | Distance to |
|---|---|---|---|---|
| Low | tidal marsh, topographically low areas | poorly-drained | < 2 % | n/a |
| | terrace, knoll, ridge, and bluff edges | all types | > 10 % | n/a |
| | terrace, knoll, ridge, bluff | all types | n/a | > 160 meters (> 500 feet) |
| Moderate | terrace, knoll, ridge, bluff, barrier island | moderately-drained | 2 – 10 % | < 160 meters (< 500 feet) |
| High | terrace, knoll, ridge, bluff, barrier island | well-drained | 2 – 10 % | < 160 meters (< 500 feet) |
| | hummock or knoll in tidal marsh | moderately- to well-drained | 2 – 10 % | n/a |

The same document later (p. 5-51) provides a more thorough description of the models.

The predictive models for historic site locations within the current project area are summarized in Tables 5-4 and 5-5.

Table 5-4. Non-Maritime Historic Site Predictive Model for the Project Area

| Sensitivity | Landform | Soil Drainage Type | Slope | Distance to |
|---|---|---|---|---|
| Low | tidal marsh | poorly-drained | < 2 % | 0 |
| | terrace or bluff edge | all types | > 20 % | > 15 meters (> 50 feet) |
| Moderate | terrace, ridge, knoll | moderately to well-drained | 10 – 20 % | n/a |
| High (all site types except mills) | terrace, ridge, knoll | well-drained | 2 – 10 % | < 300 meters (< 900 feet) |
| High (mills only) | terrace or bluff edge adjacent to freshwater source | n/a | > 20 % | 0 |

Domestic sites and cemeteries, as well as commercial and industrial sites such as taverns, tanneries, and mills, are included in the non-maritime sites. Low archaeological sensitivity areas include severe disturbance from modern activities, such as construction and earth-moving.

Table 5-5. Maritime Historic Site Predictive Model for the Project Area

| Sensitivity | Landform | Soil Drainage Type | Slope | Distance to water |
|---|---|---|---|---|
| Low | terrace | all types | n/a | > 30 meters (> 100 feet) |
| Moderate | shoreline, tidal marsh, barrier island | poorly to moderately-drained | n/a | n/a |
| High (domestic*) | barrier island | well-drained | > 2 % and < 10 % | < 30 meters (< 100 feet) |
| High (other than domestic) | barrier island, beach shoreline, tidal marsh | poorly to well-drained | n/a | < 30 meters (< 100 feet) |

Note: Maritime sites include domestic sites such as fishing village communities

The model has been validated on a project-specific basis only; i.e., if a project proposes to break ground in an area of increased sensitivity, a Phase I assessment is first performed. The CRPM system has been included in the PA and Wallops has a very good working relationship with SHPO.

Lessons Learned: There is a dig request process at NASA WFF for any ground-breaking activities. The SHPO and staff are tied into this process and can quickly determine if a proposal would occur in modelled areas. Additionally, all cultural sensitivity layers have been added to the GIS FlexFinal and are available to all program managers to reference. Having the SHPO's buy-in on the model made it much easier to get concurrence on the PA.

### 2.2.7 Aberdeen Test Center

POC mark.t.gallihue.civ@mail.mil.

Aberdeen does have CR properties to manage but does not have a formal CRPM system at the installation. A study from the 1990s developed a pseudo-model that is still in use. That study produced GIS layers that show cemeteries, high-potential archeological areas, known disturbed archeological areas, locally disturbed archeological areas, historic districts, archeological sites, and historic ruins. The layers are interpreted along with other topographical features, such as distance to water, to make determinations on potential for CRs. This system has not been formally approved by the SHPO, but works well for management. Relationship with SHPO at Aberdeen is good to very good. One barrier to a computer model would be obtaining a certificate of net-worthiness from the Network Enterprise Center.

### 2.2.8 NAVAIR PR

POC Michael A. Smolek, Cultural Resources Program Manager, michael.a.smolek@navy.mil, 301-757-4774.

The NAVAIR PR facility does have CR properties to manage but does not have a CRPM system. A predictive model for prehistoric archaeological resources was developed in 2003 for the main base (6500 acres). Since that time approximately 90% of the surveyable terrestrial areas of the NAVAIR PR complex (some 20,000 acres) have been surveyed. The areas of the water ranges have not been systematically surveyed. The model was developed before the current CRM was employed here. Table 2-3 displays the model predictors.

**Table 2-3. NAVAIR PR Model Predictors**

| Resource | Variable |
|---|---|
| Topographic | Soils, proximity to water, elevation, slope, aspect. |
| Soil | Existing sites were correlated with six different soil types as defined by county soil conservation service mapping, which considers many variables to define soil type. |
| Water | Greater or less than 400 feet from water (fresh and brackish). |
| Vegetation | Not considered. |
| Social | Not considered because not relevant in coastal plain environment with plentiful water and few barriers. |

The NAVAIR-PR POC stated that SHPO does not have any faith in the predictive models at this time but does have a very good relationship with SHPO.

Lessons Learned: If there is an undertaking proposed in an unsurveyed area, generally a survey is required, model or no model. So while the model may be useful in some situations, it is not particularly useful in this situation. The model also only deals with Native American archaeological sites, so the 350+ years of historic period Euro-American occupation is not considered and, in any case, is more difficult to model. The model does not deal with the huge areas of the Chesapeake Bay or Atlantic Ranges, which are water ranges with the potential for historic and prehistoric sites.

### 2.2.9 Edwards AFB (412th Test Wing)

POC Roscoe Loetzerich, roscoe.loetzeric.1@us.af.mil, 661-277-1413.

Edwards does have CR properties to manage and does have a CRPM system and only uses it about one time per year. It is based on ArcGIS, version 10.3. The strategy is for a stratified random sample of 460 ¼ sections located in the southwest quarter of each one-square-mile section on Edwards AFB. The number and quantity of acreage per sample survey unit (SSU) (1/4 square mile) is known across the entire base allowing the base archaeologist to interpolate the number or sites or the acres of site per adjoining area to an SSU.

Edwards uses GIS layers such as archaeological, site features, and sample survey features. The CRPM system has not been validated, is not in the PA, and has not been concurred on by SHPO. Edwards has a working relationship with SHPO. Approximately 70% of the installation has been surveyed.

Lessons Learned: Predictive modeling based on environmental variables (landforms, distance to water source, slope, aspect, vegetation, etc.) is useful for bases with very large tracts of land with a high degree of environmental heterogeneity. Obviously the more similar the environment is across the base with no major differences in vegetation, soil types, etc., the less beneficial a predictive model will be. Edwards AFB is by and large a fairly homogenous base. Furthermore, while the base has current environmental data, it lacks GIS layers that represent soil, vegetation, or hydrographical layers for the recent and distant past, making predictions of site types for specified periods of time in relation to environmental variables basically impossible to determine.

Recognizing this shortcoming, it was decided to focus on the physical archaeological survey of the base. A five-year project was launched in 1999 to conduct a 25% sample of the base, resulting in the survey of the southwest quarter of each one-square-mile United States Geological Survey section across the base. From this data it is possible to estimate the number of acres of archaeological site between the ¼ mile quarter sections.

The CR program is well into its 3rd decade of existence. Hundreds of federal undertakings have resulted in additional surveys being performed so that currently approximately 70% of the base has been inventoried for archaeological resources. This wealth of survey data is often consulted in those cases where a need exists to predict the potential to encounter an archaeological site in a previously uninvestigated portion of the base.

If a graphic is needed to demonstrate the predicted density of archaeological sites in an area, this is most commonly achieved by creating a density map. The density map is calculated by establishing a point at the center of each of the SSUs. The total acreage of archaeological site is calculated for the unit and the number is associated with the center point. The ArcGIS software includes a tool to generate contour lines based on the value of each center point. The ArcGIS technician then enters the number of contour lines to generate between values. The area between the contour lines essentially represents the expected acreage, expressed as a range, of archaeological site to expect within that band.

This is a very straight-forward and simple model, but it is based on reliable data and commensurate with the environment found at Edwards AFB. Given the large body of data currently available there is no limit to the number of academic models that could be developed, but they are not an immediate requirement for the day-to-day management of the resource. That said, the base is always interested in pursuing or supporting models that can help explain the archaeological sites and their distribution across the base.

### 2.2.10 White Sands Missile Range

POC Jim Bowman, james.e.bowman68.civ@mail.mil, 575-678-7925.

White Sands has CR properties to manage and does have a CRPM system. It is used about two times per year and uses ArcGIS and SRI. It was implemented in 2001.

The model predictors are listed in Table 2-4.

**Table 2-4. White Sands Missile Range Model Predictors**

| Resource | Variable |
|---|---|
| Topographic | Slope: 1) Cost Surface - relative cost of moving across landscape; 2) Aspect – direction in which a slope is facing, terrain roughness/surface texture; 3) Shelter - degree to which topographic features afford shelter, cost distance to uplands. |
| Soils | Soil Survey – organic matter, available water capacity, bulk density, etc. |
| Water | Landscape features that could have provided surface water resources after precipitation episodes: 1) distance to tanks-location of artificial tanks for water storage; 2) distance to streamlines-distance to drainages, elevation relative to water. |
| Vegetation | Data from gap analysis program and national land cover data program. |

| | |
|---|---|
| Social | Calculation of least cost path for water |

The CRPM system has not been included in the PA and SHPO has not concurred on it. White Sands has a very good working relationship with SHPO. Out of 2.2 million acres, only 28% of the installation has been surveyed.

Lessons Learned: It works well on inaccessible areas where survey can be focused on a sample of areas. It is only for areas that are in the basin; additional data layers for the mountain slopes would be necessary if the capability was to be expanded.

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# CHAPTER 3

# Conclusion

## 3.1 Summary

While CRPM is an on-going process that can be utilized by ranges as a planning tool that can assist in compliance with historic preservation laws, it cannot completely replace the need to conduct Section 106 and Section 110 surveys. Realistic objectives for predictive modeling must consider that they require a long-term commitment. These commitments are in terms of time, cost, and future maintenance as new data becomes available to refine the models.

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 not enough is known to have confidence in models and that sites will inevitably be lost. Many stakeholders remain skeptical of both models and government agency motives in promoting models. It would be a mistake for the DoD as a federal agency or a military installation to decide on its own 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 the ESTCP demonstration project (Green et al., 2012), the New York SHPO was strongly opposed to predictive modeling. Before initiating the demonstration project, the 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. The SEG 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.

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. The SEG strongly believes 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 the SEG knows quite a lot, as you can see from the surveys taken throughout the DoD's MRTFBs. The surveys show that there are various levels of use but a way to manage CRs throughout the DoD. 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 (Green et al., 2012).

## 3.2 Recommendation

The Strategic Environmental Research and Development Program/ESTCP already performed an incredible amount of research in the field of CRPM. Their final report (Green et al., 2012) provides detailed information on how to use CRPM as well as the experiences while trying the process on five installations. Rather than the end-all be-all solution to management, CRPM is only a tool to assist in the management of CRs on the installation. It still takes dedicated resources to implement this type of program and requires proactive coordination with the local SHPO and tribes in order for stakeholder buy-in.

This report in not recommending that CRPM is the only way to proceed to have a viable CR program. The installation needs to make that decision depending on SHPO, stakeholders, funding resources, and the site-specific CRs it manages. Installations are not funded evenly across the board. Some installations have 100% surveyed lands; therefore, modeling is not necessary. If getting 100% survey does not look like an option, CRPM is one way to apply what has been surveyed and put into a model. It would be beneficial to fund the MRTFBs that are lacking the resources to have a good baseline of surveyed areas in order to pursue CRPM. Having this lack of data on MRTFBs slows down the approval process for customers wanting to test.

Development of predictive models requires a long-term commitment in both time and funding in order to create models that are reliable, replicable, and can be improved over time. Buy-in from stakeholders is also important before proceeding down the CRPM path.

# Appendix A

## Survey

Cultural Resource Predictive Modeling (CRPM) Survey
Sustainability and Environmental Group (SEG) Task-002
Range Commanders Council 2016

Installation Name: ____________________________________________
Address: ______________________________________________________
Person filing out survey form POC: ____________________________
Email: ________________________________ Phone: _______________

1) Do you have Cultural Resource property to manage?
   a. Yes
   b. No (If No, survey complete)
2) Do you use CRPM (Cultural Resource Predictive Modeling)
   a. Yes How Often:
   b. No (If No, please explain why you don't have one. Would you like to have one? Is there a shortage of resources? Do you not need CRPM?) (You are done with the survey if you answered "No".)
3) What is the Program Name:
   a. Software version:
   b. Date implemented:
   c. Software Architect:
4) Subject Matter Expert (SME) for CRPM implementation/use.
   a. Name:
   b. Position:
5) Has a "Sampling Plan/Strategy" been used for model? (Prescribed burns for instance)
   a. Yes, describe:
      ______________________________________________________
      ______________________________________________________
      __________________
   b. No
6) Model Predictors (reference only)
   a. Topographic Variables: (GIS Layers)
      i. ______________________________________________________
      ______________________________________
      ii. ______________________________________________________
      ______________________________________

iii. ______________________________________

iv. ______________________________________

v. ______________________________________

vi. ______________________________________

b. Soil-Attribute Variables: (GIS Layers)

i. ______________________________________

ii. ______________________________________

iii. ______________________________________

iv. ______________________________________

c. Water Resource Variables: (GIS Layers)

i. ______________________________________

ii. ______________________________________

iii. ______________________________________

iv. ______________________________________

v. ______________________________________

d. Vegetation Variables: (GIS Layers)

i. ______________________________________

ii. ______________________________________

iii. ______________________________________

iv. ______________________________________

e. Social Factors: “Least Cost Path” to water resource for instance. (GIS Layers)

i. ______________________________________

ii. ______________________________________

iii. ______________________________________________

7) Has the CRPM been validated?

a. Yes (If yes, please describe process used), include (%) percent accuracy if available.

______________________________________________

b. No

8) Has the CRPM program been included in your Programmatic Agreement (PA)?

a. Yes
b. No

9) SHPO concurrence on use?

a. Yes
b. No

10) What is the relationship with SHPO?

a. Very Good
b. Good
c. Working
d. Strained

11) What is the percent of installation currently surveyed?

a. %:

12) Does the CRPM include any of the following components:

a. Significance Model: Yes/No

i. If yes, does it include subsurface testing for site Integrity aspect

______________________________________________

b. Geomorph Model: Yes/No
c. Historic Model: Yes/No

13) Lessons Learned: Some ideas to consider: What would you do different? Issues you run into using CRPM? What works best for your cultural resource management program and how do you make it work well with the mission of your installation? What factors make a CRPM a value to the cultural resource program?

# Appendix B

## Completed Surveys

The following pages contain all surveys that participants submitted in response to this task.

# Appendix C

# Citations

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# Appendix D

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Heilen, Michael, Lynne Sebastian, Jeffrey H. Altschul, Phillip Leckman, and Adam Byrd. *Modeling of Archaeological Site Location and Significance at White Sands Missile Range, New Mexico*. Technical Report 12-06. March 2012. Statistical Research, Inc: Tucson.

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