Department of Defense
Legacy Resource Management

Legacy Project # 10-122

Prioritizing Site Treatment Actions

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February 2012

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1.0 Abstract

Several federal cultural resources statutes and regulations require Department of Defense (DoD) installations to prevent the deterioration of archaeological sites on their lands. Both natural and human processes on DoD installations have the potential to produce cumulative impacts to archaeological sites. This project builds on the results of DoD Legacy Program Project 09-442, which developed recommended procedures for a program of archaeological site condition monitoring. Based on the monitoring protocols developed by that project and the categories of site condition threats it identified, this project develops site treatment protocols designed to prevent further deterioration of archaeological sites on DoD lands. Erosion and vandalism are among a list of threats identified by long-term site monitoring that produce cumulative impacts. These effects differ from the kinds of site impacts produced by planned projects, such as construction. Thus, the catalog of potential site treatments is broader than such measures as site stabilization, burial, or mitigation through excavation that are typically considered under National Historic Preservation Act (NHPA) Section 106 projects. Additional treatments examined include landscaping around sites to change erosion patterns or divert pedestrian traffic, as well as education programs or enhanced site monitoring to prevent/deter site vandalism.

2.0 Introduction

The U.S. military is one of the largest federal landholders in the U.S. and it must strive to maintain readiness and meet national security requirements while at the same time ensuring proper stewardship of its environmental resources. Many military installations are geographically extensive and contain large numbers of diverse and potentially significant archaeological sites, considered part of the non-renewable resource base that the DoD manages in trust for the American people. These resources are of high educational and scientific value to the public. Compliance with federal cultural resources legislation on DoD lands has typically focused on the critical task of identifying these resources. The resulting site inventories enable installation Cultural Resources Managers (CRMs) to develop avoidance strategies that minimize negative impacts to known archaeological sites. However, unless planned impacts necessitate that potential effects to the sites be evaluated under Section 106 of the National Historic Protection Act (NHPA) (ACHP 2008; Little et al. 2000), archaeological sites often do not receive further attention due to the limited budgets and staff available to public land managers (Kelly 2007). Nevertheless, Section 110 of the NHPA calls for the long-term preservation and protection of archaeological resources even if destruction is not imminent, a regulation sometimes overlooked by public land managers (Kunde 1999:ii).

Archaeological sites are not static entities. Avoidance strategies may be developed at the time an archaeological site is recorded, but these may become ineffective over time as a consequence of the dynamic forces acting on the site. Environmental forces, such as erosion or animal burrowing, can affect the physical integrity of a site if left unchecked, leading to a loss of critical cultural information and possibly undermining the site's eligibility to the National Register of Historic Places (NRHP). Additionally, human-related impacts, whether inadvertent or intentional, can be unpredictable. The intensity of human impacts may grow dramatically with enhanced accessibility to a site, perhaps through expansion of residential or military training areas, or increased off-road vehicle use (Affleck 2005; Ouren et al. 2007; Sampson 2007; Sowl and Poetter 2004; Stokowski and LaPointe 2000; Kathy Strain, personal communication 2009).

There is a growing recognition that proper stewardship of archaeological resources on public lands cannot rely on avoidance strategies alone, but must become more proactive (Kelly 2007). Archaeological resources must be monitored to examine the dynamic forces acting on a site if public land managers hope to develop long-term strategies that will alleviate or redirect these impacts (Kelly 2007). DoD Legacy Program Project 09-442 addressed this need by recommending procedures for a program of archaeological site condition monitoring. The project included developing initial site condition assessment forms and periodic site visit forms to monitor and record the condition of archaeological sites over time. The program allowed for the identification and measurement of cumulative, long-term impacts to archaeological sites, in a process that has not been routinely carried out before. The cumulative impacts considered may be either man-made or natural and they may be pervasive, potentially representing serious threats to the integrity and significance of sites. CRMS may need to consider active treatment to lessen the effects of these threats when identified.

But there are good reasons to embark on a program of long-term site monitoring and maintenance beyond preservation concerns. There is an opportunity to use these resources as training assets for instructing troops in heritage assets issues. This can be critically important in an era when U.S. troops are active in areas of the world with numerous highly sensitive heritage assets. Furthermore, some archaeological sites have been hardened at Fort Drum allowing them to be used as fighting position training assets (Wagner et al. 2007), so archaeological sites need not always be viewed as encroachments on training lands, and preservation actions can be a win-win for archaeology, and an installation mission.

The current project aims to assess the variety of threats that might be present at DoD installations and to match those threats to appropriate treatment actions. This study identifies variables that may influence site threats, such as the type of archaeological site, surrounding land use, soil type, or climate. The report presents classifications of each group of variable and discusses their relevance to the maintenance of archaeological site integrity. Recommendations for relevant treatment options are presented in Section 7 and overall program recommendations in Section 8. Installation CRMs can use the information in this report to identify archaeological sites at risk for adverse effects due to various cumulative effects. In an example review process, a CRM would:

- review Installation GIS and Sections 4 - 6 of this report to identify land use and environmental contexts applicable to the installation;
- compare identified threats from those contexts against the installation archaeological inventory;
- conduct monitoring program to assess state of sites and threats;
- identify priority issues based on identified threats and cumulative impacts;
- develop treatment plan using Section 8 as a starting point;
- consult with stakeholders, including the SHPO and Tribes; and
- implement a treatment plan as appropriate and funds are available.

3.0 Methodology

Appropriate treatments for threatened archaeological sites will depend on the specific situation and context. To understand the variety of situations that might be encountered at a particular DoD installation, we will classify the variables mentioned above, including site types, their physical settings, and potential impact. For each category, the team reviewed relevant literature to identify existing classification systems. In some cases, such as land use, soil type, and climate, there are well-documented classifications that we used. In other cases, such as landform, existing classifications proved to be unsatisfactory because they were too particularistic. In such cases, we developed simplified categories suitable for the purposes of this study. We then constructed matrices that match potential impacts to site types, land uses, and dimensions of physical context. These form the basis of recommendations for treatment options applicable to a variety of situations.

The perspective of this study is interdisciplinary. The environmental contexts that can affect archaeological site preservation are interdependent in complex ways. Changes in land use can bring out changes in animal species present, land cover, storm water runoff, and soil moisture content. This can in turn result in changes to soil characteristics that affect site preservation. Changes in land use can also affect the human interaction with sites, bringing them into contact with more or with fewer people.

The sections that follow summarize the potential impacts to which a site may be subject, then proceed through a discussion of land use on military installations, the preservation implications of environmental contexts for sites (topographic, climate, soil, and land cover), and the kinds of site vulnerabilities that may be found on military lands. From these analyses of impacts, settings, and site vulnerability types, treatment methods that may be appropriate to address specific, long-term cumulative effects to threatened sites are presented.

4.0 Impacts Classification

Treatments designed to either protect archaeological sites from harm or to repair past damage will vary according to the nature of the threat to sites. This section will outline a range of possible effects to archaeological sites to provide a foundation for discussion of site-specific conditions. Broadly speaking, all impacts can be "classified as either burial, transfer, removal, or alteration regardless of the nature of the impact agent" (Wildesen 1982:16 cited in Schiffer 1987:133). Analyzing these broad categories further helps to relate specific sources of impact to the kinds of land use and activities that may occur on military lands. Table 1 shows an impacts classification scheme developed for cultural resources planning developed by the Nature Conservancy (The Nature Conservancy 2003), which is useful because it addresses specific changes to a wide variety of potential archaeological site types.

Table 1: Types of Impact

Impacts to Site Surroundings	
Loss of Context	Loss of surrounding elements results in deterioration of some aspects of integrity (association or feeling).
Impacts to Site Stratigraphy	
Deformation	Site stratigraphy is warped.
Compaction	Site soil layers are compressed.
Dislocation	Site materials are transported away from a site.
Stratigraphic mixing	Site soils and artifacts become mixed.
Loss of volume	Site sediments are washed or blown away.
Loss of Elements	Site elements (artifacts or features) are removed.
Collapse	Structural elements (e.g. walls) collapse.
Sinking	Soils underneath a site sink.
Impacts to Artifacts or Features	
Contamination	This includes introducing artifacts or other materials to a site, undermining the information value of the data.
Mutilation	This includes vandalism.
Salination/efflorescence	The accumulation of salts on a masonry surface from loss of water.
Pulverization	Site materials are broken up into small pieces or powder.
Dissolution	Site materials are dissolved in a liquid.
Discoloration	Changes in the color of site materials.
Exfoliation	The surface of stone or masonry materials flakes off the surface.
Chemical Changes	This includes decay as well as chemical changes such as oxidation.
Cracks	Site materials begin to split apart.
Fragmentation	Site materials are broken apart.
Superficial spots/alteration	Chemical or biological processes add spots or other alterations to the surface of site materials.
Warping	Site materials warp, such as when wood dries.

4.1 Natural Sources of Site Disturbance

Some of the impacts described in Table 1 above can be caused by natural agents. Though manmade impacts will be the focus of a treatment program, human land use can cause landscape changes that may result in long-term cumulative impacts from natural agents. Not all of these changes will be discernible in a monitoring program, nor is it necessary or even advisable for a preservation program to attempt to alter long-standing natural processes on an installation. The intent of the following section is to provide an overview of processes that affect archaeological sites so that when man-made activities cause changes to these natural processes, the resulting impacts to archaeological sites can be anticipated, and remedied where appropriate and consistent with supporting the military mission.

4.1.1 Wind

Eolian processes have the potential to alter exposed features as well as redeposit soils on or away from an archaeological site. Wind-born particles are generally less than 0.2 mm in size, but even substantial artifacts can be transported by intense storms (Schiffer 1987). In instances where wind erosion deposits sediments on top of an archaeological site, the site might not be damaged, and may even be protected. But in others, wind may remove sediments destroying temporal information inherent in stratigraphy. In severe cases, wind erosion can completely deflate an archaeological site, removing all traces of soil stratigraphy, leaving the artifacts behind on the surface, or all deposited in the same stratigraphic layer. Factors that can increase a site's vulnerability to wind erosion include loss of ground cover, as well as loss of trees that may have acted as a wind break, or new construction that can create a wind tunnel effect.

4.1.2 Water

As with erosion caused by wind, water can deposit sediments (alluvium or colluvium) on top of a site, or it can transport particles away from it. Factors that can increase a site's vulnerability to erosion include being located on a stream terrace or on a slope. Reduced or absent ground cover also increases a site's vulnerability to erosion; vegetation can absorb water and reduce the kinetic energy of raindrops, leaf litter can absorb water, and roots can hold soil together (MacDonald 1990). The range of particle sizes that will be carried away by water can depend on how consolidated the sediments are, and how much energy the water has. As an example of potential indirect impacts to archaeological sites, development that covers large areas with impermeable surfaces can increase the quantity and energy of storm water runoff, resulting in greater rates of erosion along streams and in gullies. As with wind erosion, reduction of ground cover on, or in the vicinity of an archaeological site makes it more vulnerable.

4.1.3 Fauna

Faunal impacts (faunalturbation) include impacts that are the result of activity of any animals (mammals, insects, worms, etc.). The most significant impacts are likely to come from burrowing mammals, but insects and worms can also have a significant impact on archaeological sites. Earthworms mix soil, which can cause a blurring of feature boundaries. Surface casting species can also bring fine-grained sediments to the surface, burying artifacts or features (Stein 1983). While bringing fine-grained sediments to the surface, earthworm activity can cause small stones or artifacts to fall in the soil profile, and accumulate in a so-called "stone zone" at the base of the biomantle (Van Nest 2002). Earthworms are an essential part of the ecosystem, so their activity isn't something a land managing agency would want to stop. But animals that might be regarded as pests may be another matter: termites or other insects that cause damage to wooden remains in archaeological sites, and certainly burrowing animals that may produce large-scale artifact displacement and feature destruction. Erlandson (1984) in studying rodent impacts to prehistoric sites in Southern Coastal California found evidence for artifact downward migration rates of 5% per century. That artifact migration is generally downward is reflected in the downward skewed vertical distribution of artifacts in faunalturbated soils (Morin 2006). Burrowing animals can turn over the upper 1 to 2 m of a soil column in a matter of decades (MacDonald 1990). Larger burrowing mammals, such as ground hogs (marmota monax) can bring quite large artifacts to the surface when digging their burrows. This was the case at the John Wesley Church and Cemetery site at Dover AFB, where groundhogs had brought human remains and pieces of coffin hardware to the surface (AMC 2004).

4.1.4 Flora

Root action can have a significant effect on archaeological deposits. Roots expand into voids in the soil, and then expand radially. While not displacing artifacts very far, this can cross-cut features. Roots can also grow into masonry walls, causing them to break apart. Even without causing damage that extensive, roots can leave marks on artifacts, masonry, or other site materials. However, the most significant damage from roots arguably comes in the case of tree-falls, where an entire root system is pulled out of the ground displacing archaeological materials vertically and horizontally (MacDonald 1990). Vegetation on sites can result in the inclusion of pollen or other ecofacts into site soil horizons. Site vegetation can help protect sites from wind or water erosion, and in some cases, can lead to increased sedimentation on a site by slowing down wind or water, allowing particles to drop and accumulate (Schiffer 1987).

4.1.5 Freezing and Thawing

Freezing and thawing cycles is a source of soil disturbance in northern latitudes and higher altitudes called cryoturbation. This action results in the upward thrust of artifacts in the soil column. In one laboratory experiment, a wooden peg moved up over 7 cm after 7 freeze thaw cycles (Schiffer 1987). Cryoturbation can also result in contorted stratigraphic patterns. There is some evidence that the presence of vegetation can provide insulation for soil, reducing the effects of cryoturbation (Peterson et al. 2003).

4.1.6 Gravity

Gravity related disturbance (graviturbation) refers to a family of processes, including mudslides, avalanches, as well as slower acting processes such as solifluction (the slow downslope movement of water saturated soils), gelifluction (which occurs in permafrost regions), and soil creep (the poorly understood, slow downward flow of soil, not clearly caused by water saturation, frost action, or other processes) (Schiffer 1987). As a result of graviturbation, archaeological site materials can slowly migrate downslope, compromising the site’s integrity. As with other forms of erosion or soil displacement, the presence of vegetation on a site will help slow or forestall the effects.

4.1.7 Swelling and Shrinking

Cycles of swelling and shrinking can mix archaeological deposits (argilliturbation) in soils with high clay content in areas with distinct dry and wet seasons. In the dry season, the clays shrink and crack, opening fissures into which small particles and artifacts may fall. When the soils are moistened, the clay expands, creating upward pressure that moves artifacts upward in the soil column (Schiffer 1987). The effect of argilliturbation on sites will be a gradual vertical mixing of stratigraphic layers, which will undermine the information potential of the site over time.

4.1.8 Fire

The effect of a forest fire on an archaeological site depends on a number of factors, including the intensity and duration of the fire, as well as the texture, depth and moisture content of the soil. Sites with above ground deposits, particularly those with organic artifacts or features may be more vulnerable to the effects of fire than buried sites consisting primarily of stable inorganic materials. Forest management studies involving soil temperature monitoring of fires of varying intensity and short duration have shown that artifacts buried as little as 5 cm below the surface have sustained little to no damage even during high intensity fires that can reach temperatures of up to 700° C. However, prolonged fires can affect deposits to depths of 10-15 cm below surface (Debano et al. 1998). High temperatures can not only combust organic material, but bring about thermal alterations to inorganic objects (Munson 2006). Bone, wood, and shell can be destroyed at temperatures above 300° C whereas ceramic, glass, and stone artifacts require much higher temperatures for total destruction. However, the archaeological value of inorganic artifacts can be diminished at lower temperatures in the form of melting, spalling, crazing, sooting, and discoloration (Debano et al. 1998). High heat and fire also can affect the accuracy of dating techniques such as radiometric dating, obsidian hydration, thermoluminescence, and dendrochronology while introducing modern ash and charcoal into archaeological contexts.

The protection of cultural resources is becoming integrated into fire management programs particularly in advance of prescribed or controlled burns where resources can be avoided or the effects mitigated if avoidance is not possible (Debano et al. 1998). Protection measures include prefire inventories or data recovery, minimizing or modifying fire suppression methods in and around cultural resources, creating fire breaks, and removing fuel load from site areas or around historical structures (Spoerl 1996). Archaeologists are increasingly involved in prefire planning, including the training of fire fighters in cultural site identification and in ways to avoid damage to sites. Archaeologists are in turn trained or fire-qualified to direct some fire suppression activities such as fire line excavation and heavy equipment movement in and around cultural sites (Debano et al. 1998). Land managers can also reduce the effects of wildfires by employing similar practices and planning in susceptible areas.

4.1.9 Summary

Table 2 summarizes the relationship between natural processes and potential adverse effects to archaeological sites.

Table 2: Natural Processes and Adverse Effects

	Natural							
	Wind	**Water**	**Fauna**	**Flora**	**Freezing/ Thawing**	**Gravity**	**Shrinking/ Swelling**	**Fire**
Loss of Historic Context	x	x		x				x
Deformation				x				
Compaction								
Dislocation/ Displacement	x	x	x	x	x	x	x	
Stratigraphic Mixing	x	x	x	x	x	x	x	
Loss of Volume	x	x						
Loss of Elements	x	x	x			x		
Collapse	x	x	x	x		x		
Sinking		x	x	x		x		
Contamination		x	x	x				
Mutilation			x					

Table 2: Natural Processes and Adverse Effects

	Natural							
	Wind	**Water**	**Fauna**	**Flora**	**Freezing/ Thawing**	**Gravity**	**Shrinking/ Swelling**	**Fire**
Salination/ Efflorescence		x						
Pulverization								
Fragmentation			x					
Fractures, Cracks				x				x
Dissolution		x						
Decolorization		x		x				x
Exfoliation				x				
Oxidation								x
Chemical		x						x
Superficial Spots or Alterations			x	x				x
Warping		x						x

4.2 Land Use, Land Cover and Man-Made Impacts

Man-made impacts include any effect to archaeological sites arising directly or indirectly from human activity. Military installations often represent large, extensive tracts of land that may include a variety of land use and landscape settings. In certain geographic studies, the term land cover describes the appearance of the landscape based on visible surface attributes: "the vegetational and artificial constructions covering the land surface" (Burley 1961). Anderson (et al. 1976), who developed the land cover scheme presented herein (Table 3), suggested broadly that land use data are important in understanding the environmental processes necessary for the maintenance of current living standards. This form of data is equally important to assessing potential impacts to archaeological resources. Implied in the categories of land cover are various uses to which the land is put. Each form of use can represent unique potential impacts to archaeological sites contained in them. Information about land use and land cover is available in the SDSFIE. Land Use entity types are shown in Table 4.

The U.S. Geological Survey (USGS) Land Cover Institute has developed a 21-class land cover classification scheme for use in its National Land Cover Dataset, developed in turn from Landsat Thematic Mapper satellite data (USGS LCI 2010). The classification scheme is based on a modification of the Anderson Land Cover Classification (Anderson et al. 1976), an early effort to standardize land cover and land use terminology.

The classification system is two-tiered (Table 3). Level 1 is a generalized classification that is for the most part adequate for addressing issues of archaeological site preservation and protection. Level 1 classes also correspond to land cover classes used in the Spatial Data Standards for Facilities, Infrastructure, and the Environment (SDSFIE), and so are readily available in a DoD installation GIS. Most of the additional detail in the Level II classification is not clearly relevant for preservation issues. The overall distinctions in this classification system are made largely on the basis of land cover attributes that can be identified in aerial photography. Thus, for example, cropland and pasturage are lumped together, since they cannot easily be distinguished in photographs. Other distinctions beyond those from aerial imagery may include such things as separating pasturage from rangeland on the basis of geographic region.

Table 3: Land Cover Classification from Anderson et al. (1976).

Level I	**Level II**
1 Urban or Built-up Land	11 Residential
	12 Commercial and Services
	13 Industrial
	14 Transportation, Communications, and Utilities
	15 Industrial and Commercial Complexes
	16 Mixed Urban or Built-up Land
	17 Other Urban or Built-up Land
2 Agricultural Land	21 Cropland and Pasture
	22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
	23 Confined Feeding Operations
	24 Other Agricultural Land
3 Rangeland	31 Herbaceous Rangeland
	32 Shrub and Brush Rangeland
	33 Mixed Rangeland
4 Forest Land	41 Deciduous Forest Land
	42 Evergreen Forest Land
	43 Mixed Forest Land
5 Water	51 Streams and Canals
	52 Lakes
	53 Reservoirs
	54 Bays and Estuaries
6 Wetland	61 Forested Wetland
	62 Nonforested Wetland
7 Barren Land	71 Dry Salt Flats.
	72 Beaches
	73 Sandy Areas other than Beaches
	74 Bare Exposed Rock
	75 Strip Mines Quarries, and Gravel Pits
	76 Transitional Areas
	77 Mixed Barren Land
8 Tundra	81 Shrub and Brush Tundra
	82 Herbaceous Tundra
	83 Bare Ground Tundra
	84 Wet Tundra
	85 Mixed Tundra
9 Perennial Snow or Ice	91 Perennial Snowfields
	92 Glaciers

Of the nine Level 1 categories above, five are the most relevant for terrestrial archaeological site preservation issues on most DoD installations, although none focuses specifically on military land use: Urban or Built-up Land, Agricultural Land, Rangeland, Forest Land, Wetland, and Barren Land.

Table 4: Land Use (From SDSFIE 2.6 domain table d_paruse)

Class	**Description**
Administration	Administration, governmental, headquarters, HQ, school, troop support
Agriculture	Agricultural field, crop production, farming, crops, farming, grazing, farming, nuts farming, orchard fruit, farming, vineyard, grazing area, pasture
Airfield/aircraft	Airfield pavement, aircraft operations and maintenance, civil aeroplane airport, civil heliport, emergency airfield, flight line/research-development-testing-evaluation, flyway, heliport, military aeroplane airport, military heliport, noise/overflight, small planes airfield, space port.
Buffer/Restricted Area	Airfield clearance, open space/buffer zone
Community	Community commercial, community facility, community service, commercial services
Forest	Forest, timber
Housing	bachelor enlisted quarters, bachelor officer quarters, enlisted barracks, family housing, housing accompanied, housing unaccompanied, Mobile Home, residence, other, residence, primary, troop housing, visiting officers quarters
Infrastructure	Ammunition storage, flowage easement, fuels area, glider airfield, hay production area, levee, maintenance, manufacturing and production, medical/dental, railroad, road, sanitation, supply/storage, utilities corridor, utility
Land Restoration	Land restoration
Mining	Mining
Mission	Electronic combat ground test, munitions/explosive safety hazard zone, instrumentation/communication, operations, range, test range, training
R&D	Research, development, testing, and evaluation
Recreation	Hunting area, outdoor recreation, recreation center, recreational

Because categories of Land Use and Land Cover overlap in many ways, we combined them in the following discussion. Combining land use and land cover categories based on similar potential impacts to archaeological sites yields the following categories:

- Mission and Training Areas
- Remediation/UXO

- Recreation Areas
- Urban, Built-up Land
- Agricultural Land
- Rangeland
- Forest Land
- Barren Land

In addition to these categories, this section will consider the effects of vandalism and looting.

4.2.1 Mission Areas and Training

Training is essential to maintaining the military mission, and sustainable ranges that "provide contiguous, unencumbered space to replicate, as closely as possible, the operational environment of an assigned mission" are among the DoD's most valuable assets (Sustainable Range Report 2010). A military range is:

> A designated land or water area set aside, managed and used to conduct research on, develop, test, and evaluate military munitions and explosives, other ordnance, or weapon systems, or to train military personnel in their use and handling. Ranges include firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas. The definition of a military range does not include airspace used for training, testing, or research and development where military munitions have not been used.
> 40 CFR 266.201

Training ranges provide space for basic training, advanced training in weapons systems, "provide realistic environments needed for the development of tactical operational and strategic concepts, and tactics, techniques, and procedures [and] support the testing, evaluation, and improvement of system maneuverability, reliability, and effectiveness in the range environment outside of the laboratory or development facility" (SRI 2010). The military need for training land is substantial. According to the 2010 Report to Congress on Sustainable Ranges, the Army has 7 million acres devoted to training, compared to a projected need of 12 million acres. Training in the military encompasses a wide range of activities, including virtual and simulated training. But a substantial amount of training includes live training, "where the training audience operates their operational systems and platforms (including their full range of mobility and capability) in the physical environment for which they were intended." The support of sustainable live training that is a concern for cultural resources management since cultural resources are sometimes seen as an encroachment on acreage available for training, and because certain training activities can have an adverse effect on archaeological sites. Proper management of both can reduce the extent to which archaeological sites encroach on training lands, or to which training impacts sites. In some cases, as at Fort Drum, archaeological sites have successfully been hardened for their protection and converted into training assets, resulting in a win-win for training and preservation (Wagner et al. 2007). That archaeological sites can be used as training assets is particularly important not only because training lands are scarce and valuable assets in the United States, but because many areas around the world where U.S. forces are deployed contain numerous culturally and politically sensitive resources. It is therefore important that U.S. troops in training for service overseas become familiar with how to conduct their mission successfully in such environments.

Vehicle

DoD Legacy Program Project 09-435 explores the impact of military vehicles on archaeological sites in detail. The following is a brief summary of those impacts excerpted from that study. The impacts that military vehicles have on cultural resources in training landscapes is clearly central to this study. Vehicle traffic at any frequency is viewed by some as always harmful to archaeological sites (Sampson 2007), although the point at which vehicle damage becomes sufficient to cause loss of site significance is an issue that is not well explored. Some vehicle damage can prove subtle and lead to loss of information potential from an archaeological site, which could affect determinations of eligibility. For example, vehicle traffic can impede the ability to conduct geophysical prospecting by “clouding” sites with additional data or “noise” unrelated to the archaeological deposits of interest (Archaeo-physics 2009; Somers et al. 2004; Zeidler et al. 2004). To better understand how military vehicles might affect cultural resources, it is important to examine existing research on the interaction between military vehicles and training landscapes.

Terramechanics is a specialized branch of research that focuses on the interaction between the terrain and wheeled or tracked vehicles, especially on the ability of a section of terrain to support mobility, referred to as its trafficability (Muro 2004:ix, 1). Numerous environmental studies present analyses of direct and indirect impacts of military vehicles on the natural landscape. While few additional studies focus on impacts to archaeological sites, the effects described on the natural environment are comparable or directly related. Military vehicle training can lead to reduced plant cover, for example, exposing large areas of soil and increasing susceptibility to erosion (Quist et al. 2003). The impact of military training vehicles on biological communities, especially vegetation, can be significant for archaeological preservation if a threshold is reached beyond which the damage becomes too great for the original plant communities to recover (Althoff et al. 2007; Anderson et al. 2005; Demarais et al. 1999:386; Kade and Warren 2002; Lathrop 1983). Plants reduce the degree to which rain impacts soils, decrease runoff by increasing surface roughness, and their roots help bind soils, decreasing erosion (Fuchs et al. 2003:346). Dense surface vegetation also minimizes the impact military vehicles have on natural—and cultural—landscapes. Consequently, sufficient vegetation cover can provide protection to cultural remains located at or near the surface while enhancing ranges for training purposes.

Impacts from military training may prove incremental rather than catastrophic and is often cumulative (Althoff and Thien 2005; Carlson and Briuer 1986). Military vehicles do not operate individually during training—formations that consist of multiple columns, for example, which may pass over an area more than once, will cause greater damage than more laterally dispersed vehicles (Affleck 2005; Herl et al. 2005).

Military vehicles operate on training landscapes distributed across a variety of environments and at different times of the year. Seasonality and landscape characteristics together can influence the degree to which wheeled or tracked military vehicles impact a given training facility (Affleck

2005; Anderson et al. 2005a). Soil moisture content, strength, and type influence how much the environment is affected by military vehicle traffic (Affleck 2005:ii, 6; Bacon et al. 2008:169; Department of the Army 1994). Military vehicles driven over wet soils tend to more adversely impact a landscape than vehicles driven over dry soils (Anderson et al. 2005b:215; see also Department of the Army 1994:7-27).

Vehicles moving across the landscape affect more than the stability, structure, and viability of plant and animal communities. Soil deformation and displacement, especially in the form of rutting, are significant and highly visible consequences of military vehicle training activities (Affleck 2005:ii) and can have a direct impact on archaeological sites. Movement of vehicles across the landscape can disaggregate soil and decrease micro-topographic variation by smoothing slopes, with both processes leading to sediment loss (e.g. erosion) and decreased plant development (Affleck 2005:1; Brooks and Lair 2005:7; Diersing et al. 1988; Iverson et al. 1981:916; Sampson 2007). Damage caused by vehicle movements extend beyond the ruts themselves. Surface water flow is concentrated by ruts, depending on their orientation, slope, soils, and position on the landscape, and these ruts can increase erosion (Halvorson et al. 2001:143).

Not all damage caused by military vehicle movements produces visible evidence on the landscape. Military vehicles can cause significant soil compaction even if there are no other obvious traces of military training activities (Raper 2005:262). Soil compaction results when vehicles reduce the volume of air in the soil, pushing the mineral components together (Affleck 2005:4; Dregne 1983; Palazzo et al. 2005:178; Raper 2005:259; Sojka 1999; Stokowski and LaPointe 2000:3; Webb 1983:62). Soil compaction slows water infiltration, and this can lead to changes in soil chemistry, organic content, and hydrology, as well as increased runoff and erosion (Althoff et al. 2007:269; Belnap and Warren 2002:251; BLM 2003:3; Fuchs et al. 2003:343; Garten et al. 2003:172). Soil compaction can also lead to the collapse of animal burrows (Davenport and Switalski 2006), which might cause the downward movement of cultural objects in strata above the burrows.

Infantry

Direct, non-vehicle training impacts to archaeological sites can occur in the form of trampling, hand excavation of defensive positions, and unauthorized collection of artifacts. Trampling as a result of foot traffic by humans or animals can lead to lateral and vertical displacement of cultural objects. Artifacts may move up or down in response to trampling with substantial movement particularly evident in loose, sandy soil (Gifford-Gonzales et al. 1984). The migration of artifacts downward ceases when a compacted soil layer is reached (Nielsen 1991). Compacted layers may themselves result from trampling (Weaver and Dale 1978)—foot traffic from military training created significant compaction in the upper six centimeters of soil after two years of training at sites on the U.S. Air Force Academy (Whitecotton et al. 2000:697). Early studies of vertical displacement as a result of trampling documented the dispersal of artifacts up to a meter deep and across two or more strata with no evidence of the movement reflected in soil profiles (Gifford-Gonzales et al. 1984). Trampling may lead to size sorting of artifacts with larger artifacts moving to positions higher in a soil profile than smaller fragments (Blackham 2000; Gifford-Gonzales et al. 1984).

Lateral displacement of cultural objects is not as well studied as vertical movement, but it has been noted that trampling will displace larger objects laterally within the trafficked area, blurring horizontal patterns (Nielsen 1991).

In addition to moving cultural objects within soil deposits, trampling can result in damage to artifacts that mirror cultural behaviors. Unmodified animal bones may become abraded, creating apparent cut marks, while chipped stone flakes can exhibit edge damage indistinguishable from deliberate retouch or use (Behrensmeyer et al. 1986; McBrearty et al. 1998).

Other impacts could arise from development preparatory to using a training range, such as fences, signage, and access roads or landing areas. Indirect impacts arising from non-vehicle training could also result from changes to local topography or ground cover that could then result in erosion or other changes to a site. Whitecotton et al. (2000), in their work on the effects of foot traffic on soils at the Air Force Academy found that " training use appears to adversely affect bulk density, infiltration, total aboveground biomass, litter, and erosion." Foot traffic, camping, and small scale hand excavation can all damage sites, or expose them to erosion.

Much has also been learned about the potential impacts of infantry operations on archaeological sites from U.S. deployment in Iraq and Afghanistan where archaeological sites are numerous and politically and culturally sensitive. The Center for Environmental Management of Military Lands (CEMML) and the Fort Drum Cultural Resources Management Program have summarized much of these lessons learned (see US DoD CENTCOM nd: http://www.cemml.colostate.edu/cultural/09476/iraqstart.html). Recommendations related to bedding down activities may be applicable to training lands. For example, avoid digging unnecessary trenches in archaeologically sensitive areas, and use HESCO barriers instead. When filling HESCO barriers or sand bags, avoid digging in archaeologically sensitive areas (U.S. DoD CENTCOM nd). The CEMML website also notes that locations infantry troops stationed overseas find to be strategic may have been found strategic many times before, and thus harbor ancient remains. The same may be true on training lands in the United States as well.

Air Assault/Airborne Training

Air Assault training involves the deployment of troops using vertical take-off and landing aircraft such as helicopters. The powerful winds generated by helicopter rotor wash have the potential to adversely affect archaeological sites by displacing sediment at the surface. This is particularly true of shallow sites, and sites with little or no ground cover. Sites with above ground features (masonry, rock art) can also be damaged by the scouring effects of windblown particles. Airborne training for military parachutists can be expected to have smaller impacts to archaeological sites. However, activities associated with drop zones would likely have similar effects to archaeological sites as mechanized or infantry training, including ground compaction and displacement, and artifact trampling. Secondary effects from such training could arise if vegetation loss exposes nearby archaeological sites to changes in erosion patterns.

Bombing/Firing Range

Ordnance and firing ranges provide critical resources for weapons development and training. However, as a result of this critical mission activity, “DoD has estimated that millions of acres of training ranges in the United States and its territories are contaminated with unexploded ordnance that could potentially harm the public and the environment if not properly managed or cleaned up (GAO 2001 pg 4).” The response to this “may include unexploded ordnance (UXO) clearance, range remediation to address other constituents, posting range warning signs, erecting fences or alternative measures to control access, and other effective engineering, institutional, and exposure controls” Teachman, G. and Getlein, S. (2002).

The potential direct impact to cultural resources from ordnance training is obvious, but new ranges would be subject to Section 106 consultation that would protect sites before the training began. However, some ranges with archaeological sites have been used as firing ranges in the past, and may have unexploded ordnance or other forms of contamination. While new ranges will be subject to Section 106 consultation, a question remains about how to handle archaeological sites on older ranges, considered unsafe to survey. In some cases, existing ranges are excluded from survey requirements for Section 106 purposes (Fort Dix, for example). In other cases, (Vandenburg AFB), pedestrian survey is permitted, but subsurface excavation locations must be cleared by EOD specialists first. In other cases, cleanup operations are conducted by UXO specialists, but archaeologists are available on-call to record and evaluate archaeological finds as needed once physical danger has been eliminated (e.g., Formerly Used Defense Sites (FUDS) like the Former Nansemond Ordnance Disposal Site (FNOD)). In cases where UXO teams have cleared a FUDS for ordnance, the “clearance” is typically only to a certain depth, based on the anticipated future use of the area, which could be anything from the depth of proposed construction plus 4 feet for new construction, to less than a foot for areas intended to remain undeveloped with limited public access (Poirier and Feder 2001). Thus, ordnance may still exist at deeper levels. While the persistence of ordnance or other contaminants may pose a safety risk to archaeologists, their effects on archaeological deposits is unclear, though it is conceivable that chemical contamination of archaeological remains may alter them in significant ways.

4.2.2 Remediation

The use of military lands for training and other mission-related activities in some instances have resulted in the presence of various contaminants and hazardous materials in the ground. Remediation activities in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) on DoD lands is carried out under the Defense Environmental Restoration Program (DERP), established by Section 211 of the Superfund Amendments and Reauthorization Act (SARA) of 1986. The goals of DERP include:

> (1) The identification, investigation, research and development, and cleanup of contamination from hazardous substances, and pollutants and contaminants.
> (2) Correction of other environmental damage (such as detection and disposal of unexploded ordnance) which creates an imminent and substantial endangerment to the public health or welfare or to the environment.

> (3) Demolition and removal of unsafe buildings and structures, including buildings and structures of the Department of Defense at sites formerly used by or under the jurisdiction of the Secretary
> 10 USC §2701(b)

Remedial actions may include removal of soil, which could have an effect on archaeological sites if archaeological site soils have become contaminated. Remediation activities carried out on DoD lands is subject to Section 106 of the NHPA. According to the 2010 Annual Report to Congress the restoration program had over 34,000 restoration sites, and had "achieved remedy in place / response complete status at 86 percent of its Installation Restoration Program (IRP) sites on active installations and at 87 percent of IRP sites on Legacy BRAC and BRAC 2005 installations" (Fiscal Year 2010 Defense Environmental Programs Annual Report to Congress).

4.2.3 Recreation

Morale, Welfare, and Recreation programs (MWRs) are intended to provide free and low-cost recreational opportunities for DoD personnel and their families on DoD lands. Recreation on military lands includes the use of developed recreational facilities such as sports fields, golf courses, and marinas, as well as backcountry activities such as hiking, horseback riding, biking and camping (Family and Morale, Welfare & Recreation Command's Fiscal Year 2009 Annual Report; MCCS 2011). Hunting and fishing is also permitted on many DoD installations. Some of these activities, particularly backcountry activities, may bring visitors into contact with archaeological sites. For example, there are maintained hiking trails and picnic areas in the vicinity of the Garden Canyon Petroglyphs on Fort Huachuca, Arizona (DoD Legacy 2003). Activities that bring uninformed visitors on or near unmarked archaeological sites may expose those sites to intentional or unintentional impacts. Such impacts could include erosion or trampling related to walking trails, camping, littering, displacement of artifacts or feature components, and minor ground disturbance.

There is also the potential for impacts from recreational use of off-road vehicles (ORV). Recreational ORV use is a major contributor to erosion on archaeological sites, particularly in the western United States, and has parallels to the impacts caused by military training vehicles. ORVs can lead to loss of soils and the vegetation that helps bind soils. They can create scars on the landscape up to 4.7 meters wide and 1.42 meters deep that promote further erosion, they can break or crush artifacts, and they can enhance visibility of archaeological remains and thus their attractiveness to looters and collectors (BLM 2003:30; Sampson 2007; Sowl and Poetter 2004:12).

The most significant potential impact from recreation activities to archaeological sites will come from outdoor recreation. Areas designated for outdoor recreation should be designated on the Installation Master Plan. The use of these areas should be considered when developing an installation's ICRMP so that potential effects to archaeological sites can be considered. UFC 3-210-03A, Planning of Outdoor Recreation Areas, lists archaeological sites as a potential constraint on the development and use of an area for recreation, along with threatened and endangered species and a variety of other environmental concerns. However, with proper planning and mitigation, archaeological sites have the potential to contribute to recreational programs by presenting educational opportunities. Developing significant sites for interpretation in MWR areas may help prevent impacts to those sites and may raise awareness about the sensitivity of unmarked sites elsewhere.

4.2.4 Urban or Built-up Land

Urban or built-up land is a land cover type that may overlap with SDSFIE land use Categories such as:

- Administration
- Airfield/Aircraft
- Community
- Housing
- Infrastructure
- Mining

Urban or Built-up Land is described briefly in the Anderson classification as areas of intensive use with much of the land covered by structures. This type of land cover is common on DoD properties. In some cases, land having less intensive use (also referred to as nonconforming use) may be located in the midst of Urban or Built-up areas and will generally be included in this category. These typically small, undeveloped or partially developed patches of ground may or may not be referred to as Mixed Urban or Built-up Land, a catch-all category describing areas that cannot be mapped individually as residential, commercial or industrial. In general, the principal threat to archaeological sites in developed areas is from further development. On DoD installations, however, such projects fall under the provisions of Section 106 of the NHPA, which requires cultural resource review prior to specific development projects, referred to as undertakings.

In some cases, archaeological sites that have survived in developed portions of installations may be better protected than sites in other settings because of Section 106 review for undertakings. Additionally, although development may bring more people into contact with a site, high visibility could deter unauthorized collecting or vandalism. Yet, impacts related to existing development may occur over a wider area than the development itself and thus may affect sites in adjacent undeveloped spaces. Some of the most prominent effects of this process include erosion and other changes in groundwater and run-off patterns. Wolman and Schick (1967), for example, reported the tripling of sediment yield across an entire watershed in which agricultural land was developed for urban use, suggesting the degree to which erosion may extend beyond the formal limit of disturbance of a specific development project.

Another threat to archaeological sites in developed areas resulting from site exposure and ease of access is related to inadvertent or unintentional impacts, such as walking on earthwork features. While an urban location on a military reservation, if in a high-traffic area, could provide enough prominence or visibility to discourage intentional acts of vandalism, a high volume of foot traffic can cause trampling of a site, or prompt incidental collection of surface finds by people unaware of the preservation issues involved. On the other hand, such a setting may provide an opportunity for educating installation personnel about historic preservation issues, as well as about the history of the installation. Sites in developed areas may also be reasonably well protected from erosion or from floral or faunal disturbance by landscaping controls, if landscaping is aimed at long-term stabilization rather than merely at appearance.

4.2.5 Agricultural Land

Agricultural land is a land cover type that may overlap with SDSFIE land use Categories such as:

- Agriculture
- Buffer/Restricted Area
- Mission
- Recreation

Military lands often encompass former agricultural fields or include lands leased for farming. Archaeological sites commonly occur in agricultural fields, and thus understanding the archaeological research potential of tilled ground is important for ongoing site preservation efforts. The Anderson classification system broadly defines agricultural land as that used primarily for production of food and fiber. Included in the secondary level of this category are cropland, pasturage, orchards, and feed lots. Archaeological sites occurring in agricultural cropland and orchards are mostly at risk from the effects of ground preparation such as plowing. Unless an area is being converted into agricultural use for the first time (in which case Section 106 would apply), it has likely been plowed for an extended period of time. Investigations into the effects of plowing to archaeological sites have been conducted since the 1980s. Briefly, studies have noted two main consequences: 1) damage to artifacts; and 2) dislocation, or what some researchers refer to as transfer and removal, or transportation (Wildesen 1982). In both cases—damage and dislocation—the effects of the processes to site significance overall have been found to be less severe than might be assumed. Except for fragile materials, such as ceramic, glass or bone, direct damage to artifacts from plowing is generally minimal. While fragmentation of bone can make useful identification of individual pieces impossible (Lyman and O'Brien 1987), artifact damage overall is considered less of a factor in data loss than dislocation (DeBloois et al. 1978; Gallagher 1979; Wildesen 1982).

Studies indicate that plowing is indeed destructive to detailed archaeological patterns in sediment deposits lying within reach of plowing, typically the upper 20 to 40 centimeters of an agricultural field. Lateral movement of artifacts is variable. Although distances as great as 100 meters have been documented, the average horizontal displacement appears to be approximately two meters (Navazo and Diez 2008; Odell and Cowan 1987; Roper 1976). Such movement can lead to an expansion of site boundaries to twice the original size of a site, and a corresponding decrease in overall density across the site (Navazo and Diez 2008; Odell and Cowan 1987). Nevertheless, large-scale site structure is often maintained. Moreover, a degree of stability in the spreading of artifacts may in fact be attained after a period of time due to the often patterned nature of plowing (Carr 2008; King 2004; Lewarch and O'Brien 1981; MacManamon 1984; Mallouf 1982). Other studies have argued that artificial clustering of artifacts may result from continued long-term tillage (Odell and Cowan 1987). Soil type can influence the extent to which cultural objects are affected by plowing. Clayey soils may tend to clump more than sandy soils, and artifacts may aggregate within or adhere to clays and move farther than they would in non-clayey soils. Artifacts may also encounter enhanced static stresses and compacted soil ahead of a plow blade, which can increase rates of breakage (Mallouff 1982). The consensus view, though, is that continued plowing is unlikely to produce substantial, new adverse effects to already plowed archaeological sites.

Archaeological sites in agricultural fields may be at risk in other ways. Artifacts—and in particular, large artifacts—that are brought to the surface by plowing may become highly visible and thus are more likely to be collected (Baker 1978). Continued plowing may also cut into undisturbed deposits if deeper plowing is undertaken for some reason—for example, root plowing to remove scrubby vegetation from fallow fields; or deep plowing to break up a plow pan (a compacted layer the can develop from compression due to repeated tillage [Haglund et al. 2002; TAMU n.d.]). Long-term erosion of an agricultural field may also effectively lower surface elevation and allow standard plowing to extend into underlying soils. One estimate suggests that in a level field, soil may be lost from an active agricultural field through erosion at a rate of 2-10 tons per acre per year (MacDonald 1990:12). Each ton of soil lost represents an average lowering of ground surface by 0.15 mm, and thus, 10 tons over a 100-year period would represent a loss of 150 mm (1.5 cm or 0.6 in). While the amount appears trivial, the process may be greatly intensified on sloped ground—even a nominal slope of 3-percent results in a calculated loss of ground surface elevation of 20 cm (7.9 in) over the same period (MacDonald 1990:20).

Other direct effects of agriculture might include the clearing of new or long-fallow fields through the use of destructive techniques such as chaining, grubbing, or bulldozing. Changes in soil chemistry may also occur in association with cultivation. Fertilizers or pesticides added to farmland may alter geochemistry, raising or lowering pH, for example, which could affect the preservation of certain artifacts, particularly those made of iron (Gerwin and Baumhauer 2000; Kars 1998; Means 2002; Williams and Corfield 2002). Fertilizers typically consist of compounds rich in oxygen, nitrogen and phosphorous, and thus they may promote bacterial growth that can be detrimental to organic remains. The chemical composition of archaeological bone, which may reflect aspects of historic or prehistoric diet or overall health, may be affected by pesticides masking potentially significant information (Haglund et al. 2002; Lillie and Smith 2007). Changes in crop selection may also result in impacts on soil chemistry or soil drainage, further affecting buried archaeological remains.

The Anderson land cover classification includes pasturage in the Agricultural Land category. The potential risks to archaeological sites in pastures are similar to those for sites in rangeland, and are discussed in the following section.

4.2.6 Rangeland

Rangeland land cover may overlap with SDSFIE land use Categories such as:

- Agriculture
- Mining
- Mission
- Buffer/Restricted Area
- Recreation

Rangeland is common on military installations, and potential impacts to archaeological sites contained in this land type are of concern to ongoing preservation efforts. Rangeland occurs mostly in the Western U.S. and is defined as land where natural vegetation consists predominantly of grasses, grass-like plants, sedges, forbs, or shrubs. Archaeological sites in rangeland that are most at risk are those in surface or near-surface contexts, where they may be subject to grazing and trampling. Beyond obvious effects related to breakage of fragile artifacts, MacDonald (1990) notes that the hooves of cattle may break up exposed sediments at ground surface thereby aggravating erosion. In addition, grazing livestock tend to walk along paths that they establish across a range, and in so doing they may alter drainage patterns in a variety of ways, even generating a terracing effect on sloped ground (Higgins 1979; Rich and Reynolds 1963; Walsh et al. 2001). Repeated traffic may also produce a compacted layer below ground surface that mimics a buried archaeological surface (Nielsen 1991; Weaver and Dale 1978; Whitecotton et al. 2000). And finally, the obvious effects of trampling may include displacement or breakage of artifacts at the surface of a site (Blackham 2000; Gifford-Gonzales et al. 1984; Osborn and Hartley 1991).

Poorly managed rangeland, and in particular rangeland that is allowed to be overgrazed, can become vulnerable to erosion through the mechanisms detailed above: reduced vegetation cover, soil compaction, and terracing. In instances of intensive grazing, animal waste could change soil chemistry on sites, obscuring past locations of animal husbandry or other activity that might otherwise be identifiable through geochemical analysis.

However, if not overgrazed, rangeland may in fact offer protection from erosion to archaeological sites, since the effects of erosion are markedly diminished by the presence of ground cover that stabilizes surface sediments. Using a Universal Soil Loss Equation developed by Wischmeier and Smith (1978), MacDonald (1990:20-21) estimated soil loss, expressed as change in surface elevation over the course of 100 years, for several landcover/slope combinations. Notably, groundcover offers good protection from erosion, while the effects of erosion are intensified by slope. For bare, exposed soil:

- at 3-percent slope, ground surface elevation would be lowered 20 cm (7.9 in) over the course of 100 years,
- at 14-percent slope, elevation would be lowered 170 cm (67 in) over 100 years.

In comparison, calculated losses from surfaces with some form of extensive ground cover would be almost negligible . For a fallow meadow that had recently been plowed and exhibited 80 percent grass cover:

- at 3-percent slope, elevation would be lowered 0.013 cm (0.005 in) in 100 years,
- at 14-percent slope, elevation would be lowered 1.6 cm (0.6 in) in 100 years.
- for a typical undisturbed forest area with 70 percent overhead canopy and 85 percent ground cover, including herbaceous plants and forest duff:
- at 3-percent slope, elevation would be lowered 0.04 cm (0.0016 in) in 100 years,
- at 14-percent slope, elevation would be lowered 0.35 cm (0.14 in) in 100 years.

In a final observation, archaeological sites in rangeland overlain by grass cover would not be subject to the degree of root disturbance common in forested areas (discussed below). Nevertheless, depending on the regional plant communities present, shrubs and other scrubby vegetation could result in some root disturbance to near-surface archaeological remains.

4.2.7 Forest Land

Forest land may overlap with SDSFIE land use categories such as:

- Forest
- Mining
- Mission
- Buffer/Restricted Area
- Recreation

Military installations, especially when located far from urbanized areas, often include tracts of forested land. As indicated in the analysis above, archaeological sites in forested areas may be protected to a large extent from the effects of erosion. On uncovered ground, erosion is often initiated by raindrops directly striking surface sediments, loosening and scattering them so that they are more easily transported by water moving across the ground surface. In forests, rain is filtered by leaves and branches and thus does not directly contact surface sediments—in formal terms, the kinetic energy of the rain is intercepted and dissipated (MacDonald 1990). Further, the forest leaf mat or duff retains water, thereby slowing run-off, while the decomposing vegetation generates organic-rich soils that are loose and have a high infiltration capacity (water soaks in easily rather than running off). Roots may also both promote drainage by loosening the soil and add cohesion to the sediments.

While the forest canopy and ground cover may protect archaeological sites from many of the effects of erosion, sites in forest land can be damaged by root action, tree falls, fires, and logging-related activity. When a tree falls, its roots may pull sediments and artifacts adhering to them to the surface, exposing the soils to erosive forces and effectively mixing stratigraphy in the immediate area. Over time, artifacts can be cycled through the soil column by a succession of falls (Schiffer 1987). Root growth can also disturb sites by displacing artifacts and stratigraphy directly or by breaking apart masonry and other features. While these effects are generally confined to the first two feet of the soil column, trees with deep root taps can similarly displace deeply buried archaeological remains (NRCS 2006). While tree roots may loosen soils promoting drainage, they can have a variety of other effects, such as localized desiccation, which may enhance erosion. Roots also secrete humic acid, as does the decomposition of leaf litter, which can damage bone and other organic materials (Schiffer 1987). Leaf litter, on the other hand, may have a beneficial effect by obscuring sites, particularly if there are obvious features present, and thus may offer some protection from unauthorized collection or vandalism.

Military lands may also include timber plantations, where trees are planted, grown, and harvested for wood products. Logging or timber harvests can introduce a variety of impacts onto the archaeological landscape. Heavy vehicles may drive over or near archaeological sites creating rut and compaction impacts, or creating opportunities for erosion. Once trees are cut down, the stumps may be pulled out of the ground, resulting in further disturbance to sites. Munson (2006) described a situation in which chaining to uproot trees planted less than 15 meters apart, disturbed an entire area to a minimum depth of 50 centimeters. Severe impacts to archaeological sites can also be associated with scarification of soil for replanting trees, high lead logging and rubber tired tractor log yarding, log skidding on skid trails, construction of access roads, and prescribed burns (Munson 2006).

4.2.8 Barren Land

Barren land may overlap with SDSFIE land use categories such as:

- Mining
- Mission
- Buffer/Restricted Area
- Recreation

Also in the western U.S., extensive tracts of undeveloped and largely un-vegetated land may be present on military installations. The Anderson classification defines this form of land cover as Barren Land, described as having limited ability to support life and exhibiting vegetation or ground cover on less than one-third of a given area. Soils are typically thin and rocky, and such vegetation as is present tends to be widely distributed and scrubby. Archaeological sites in barren land are likely to be in surface or shallow, near-surface contexts, and so may be highly vulnerable to erosion. Surface sites may also be exposed to pedestrian trampling or vehicle impacts, discussed under 4.2.1 Training and 4.2.3 Recreation. Surface visibility in barren lands is frequently high, and archaeological sites can be visible and easily recognized. Being conspicuous in this manner can leave the sites vulnerable to unauthorized collecting or vandalism. Depending on location, barren lands may be isolated, in which case they are less likely to suffer from casual vandalism. However, their remoteness and inaccessibility may render consistent monitoring difficult, providing an opportunity for concerted, large-scale looting.

Some DoD lands may be used for mining and resource extraction: DoDI 4165.70 specifies that "DoD property holdings shall be made available for mineral exploration and extraction to the maximum extent consistent with military operations, national defense activities, environmental conservation and protection, and Army civil works activities" (DoDI 4165.70 6.14.1). Mining or ore extraction is a type of land use that is not directly encompassed by the Level 1 land cover categories in Table 3. Certain types of mining operation—strip mines, quarries, gravel pits—may be included as a Level 2 subcategory of Barren Land since the areas do not support vegetation. If mining areas are classed as such, it is usually done on a temporary basis "until other cover or use has been established" (Anderson et al. 1976:31). In some instances, mines are included as a Level 2 subcategory of Urban or Built-up Land, particularly if there are substantial surface structures associated with the activity.

In addition to potential impacts from construction of buildings or related infrastructure, the primary risk to archaeological sites from mining would be from surface excavation and the often substantial effects of surface erosion to both the immediate and the surrounding areas. As with other forms of construction activity, effects likely would be direct if present and would be resolved through Section 106 consultation on a project-by-project basis. Strategies for compatible use (as in grazing or training around archaeological sites) would likely not be applicable.

4.3 Illegal Activity

Illegal activity here comprises looting and vandalism of archaeological sites on federal land in violation of the Archaeological Resources Protection Act (ARPA). Such violations are a serious and growing problem. The most recent Secretary of the Interior's report to Congress describes "3,143 documented incidents of looting and vandalism of archeological resources on federal lands between 2004 and 2007, an average of 785 incidents per year", and that "the number of documented violations reported annually has increased over the period of data collection, from 438 in 1985 to 601 in 2007" (Departmental Consulting Archeologist 2010a).

4.3.1 Vandalism

Vandalism, the deliberate, willful damage or destruction of property, is a significant problem on archaeological sites. There are hundreds of archaeological sites intentionally damaged each year in the Unites States. Arizona volunteer site monitors recorded more than one hundred incidents in 2009-10 (*The Arizona Republic* Oct. 3, 2010). Incidents include graffiti or other kinds of defacing of archaeological features or components, setting fire to historical buildings, or mutilation of artifacts and features. Damaging or defacing an archaeological site is a violation of ARPA.

The problem encompasses a wide range of behaviors. A 1978 survey of cultural resources vandalism incidents on federal land (Williams, quoted in Nickens 1993) noted the following activities:

a. Excavation (digging, pothunting, and use of heavy machinery).
b. Carving, scratching, chipping, and general defacement.
c. Surface collection of artifacts (especially lithic artifacts).
d. Removing, shooting at, painting, chalking, and making casts and tracings of rock art.
e. Theft of artifacts from structures.
f. Stripping weathered boards or other timbers.
g. Removing part or all of a structure or causing structural damage.
h. Dismantling; general destruction of structure (but apparently no removal).
i. Arson.
j. Climbing or walking on resources.
k. Building new roads over and using modern vehicles on historic roads; off-road recreational use.
l. Rearrangement of or relocating of resources.
m. Breaking of artifacts, objects, and windows.
n. Knocking structures over.
o. Use as firewood.
p. Throwing rocks into excavated ruin.
q. Handling and touching.

The motives behind acts of vandalism are equally diverse. Nickens (1993) reviews the reasons a person might commit an act of vandalism, and then discusses which of those behaviors might be modified by different kinds of signage, following the work of Gramann and Vander Stoep (1987). Nickens notes that vandalism is typically goal oriented, not random or senseless, and that the problem is very complex. Citing a study by Knopf and Dustin (1992), Nickens (1993 pg 6) notes that:

a. The propensity to vandalize is more widely distributed throughout society than commonly thought. No socioeconomic or ethnic group is immune to vandalism tendencies.
b. Motives for vandalism are largely goal directed, neither meaningless nor senseless.
c. Motives for vandalism are complex and diverse.
d. Different people engaging in the same kinds of vandalism can be searching for different kinds of psychological results.
e. Vandalism is generally directed more toward public property than private property.

Nickens (1993 pg 6) further notes that:

> The attraction to public property appears to be associated with several factors: (a) diffusion of ownership and the consequent diffusion of guilt since clear owners cannot be identified; (b) a lower probability of being apprehended; (c) the obvious symbol as a societal or cultural good--a symbol against which statements can be made; (d) a sense that vandalism of public property is expected, even built in the budget; and (e) belief that "someone else" will have to bear the costs of restitution rather than an immediately recognizable party.

Research into the causes of depreciative behavior have identified distinct types of behavior with different motivations (Nickens 1993, pg 10-12; Gramann and Vander Stoep 1987; Nickens 1993).

- Unintentional Violations – This category includes accidental damage done to historic properties by visitors unaware that a site is present, or without realizing their actions can affect a site.
- Releaser-Cue Violations – These occur when signs of previous illegal activity prompt a visitor to engage in activity they would not otherwise do, thinking for example, that signs of past collecting at a site indicate that such behavior is tolerated if not legal, or that they will not get caught.
- Uninformed Violations – This may include small scale collection of artifacts from a site by people uninformed that such collection is prohibited and that it is damaging to the archaeological record.
- Responsibility Denial Violations – This describes actions by people who realize that their actions are not permitted, but under particular circumstances, believe the restriction to be unreasonable. For example, someone who sees a site being eroded or damaged by some other action may conclude that it is acceptable to collect artifacts from the site because the material is going to be lost or destroyed anyway.
- Status-confirming Violations – These are actions arising from giving in to peer pressure.
- Willful Violations – This last category of violations includes actions by those who are aware of the regulations, but are pursuing their own objectives, contrary to historic preservation, such as looting archaeological sites for commercial profit.

Similarly, Swadley (2008) observes that factors that seem to contribute to site vandalism appear to include the following:

- Graffiti is already present.
- Little or no evidence of facilities or other improvements exist.
- Little or no interpretive or educational information is available.
- The site is located close to parking or is directly access by vehicle.
- The site is located in an isolated area where there is no sign of the presence of park (or site) staff or other authority.
- Facilities, structures or site components are in disrepair.
- Trash or litter is present.

This suggests that keeping the environs of accessible archaeological sites well maintained can reduce the chances of vandalism in some cases.

Sites that are in remote areas may be more vulnerable than sites with regular visitors because the risk of getting caught is less. On the other hand, Swadley (2008) notes that rock art sites more than a few tenths of a mile from paved areas generally remain untouched by graffiti. Highly visible sites are likely also more vulnerable than buried sites. How well informed people in the area are about archaeology and preservation may also play a role (Nickens 1993). Rock art sites or prominent natural landmarks that are also archaeological sites (like some hoodoos) may be especially vulnerable to such impacts if the visitor population is unaware of the impacts of their activities. Cathedral Rock, at the United States Air Force Academy, has been a target for graffiti for over 100 years (AFCEE 2008). In addition to potentially destroying the information value of archaeological sites, vandalism can detract from a historic property's integrity by undermining its integrity of workmanship, design, materials, feeling and setting. Vandalism can also be an act of desecration on sacred sites.

4.3.2 Looting

Archaeological sites on DoD lands are sometimes subjected to incidental collecting or substantial looting. Between 2004 and 2008, the Secretary of the Interior reported 119 ARPA violations on DoD Lands (Departmental Consulting Archeologist 2010b; *Quantico Sentry* May 1, 2009). Apart from the disturbance to stratigraphy and features that unauthorized excavation can cause, selective collection of artifacts with a market or curiosity value can leave some sites bereft of important classes of objects such as ceramics or diagnostic lithics from prehistoric sites, metal objects from military sites, or bottles from other historic sites. This removal can reduce the research potential of the site, and render artifact collection comparison and analysis meaningless. Sites significant for being Sacred Sites could also be desecrated by such intrusions.
Motives vary from incidental collecting or substantial looting for financial gain. The Archaeological Resources Protection Act (ARPA) provides civil and criminal penalties for unauthorized excavation or collecting from archaeological sites on public lands, but incidental collectors may not realize this, or that their actions pose a problem for archaeology. Looting or vandalism done out of ignorance may be effectively addressed through education and signage, but intentional looting of archaeological sites for profit is unlikely to be deterred by such actions, and may need additional monitoring and law enforcement. While restricted access to military

installations helps protect archaeological sites from unauthorized collection, it does not solve the problem entirely.

4.4 Summary

Table 5 summarizes man-made potential impacts to archaeological sites. Installation CRMs can use the following table to help identify which kinds of site threats may be a possibility on their installation based on the kinds of land use and land cover at the installation.

Table 5: Man-made Impacts to Archaeological Sites

	Timber	Plowing	Grazing	Mining	Construction	IRP	Vehicle Training	Infantry Training	Air Assault Training	Ordnance Training	MWR	Looting
Loss of Historic Context	x				x				x	x		x
Deformation		x					x	x		x		x
Compaction	x				x		x		x			
Dislocation/Displacement	x	x		x	x	x	x	x	x	x	x	x
Stratigraphic Mixing	x	x		x	x	x	x	x		x	x	x
Loss of Volume									x			
Loss of Elements	x				x	x						x
Collapse												
Sinking												
Contamination				x						x	x	
Mutilation	x	x	x	x	x	x	x	x		x	x	x
Salination/Efflorescence												
Pulverization	x	x	x		x		x			x		
Fragmentation	x	x	x		x		x			x		
Fractures, Cracks	x						x			x	x	x
Dissolution												
Decolorization												
Exfoliation									x			
Oxidation												
Chemical				x						x		
Superficial Spots or Alterations												
Warping												

5.0 Site Physical Setting Classification

Physical setting is an essential dimension of site preservation, particularly as regards natural processes of site formation and change. This section elaborates dimensions of site setting that relate aspects of preservation and vulnerability to the kinds of impacts outlined above in Section 4. For example, sites on flood plains tend to be susceptible to erosion and deposition from floods; sites on hill slopes may gradually be pulled down slope by gravity. Topographic setting also affects the kinds of sites likely to be found in a given area. Sites tend to be most common in many regions on the terraces above permanent streams. Permanent, long-term dwelling sites are less likely on steep slopes or flood plains. Rock Art sites may be found in areas with prominent rock outcroppings.

Types of settings that will be considered in this section include: topography, climate, and soil characteristics.

5.1 Topographic Setting

5.1.1 Topographic Typologies

Topography is an essential element to an understanding of both the distribution of archaeological sites across a landscape and the potential natural or human-related risks those sites face. Research for this report showed that a broad-based classificatory scheme is difficult to find. We consulted a variety of sources for a universally descriptive system of landform classes. The sources included texts and web-based encyclopedias of geoarchaeology and geology, such as Waters (1992), Rapp and Hill (2006), Pedosphere.com, and Wikipedia, as well as instruction manuals for archaeological site forms from states across the continental U.S. None contained a consistent, comprehensive classification scheme. These sources did typically provide long lists covering a wide variety of landforms. But while the lists were useful for understanding cultural contexts in specific geographic areas, they tended to be regionally focused and therefore not suitable to understanding broad patterns concerning site vulnerability.

Landform is also not typically recorded directly in an installation GIS. A few features such as watercourses and wetlands may be included as part of the SDSFIE, but for the most part, topographic features must be inferred on the basis of other features such as elevation contours and surface water (streams, lakes, and shorelines). Such a breakout could be prepared as part of an ICRMP, however. With that information, an installation CRM can compare the topographic settings of their installation’s archaeological inventory to help identify potential topography related vulnerabilities.

5.1.2 Topographic Setting and Site Preservation

Since vulnerability and protection are at issue here, a generalized typology is probably more useful than an exhaustive list of known topographic features. The major concerns of the current study are susceptibility to erosion and the likelihood of human, plant or animal impacts. Thus, we developed the following generalized typology for this study, emphasizing morphology and likely exposure to erosional forces and other sources of potential impacts to archaeological sites.

Alluvial fan

Alluvium, or an alluvial deposit, consists of material such as clay, silt, sand and gravel deposited by modern rivers and streams (Pedosphere.com 2009). An alluvial fan is a fan-shaped deposit of alluvium laid down by a stream where it emerges from an upland area into less steeply sloping terrain (Pedosphere.com 2009). The resulting decrease in velocity of the watercourse leads to the deposition of large amounts of sediment, especially in arid or semi-arid regions with intermittent rainfall (Schiffer 1987:250). The size and shape of individual alluvial fans vary based on climate, drainage basin area, and drainage basin physical characteristics. Deposition on a fan surface tends not to be uniform, with a shifting locus of deposition. The coarsest sediments tend to accumulate at the fan head, and grain size decreases toward the base of the fan (Waters 1992:154-156).

Preservation of sites on alluvial fans depends on their position relative to the processes operating on the fan. Shallow sites may be displaced by erosion if they are in the direct path of a major flow event of water or mud. However, if sites were already buried deeply enough before major flow episodes, they may be preserved, especially if they are near the toe or lower portion of the fan. For example, a number of prehistoric sites have been identified in alluvial fans in Great Basin National Park in Nevada (Wells 1990), at prairie-forest transitions in the Central United States (Bettis 2003); and at Camp Pendleton in California (Rasmussen Foster 1999).

Beach

Beaches are narrow zones of unconsolidated clastic sediment attached to the land (Waters 1992:256). Clastic sediment is fragmental rock material that has been mechanically transported and deposited in a sedimentary environment (Rapp and Hill 2006:237). A typical beach can be divided into three zones: the shore face, foreshore, and backshore. The backshore lies at the nearly level berm that extends from the landward margin of the beach (marked by sand dunes, bluffs, or bedrock cliffs) to the high-tide water level. The foreshore (or the beach face) slopes seaward from the berm crest and consists of the zone between high and low tides. The shore face is a wide zone from the low-tide mark to the fair-weather wave base; it includes the high-energy surf and breaker zones (Waters 1992:256).

Beach areas have a potential for archaeological sites from wide period of time. Coastlines move over time due to changing sea levels. For example, along the Atlantic and Gulf coasts, prehistoric sites on former coastlines older than 2,500 BC have been submerged and are now in offshore locations (Waters 1992:266). More recent sites on the extant coastline typically may occur on beach berms or backshore dunes behind the high-energy wave zones (Waters 1992:270). These sites may be subject to erosion from intensified waves and currents during storms. Sites like ship wrecks or wharves and docks will be along the water line. Buried sites, upon exposure, are subject to having the artifacts and heavier archaeological material abraded and reworked into a lag deposit along the beach, while the fine-grained fraction of the site matrix is carried away. Artifacts made of bone, antler, and ivory tend to become water-borne and tumbled before being redeposited (Rapp and Hill 2006:79). Nevertheless, consistently buried portions of shipwreck or wharf sites can be preserved for centuries.

Cave

Cave sites are likely to be well protected from many forms of natural erosion, though caves are generally formed by water action, so water-related impacts may be an issue. For example, precipitation of calcium carbonate from dripping water in the Devil's Lair site caused the formation of a knobby rind around grains of quartz sand, eventually binding the sediments chemically and physically (Shackley 1981:30 in Schiffer 1987:205-206). Sites in accessible caves, or accessible portions of caves, may be subject to human visitation and related impacts. Even remote caves can be subject to disturbance by occupying or visiting animals. Miller's Cave on Fort Leonard Wood in Missouri was found to have been disturbed repeatedly by casual digging but still retained some intact prehistoric archaeological deposits. Increased surveillance of the cave or more extensive archaeological excavations were recommended (Markman 1993:v).

Colluvial fan

Colluvium refers to any loose, heterogeneous, and incoherent mass of soil material and/or rock fragments deposited by rainwash, sheetwash, or slow, continuous downslope creep. Colluvium tends to collect at the base of gentle slopes or hillsides (USGS 2010). Runoff on hillsides may lay down colluvial or slopewash deposits. In areas subject to slopewash, cultural remains may end up being buried under deep layers of colluvium (Schiffer 1987:250). For example, at the base of cliffs once used by hunters as animal jumps, bone beds have been discovered under multiple layers of colluvium (Frison 1978 in Waters 1992:232). Such conditions may help keep sites well preserved for very long periods of time. However, changing conditions upslope, particularly in groundcover, can result in increased or decreased rates of accumulation. Greatly increased water flow downslope could erode away layers of colluvium, exposing previously buried archaeological remains.

Dune

Sand dunes are likely to be found in seashore and desert environments. Their formation – as well as their constantly changing form – is due mainly to eolian (wind-blown) deposition and erosion (Schiffer 1987:241). Wind can blow sand from one portion of a dune to another, leading to movement or creeping of dunes. Archaeological deposits that originated on dunes may be altered in several ways. If the deposits are on the windward slope of the dune, they are subject to being moved upward to the upper part of the slip face, from which they avalanche. Archaeological deposits on the leeward slope of a dune may become covered by the avalanching collapse. If the dune continues to advance, cultural materials will be exposed and deflated on the windward slope (Schiffer 1987:242). In contrast, archaeological deposits that originate near dunes may be preserved if the encroaching sand covers them, promoting preservation. However, in general the action of dunes reduces visibility and accessibility of sites. For example, the Tolowa Indians of California occupied sand dunes near the shore for smelting camps. The camps were in use for only short periods in late summer, and wind erosion has resulted in the loss of stratigraphic and cultural information on these sites (Gould 1974:32 in Schiffer 1987:243).

Floodplain

Former occupation surfaces on floodplains were typically on point bars and stream banks and not in active channel areas; however, erosional and depositional processes affect these settings too. Artifacts in floodplain sites are likely to be moved downstream by water action in channels, or can be washed from their setting along channels as part of bank erosion (Rapp and Hill 2006:64). Overbank flooding can leave behind sediments suspended in the floodwaters, burying and preserving cultural deposits. Repeated instances of such floodplain deposits results in upward growth of the floodplain known as vertical accretion or top stratum deposits (Waters 1992:132). Fine-grained sediments tend to accumulate on the upper portions of point bars, natural levees, oxbow lakes, and the floodbasin. Over time, streams may change their course, eroding away areas that had previously been subject to alluvial deposition. This process can become accelerated due to changes in landcover upstream. Reduction of forest cover, and increases in areas covered with impervious surfaces can greatly increase storm water runoff, resulting in downstream erosion, and archaeological site destruction.

Lake margin

Where closed topographic basins exist and where sufficient water is available as groundwater or surface run-off, lakes or swamps will form. Lake formation depends on water being impounded, while swamps are characterized by low relief and infilling with sediment and vegetation (Sulkin 1966:116). Areas around lakes will have some of the same issues as streams, though they are likely to be less vulnerable to erosion, unless water levels in the lake have a tendency to fluctuate (as with a reservoir lake). If the lake is subject to recreational use, the lake margin could be eroded by wake effects from passing boats or jet skis. Previously-identified or unknown sites can be exposed during droughts or floods when lake margins shift. For example, flooding at Malheur Lake in Oregon led to the drowning of vegetation in newly-flooded areas, causing the former ground surface to erode. Newly-exposed cultural remains in the Malheur National Wildlife Refuge attracted relic collectors. Archaeological sites and human burials were exposed, prompting the U.S. Fish and Wildlife Service to sponsor archaeological surveys and surface collections on islands and shorelines beginning to emerge as the waters receded (Oetting 1992:110).

Ridges and Hilltops

Sites located on ridges and hilltops are fairly common types of prehistoric and historic sites. Prehistoric ceremonial sites, for example, may have been located on hilltop locations to enhance the spiritual effect of the setting. Ridges and hilltops offered advantageous locations for defensive sites such as forts or for gun emplacements (e.g., the Civil War fortifications surrounding Washington, D.C.). These topographic locations may tend to be more visited by people, exposing them to collection or other human impacts. They may also exist in thinner soils, and therefore would be more vulnerable to erosion. Their prominent location would leave them susceptible to high winds, leading to aeolian erosion, especially on unvegetated ground (MacDonald 1990:23).

Slope

Sites located on hill slopes may have less risk from human impact, but may be more vulnerable to erosional forces. The exposed ground surface is subject to weathering due to water, wind, or gravitational effects, and unconsolidated sediments may move to lower elevations. Generally, archaeological sites are relatively rare on steep slopes. Where artifacts are found, they may be out of context, washed down slope from sites located at the top of the slope. Nevertheless, certain kinds of sites may be located in such settings, such as rock art sites, or resource extraction sites.

Stream

Streams can be defined as any body of flowing water of any size that is confined in a channel (Waters 1992:116). Therefore the term can refer to a range of sizes from small creeks to major rivers. Habitation sites have been frequently located near rivers to take advantage of water supply, transportation, aquatic food resources, and as an element of defense (Rapp and Hill 2006:180). Streams also may contain remains of water-related industry, such as mill features and wharves. The foundational timbers for mill races, mill wheel boxes, as well as for wharves or docks in larger streams, may be preserved underneath sediments at the bottom of the stream or river. Occasionally remains of sunken craft may also be found. The water logged anaerobic environment provided by sediments at the bottom of a stream may preserve organic remains for long periods.

Like floodplains, stream beds can be susceptible to erosion. Development upstream can change stream flow characteristics by increasing storm flow. Water areas can also be attractive for recreational activities such as fishing or picnicking, increasing visitation and possible looting effects.

Terrace

A terrace is a berm or discontinuous segments of a berm, in a valley at some height above the floodplain, representing a former floodplain of the stream (USGS 2011). Terraces above permanent streams are probably the most common physical location for archaeological sites, at least those related to habitation. Location on a river or stream terrace put site inhabitants close to needed resources (water, food, transportation) while providing some protection from flooding. Nevertheless, sites on stream terraces can still be subject to flooding or other water erosion during episodes of extreme weather.

5.2 Climate setting

5.2.1 Climate Classification

Climate conditions can directly affect the preservation of archaeological sites, especially cycles of extreme states, such as freezing and thawing or cycles of very wet and very dry weather. Climate is distinguishable from weather in that weather is an instantaneous state of the atmosphere and climate is an average state (Essenwanger 2001:2). Climate has been defined as the synthesis of weather events over the whole of a period statistically long enough to establish its statistical (mean, variation, probability of extreme events, etc.) properties (Essenwanger 2001:3).

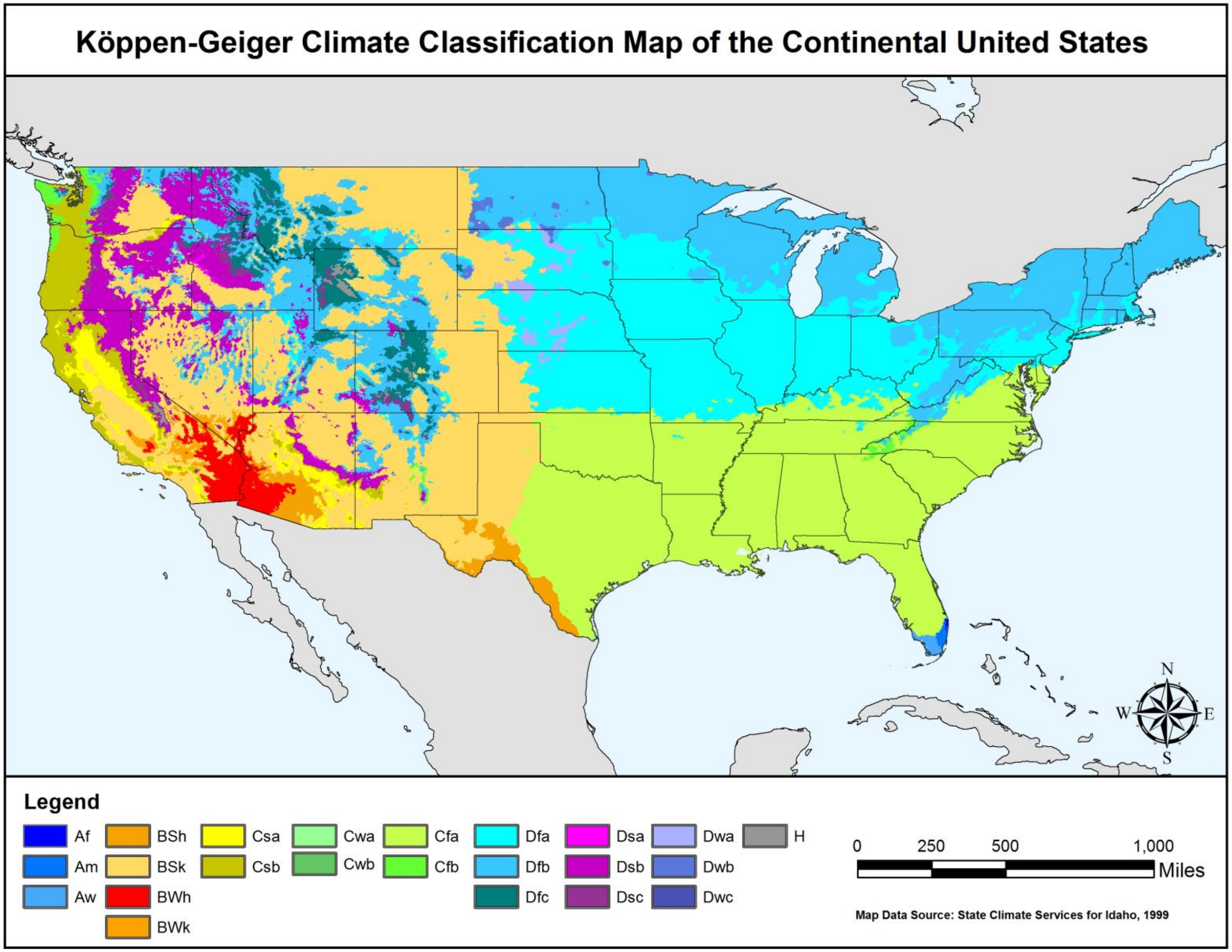
Classification of climate is a grouping of atmospheric conditions for locations showing similar climatic conditions or types separated by defined boundaries (Essenwanger 2001:3). Information about the climatic context for installations is available from a variety of sources. The SDSFIE includes Features/Entity types for temperature areas and precipitation areas. This suggests that at least some installations may have these data as a part of their GIS. Broader nation level data are available from NOAA which include data about temperature and rainfall. GIS maps of climate classification systems, such as the Köppen-Geiger climate classification, are also widely available.

Köppen-Geiger climate classification

The Köppen-Geiger system of climate classification is one of the most widely used and dates to the collaboration of German climatologists Wladimir Köppen and Rudolf Geiger in the 1930s (Köppen -Geiger 1936). It is based on the idea that the native vegetation best expresses the local climate, and considers vegetation, tree growth, and human life conditions. The system also uses an area's average annual and monthly temperatures and precipitation, and the seasonality of precipitation to define climatic zones. Köppen-Geiger zones in the Continental United States are shown in Figure 1. The Köppen-Geiger classification system includes five main climate groups and several types and subtypes:

- Group A - Tropical/megathermal climates
  - Tropical rainforest (*Af*)
  - Tropical monsoon (*Am*)
  - Tropical wet and dry or savanna (*Aw*)
- Group B - Dry (arid and semiarid) climates (B)
- Group C - Temperate/mesothermal climates
  - Dry-summer subtropical (Csa, Csb)
  - Humid subtropical climates (Cfa, Cwa)
  - Maritime Temperate climates or Oceanic climates (Cfb, Cwb, Cfc)
  - Temperate climate with dry winters (Cwb)
  - Maritime Subarctic climates or Subpolar Oceanic climates (Cfc)
- Group D - Continental/microthermal climate
  - Hot Summer Continental climates (Dfa, Dwa, Dsa)
  - Warm Summer Continental or Hemiboreal climates (Dfb, Dwb, Dsb)
  - Continental Subarctic or Boreal (taiga) climates (Dfc, Dwc, Dsc)
- Group E - Polar climates
  - Tundra climate (ET)
  - Ice Cap climate (EF)
- Alpine climates (no separate map code)

Climates found in the continental United States include: Af, Am, Aw, Bsh, Bsk, BWh, BWk, Cfa, Cfb, Csa, Csb, Cwa, Cwb, Dfa, Dfb, Dfc, Dsa, Dsb, Dsc, Dwa, Dwb, Dwc, and H.


Köppen-Geiger Climate Classification Map of the Continental United States
N
W
E
S
Legend
Af
Am
Aw
BSh
BSk
BWh
BWk
Csa
Csb
Cwa
Cwb
Cfa
Cfb
Dfa
Dfb
Dfc
Dsa
Dsb
Dsc
Dwa
Dwb
Dwc
H
0
250
500
1,000
Miles
Map Data Source: State Climate Services for Idaho, 1999

Climate and Archaeological Site Preservation

The effects of climatic conditions on archaeological site preservation can vary markedly depending on site type and potential threats. Soil erosion that damages shallow sites or exposes previously-buried sites, for example, can be caused by wind, water, and ice, conditions that may be intensified by climate extremes. Desert climates, such as in dry/arid and semiarid (B) and dry-summer subtropical (Csa, Csb), are likely to have more barren land and exposed surface sites (Table 6). In general, archaeological remains survive better in constant conditions. Cycling through changes in temperature and moisture can cause some materials, especially porous ones, to break apart as they expand and contract. In areas where climatic conditions have been stable for a long time, archaeological remains will already long since have been exposed to any such cycles in a given area.

Soil forms a structure that is filled with pore spaces, similar to a mixture of solids, water, and air. After rainstorms, excess water drains away; the rest is held in pore spaces as a film covering the soil particles. Vehicle training or recreational use of all-terrain vehicles in areas with heavy rainfall may compact the surface soil, producing tire ruts, since wet soil is generally weaker than dry soils. This could result in artifacts being broken, crushed, or displaced from their depositional context. Areas cold enough for the ground to freeze, such as Group D (Continental/Microthermal) and Group E (Polar) may be able to do vehicle training with less soil deformation.

In addition, human development can have an effect on the moisture content of the ground. For example, construction of impervious pavements near an archaeological site can redirect increased amounts of rain onto the surface of the site, possibly causing erosion. This could be more of an issue in climates with high rainfall amounts, such as Group A (Tropical/Megathermal), but could apply to areas of lesser rainfall, especially if the sites are shallow or are on a slope. Changes in plant landscaping also can alter surface water flow patterns, with species that differ in how much rainfall they allow to reach the ground and how quickly, and how much moisture they retain. For example, trees will significantly slow the fall of rain to the ground, allowing more of it to be absorbed into the soil rather than run off; trees also retain far more moisture than smaller plants. Ground covers such as grasses native to the local climate can act to consolidate surface soil and prevent erosion on level and sloping surfaces, as well as along shorelines. Non-invasive species of native grasses should be available in most climates except Group E (Polar). Table 6 lists potential effects to archaeological sites by climate subtype.

Table 6: Effects on Archaeological Sites by Climate

Climate Subtype	**Freeze/Thaw Cycles**	**Wet/Dry Cycles**	**High Winds**	**Heavy Rainfall**
Af			X	X
Am			X	X
Aw		X	X	X
BWk	X	X	X	
BWh		X	X	
BSk	X	X	X	
BSh		X	X	
Csa		X		
Csb		X		

Climate Subtype	**Freeze/Thaw Cycles**	**Wet/Dry Cycles**	**High Winds**	**Heavy Rainfall**
Cfa				X
Cfb				X
Dfa	X			
Dsa	X	X		
Dwa	X	X		
Dfb	X			
Dsb	X	X		
Dfc	X			
Dsc	X	X		

Climate Change

There is accumulating evidence that climate patterns are changing across the United States (Environmental Protection Agency 2011), and over time, these changes could conceivably have an effect on archaeological preservation. Changing climates are predicted to bring more frequent and more powerful storms, and more frequent and severe wildfires (Saunders et al. 2006:13). For example, sea level is predicted to rise four inches or more in the next hundred years, matching the rise of the past hundred years (Curry 2009). Rising sea levels could inundate coastal sites and set the stage for further erosion from high tides and storm surges (Archaeopedia New Zealand 2010). Coastal sites along the West Coast that could be vulnerable include Point Reyes National Seashore, and portions of the Presidio of San Francisco, the oldest continuously used military post in the country (National Park Service 2010). Rising temperatures may also encourage the spread of invasive plants into environments further outside of their usual range, potentially leading to site damage. For example, the kudzu vine (*Pueraria Montana*), a Japanese native introduced into the southeastern U.S. as a way to combat soil erosion, spreads rapidly and quickly covers trees and other items in its path such as above-ground ruins (ScienceDaily 2011). With milder winters in recent years, kudzu has expanded its range northward to Pennsylvania and New York (ScienceDaily 2010).

Examples of climate-related physical changes that have already been observed at DoD installations in the U.S. and its coastal waters include:

- Rising temperatures and sea level
- Increases in both heavy downpours and the extent of drought
- Thawing permafrost
- Shifts in growing seasons
- Lengthening ice-free seasons in the oceans and on lakes and rivers
- Earlier snowmelt
- Altered river and stream flows
  (Strategic Environmental Research and Development Program c.2010).

5.3 Soil setting

Attributes of soils can directly affect how archaeological sites may react to certain impacts. Sites in wet soils may be more prone to damage from freezing or from vehicle traffic, for example. Understanding the range of soil types and their characteristics is thus another critical part of assessing site vulnerability and appropriate treatments in the face of impact threats.

5.3.1 Soil type/texture/strength

The soil classification system developed by the Natural Resources Conservation Service (NRCS) recognizes 12 taxonomic orders. Most of these soil orders are classified based on zonal vegetative and climatic conditions. Azonal orders (Andisols, Entisols, Histosols, Inceptisols, and Vertisols) form under particular conditions within any climatic zone. Each order is described below along with any relevant preservation issues related to the chemical or physical properties of a given soil (after Dincauze 2000, Grunwald 2011, NRCS 2011a, 2011b, Rapp and Hill 2006, Sease 1994, Shoji et al. 1993, and Wood and Johnson 1978). The following soil order descriptions include whether the soil is predominantly acidic or alkaline which can have both positive and negative effects on certain classes of archaeological materials. These effects are discussed in detail below in section 6.3.

Alfisols

Alfisols develop under primarily deciduous forests in temperate climates. This order is characterized by the accumulation of clay horizons, weathered parent material, low organic content, and moderate-to-high alkalinity. These soils are widespread across the U.S. with heaviest concentrations in the Mississippi River watershed, Texas, Rocky Mountains, and California.

Andisols

Andisols are formed by volcanic parent materials or tephra (e.g., ash, pumice, and lava) under a variety of environmental conditions. This order is characterized by low bulk density, high porosity, and acidity. Volcanic deposits can preserve archaeological materials through what can often be rapid burial; in particular, decayed organic matter can leave molds and impressions in the soils. Andisols have a limited distribution in the U.S. and are confined to the Pacific Northwest, southern Alaska, and Hawaii.

Aridosols

Aridosols occur in dry, mostly desert environments. Primary characteristics of these soils include cemented matrices or crusts, low permeability, low organic content, high salinity, and high alkalinity. High salinity can have a negative effect on most artifact classes with the exception of some organics (wood, seed, fabric, hide) which it affects moderately. Very dry conditions can preserve some archaeological materials through desiccation and lack of moisture. This order is widespread across the western U.S.

Entisols

Entisols classify immature soils formed through recent deposition of alluvial or colluvial materials. These soils show little development and are often shallow with little to no vegetation. The chemical and physical properties of entisols depend on parent materials and setting. Due to the relatively young age and settings (base of slopes, active floodplains), archaeological deposits are rare within this soil type although they may cap older sediments. This order is distributed widely across most of the U.S., particularly in the western states and the lower Mississippi River drainage.

Gelisols

Gelisols occur in cold climates where temperatures rarely go above freezing. These soils are underlain by permafrost and the upper horizons are subject to the freeze/thaw cycle which can displace archaeological deposits through cryoturbation. Frozen environments also can preserve organic matter as they reduce bacterial decomposition and limit exposure to air. In the U.S., this soil type is confined to Alaska.

Histosols

Histosols represent soils within poorly drained areas (e.g., wetlands, peat bogs) that contain high organic content. The pH of histosols can vary depending on groundwater sources. These soils can harbor extraordinary preservation of organic artifacts. Changes in their makeup, particularly moisture content, can result in a loss of that preservation. Histosols have a limited distribution in the U.S. occurring mostly along the Gulf Coast, Virginia/North Carolina coast, and the Great Lakes region.

Inceptisols

Inceptisols are immature soils that show more development than entisols. Like entisols, these soils occur most often at the base of steep slopes (colluvium) or active floodplains (alluvium). As such, artifacts within these soils may represent secondary contexts. The chemical and physical properties of inceptisols depend on parent materials and setting. These soils eventually develop into other orders. This order is distributed widely across the most of the U.S., particularly in the Appalachian Mountains, southern New England, and the Pacific Northwest.

Mollisols

Mollisols are dark rich soils that form under grassland or prairie environments. These soils are characterized by high organic content, high fertility, and high alkalinity. Faunalturbation (i.e., worms, insects, rodents) in these organic rich soils can be extensive and has the potential to move artifacts vertically in the soil column. Mollisols are widespread in the U.S., west of the Mississippi River.

Oxisols

Oxisols form in tropical and subtropical climes where precipitation and temperatures show little variation. Named for the abundance of iron and aluminum oxides that result from weathering and leaching, these soils have high acidity and often indistinguishable horizonation. Insect faunalturbation, of termites in particular, is prevalent in tropical soils, resulting in an upward distribution of fine particles with stone lines or mantles at depth, which can incorporate large artifacts and lead to the mixing of archaeological deposits. The distribution of oxisols in the U.S. is limited to Hawaii and Puerto Rico.

Spodosols

Spodosols typically form under coniferous forests in humid temperate regions. They are characterized by eluvial horizons resulting from the leaching of minerals downward through the profile. Sand and loam textures, gray hues, and high acidity also are common traits of spodosols. The sandy composition of this order can result in the vertical movement of artifacts through faunalturbation and cryoturbation. These soils are widespread in parts of the U.S., namely Florida, the upper Great Lakes region, New England, Pacific Northwest, and southern Alaska.

Ultisols

Ultisols are common to mixed mesophytic forests. Similar to alfisols but with lower pH values, these soils are heavily leached and weathered and have a distinctive red hue due to leached iron oxides. Like most forest soils, the upper horizons of utisols can be very dynamic as a result of faunalturbation and floralturbaton. These soils are widespread across the Southeastern U.S. with some distribution in the Pacific Northwest and central California.

Vertisols

Vertisols represent soils with high clay content that form under a variety of conditions particularly in regions with seasonal drought and flood cycles with parent materials that yield clay minerals. The primary characteristic of these soils is that they are prone to expansion and contraction due to the fluctuating moisture levels, resulting in the displacement of artifacts in the soil column through argilloturbation. Vertisols also are typically dark in color and alkaline. In the U.S., veritsols are limited to the lower Mississippi River Valley, Texas, the Dakotas, and central California.

5.3.2 Soil Strength

Soil strength is generally defined as the maximum resistance of a soil to compaction or shearing stresses. Soil compaction refers to stress applied to soil that causes densification as a result of reduced structure and porosity. The strength of soil is influenced by moisture content, texture, organic content, and bulk density (van den Akker and Soane 2005; NRCS 2001). Dry soils have more friction between particles and therefore are more resistant than moist soils to compaction. Fine-textured or poorly sorted soils—such as loamy sands, sandy loams, or gravely soils—are more vulnerable to compaction than sandy or clayey soils that are relatively uniform in texture and structure (Dale et al. 2005; Kok et al. 1996; Lei 2004; Milchunas 2000; NRCS 2001; Raper 2005). Soils with high organic content, especially in the form of surface vegetation with dense root growth, help to lessen the impact of compressive forces. Bulk density, derived by dividing a soil sample’s mass by its volume, measures the compactness of a soil (Reed et al. 2000). Soils with high bulk densities have less pore space which contributes to greater strength.

Soil compaction often results from trampling by humans and livestock and vehicle activity (i.e., agricultural, forestry, and military training), although natural processes such as ice and snow loads, landslides or other mast wasting events, and persistent rainfall can be contributing factors. Compacted soil layers may not be present near the surface but rather exist deeper in a profile

(Halvorson et al. 2001). Soil compaction has been recorded to depths greater than one meter, although more typically soil compaction resulting from vehicle traffic and trampling is evident between 5 and 30 centimeters in depth (Prosser et al. 2000; Webb 1983, 2002).

The densification of soil caused by compaction limits water and air infiltration which can change soil chemistry, organic content, and hydrology, all of which can have negative effects on buried archaeological deposits (Althoff et al. 2007; Garten et al. 2003; Wolkowski and Lowery 2008; Reed et al. 2000). Inhibited rainfall permeability and root growth can promote increased runoff and erosion. Compression of archaeological deposits can accelerate the decay of bone, shell, plant remains, and cause artifact abrasion. Soil compaction can also lead to the mixing of archaeological contexts through the compression of buried living surfaces and the collapse of animal burrows, which might cause the downward movement of cultural objects in strata above the burrows (Davenport and Switalski 2006; Rapp and Hill 2006; Thorne 1991).

5.3.3 pH

The acidity or alkalinity of soil can also have an effect on buried archaeological deposits. Most soils have a pH range between 2 and 11, with 7 being neutral and values below indicating acidic soils and values above indicating alkaline soils (Soil Survey Division Staff 1993). Soils that are acidic will generally have a negative effect on metals and organic materials such as wood, leather, seed, and human and animal bone (Sease 1994). Studies of mortuary sites have found that as soil pH decreases, the destruction of osseous material increases (Gordon and Buikstra 1981, Baxter 2004, Mays 2010). These studies also found that due to their lower bone density and more porous structure, juvenile and infant remains are more susceptible to deterioration in acidic soils and can be under-represented in archaeological samples. High alkalinity in soils can have a negative effect on ceramics, glass, and pollen (Mathews 1989, Sease 1994).

Changes in soil pH can occur through both natural and cultural processes. Natural fluctuations in pH can be caused by a number of factors: rainfall can leach cations (i.e., Ca, Mg, K) from the soil; the weathering of parent rock material can raise or lower pH depending on rock type (granite-acidic; limestone-basic); and the decay of organic matter such as pine needles can lower pH (Johnson and Zhang n.d., Davidson and Wilson 2006). While natural influences on pH may occur over centuries or millennia, the effects of cultural impacts such as deforestation, grazing, mineral extraction, agricultural practices (liming and fertilization), acid rain, and development can affect pH more rapidly. For example, high yielding crops remove basic cations from the soil necessitating the application of lime to raise the pH following a harvest, and such fluctuations could have negative effects on buried archaeological deposits (Johnson and Zhang n.d.).
As result of a recent United Kingdom study, Davidson and Wilson (2006) suggest that soil pH can be a general indicator of soil health with respect to archaeological preservation. The monitoring of soil pH is seen as an economical method of archaeological site stewardship. Such a monitoring regime would require baseline data from the sites against which to measure changes in soil pH. The study also recommended more research into the effects of changing soil pH on the spectrum of archaeological materials. Gordon and Buikstra (1981) also proposed that the monitoring or sampling of soil pH within archaeological deposits, and mortuary sites in particular, could aid in the estimation of human bone preservation, thus determining the quantity and quality of the remains.

Table 7 summarizes data related to soil type and artifact preservation. The soil types cross cut the taxonomic orders noted earlier. The categories are more general, focusing on aspects of soil chemistry and water content that may be common to more than one order, and thus may be more widely applicable to a variety of DoD installation contexts.

Table 7. Artifact Preservation Potential in Different Soil Types (After Sease 1994).

Artifact Type	**Soil Type**						
	Acidic	**Alkaline**	**Saline**	**Water-logged Acidic**	**Water-logged Alkaline**	**Desert**	**Arctic**
Ceramics	R-calcareous fillers dissolve	P-basic structure affected	P	R	P	G-wind erosion possible	G
Lithics	G	G	P-soluble salts	P	P-insoluble salt encrusta-tion	G-wind erosion possible	G
Glass & Glazes	R-alkali leaching	P-basic structure affected	P	R	P	G-wind erosion possible	G
Wall Plaster	P	G	P	P	P	G	G
Metals							
Iron	P-corrosion	G	P-corrosion	G	G	G	G
Copper Alloys	P-corrosion	G	P-corrosion	G	G	G	G
Lead	P	P	R	G	G	G	G
Silver	P	G	G-slight saline, P-high saline	G	G	G	G
Organic Materials							
Bone, Ivory, Antler	P	G	P-soluble salts	P	P	G	G
Wool, Leather, Hair	slow deteriora-tion of protein	P	R-dehydrat-ion	G	G	G	G
Wood, Cotton, Linen	P	P	R-dehydrat-ion	G	G	G	G
Shell	P	G	P-soluble salts	P	P	G	G

G = Good Preservation, R = Reasonable Preservation, P = Poor Preservation

6.0 Site Vulnerability Classification

The characteristics of an archaeological site, whether a distribution of artifacts on the ground surface, for example, or buried pit features or grave shafts, will largely govern the kinds of impact from which it is likely to be at risk. Site type classifications are mostly structural, concerned with the physical makeup of a site: whether there are features, what sorts of artifacts may be present, and how deeply buried they are. These attributes are among the variables that determine what kinds of impacts may threaten a site. Site type may also have a bearing on treatment options: sites such as burials and sacred sites, for example, have special considerations that could affect potential kinds of treatment. Here, rather than employing categories such as camp site, village, or cemetery, the discussion looks at site type from the perspective of deposition, the presence of features, and the types of artifacts present.

6.1 Deposition (buried/surface)

Deposition in the present context refers to the location of an archaeological site relative to ground surface. Sites may exist primarily at ground surface, they may be buried under significant amounts of sediment, or both. Clearly, surface and shallowly buried sites will be the most vulnerable to the broadest range of impacts, from natural processes such as erosion to human impacts such as vehicle traffic or vandalism. Deeply buried sites are insulated from the kinds of impacts often associated with the surface or shallow sites. However, burrowing animals such as ground hogs can dig burrows five feet deep, while some tree root systems, particularly in desert areas, have been found to depths of up to 60 meters (Philips 1963). Furthermore, even deeply buried sites can be affected by soil compaction, or changes in soil chemistry or hydration.

6.2 Features

The kinds of cultural remains present at an archaeological site must also be factored into considerations of impact vulnerability. The presence of features and their characteristics are integral to these assessments. For example, broad and shallow features—which are present at many American Indian village sites in the eastern U.S.—are more likely to be disturbed by vehicle activity than narrow pit features that extend well below ground surface. Likewise, structural remains that protrude above ground surface are more likely to be disturbed by military vehicles than structural remains that are flush with the ground or shallowly buried.

6.2.1 Rock Art

Rock art refers to images found on outcroppings of stone or in caves, and may be either petroglyphs (etchings or carvings in stone) or pictographs (paintings). There are a number of very significant rock art sites on DoD lands, particularly in the Western U.S. Many famous examples of prehistoric rock art in that region have graffiti left by 19th-century settlers that may also be considered historically important. Rock art may be vulnerable to natural weathering from the effects of wind, rain, freeze and thaw cycles, or mineral accretions. Changes in climate, such as acid rain, can put some forms of rock art at heightened risk (Swadley 2008; Lee 1986). The growth of some plants—lichens and moss in particular—can also adversely affect rock art sites (Swadley 2008). Lichens can sink hyphae, thread-like structures, deep into rock surfaces, breaking apart the rock over time. Vandalism, especially from contemporary graffiti, is among the worst threats to rock art sites. Even apparently benign interaction, however, can damage these fragile resources. Visitors who touch rock paintings with their bare fingers may expose the art to damaging oils in their hands. Kicking up dust from paths around rock art sites can result in dust deposits accumulating on and eventually accreting to, rock art (Swadley 2008).

6.2.2 Earthen Features

Earthen features or earthworks consist of man-made piles of soil accumulated for a specific purpose. Examples include the enormous Mississippian-period pyramids of the Midwest and Southeast, the large prehistoric earthworks in the Ohio Valley, and the Civil War-era defensive works common on many DoD installations in Virginia. Earthen features can be damaged by erosion, tree growth, and damage from hiking or cycling trails. Unauthorized excavation can also be a problem for these resources. Earthen features (such as Civil War earthworks or American Indian burial mounds) can be substantial in size, and thus may attract public attention if they are in accessible locations. While accessibility may make the features vulnerable to intentional or unintentional impacts, if managed appropriately, it can serve to help preserve the sites through education and public outreach programs. Other earthen features, such as Civil War-era tent platforms can have a subtle presence on the landscape, easily missed by all but the most expert eyes. If their presence is not clearly understood, such features may be susceptible to unintended impacts even from authorized individuals.

6.2.3 Landscape Features

Dispersed features of a cultural landscape represent a particular preservation challenge. A cultural landscape is defined as “a geographic area that includes cultural and natural resources and the wildlife or domestic activity associated with an historic event, activity, or person, or exhibiting other cultural or aesthetic values” (Birnbaum 1998:36). Distinct from individual archaeological sites, cultural landscapes include sites and their associated natural settings, whether directly modified or merely integral to the context of the site (UNESCO 2005). Cultural landscapes can be various in type: some are historic sites, such as battlefields; others are designed historical landscapes, such as designed parks and gardens. Other examples of cultural landscapes include historic vernacular landscapes, which include any linkage of non-designed landscape features that have a shared historic or cultural association. Still other landscapes are ethnographic and are associated with traditional cultural properties, religious sacred sites or have geological components. The challenge for a CRM is that the individual elements that make up such landscapes may be broadly dispersed, and not clearly recognized as an integral part of a larger whole.

Landscape elements can be at risk from loss through development, extensive trails, unauthorized excavation, fire, logging, or a variety of actions. In some cases, these elements might not be obvious. For example, some historical sites may retain plantings whose relationship to the site might not be obvious to the untrained eye, or ornamental flowers or shrubs not noticeable when not in bloom. Sites with significant living landscape components may be particularly vulnerable to land management practices such as mowing, logging, or prescribed burns.

Nearly all landscapes evolve; none are static in time. The rate of evolution can vary depending on changes in both natural processes and human activity. Change can be either subtle or highly visible within the various different landscape components, such as vegetation, topography, water, and wildlife to name just a few. While landscapes do change over time, continuity in historical appearance must exist in order for a cultural landscape to possess integrity. Continuity must be expressed in form, order, use, features, and materials (National Park Service n.d.). Active landscape management and treatment programs, including historic research, and inventory/documentation/assessment plans, provide the best means to ensure that continuity is maintained even in an evolving ecosystem.

6.2.4 Masonry

Masonry features (brick or stone) are more durable than other kinds of features, but can still be damaged by weathering, plants, or human activity. If the top of a masonry wall is unfinished and unprotected, it will slowly deteriorate from the action of rain and freeze/thaw cycles. Tree roots can be very damaging to masonry walls. Such features are also more visible than other kinds of features, making a site potentially attractive to looters or vandals, or incidental or unintentional damage from unwary or uniformed visitors.

6.2.5 Artifact Concentrations

The distribution of artifacts associated with a site can vary considerably in density. Sparse scatters of prehistoric stone tools, for example, may consist of only a handful of artifacts from a wide area. Some historical sites or prehistoric quarry sites, in contrast, may contain concentrations of artifacts in densities of thousands per square meter. Dense concentrations such as these represent features, whether or not they are contained in structures or pits. The nature of these concentrations can influence the threats to which the site may be vulnerable and the impact those threats may pose. Sites with dense features visible at ground surface, for example, may be more vulnerable to looting or vandalism. In contrast, the impact of disturbance to a site with few artifact concentrations, and by implication few artifacts overall, may be greater since the site may lack the redundancy and representativeness of artifact classes present at sites with higher density features.

6.3 Artifacts

The type of artifact contained in a site directly affects the vulnerability of the site to various threats. A site whose physical integrity is closely related to fragile artifacts, such as glass vessels or bottles, in near-surface contexts may be considered more vulnerable to vehicle impacts or trampling than a site composed of more durable remains, such as chipped stone tools and debitage.

6.3.1 Organic preservation

Organic artifacts are primarily susceptible to the action of biological processes of decay, promoted by microorganisms such as bacteria, as well as by molds, fungi, insects and many animals. Sunlight and oxygen may also pose threats (Schiffer 1987). Organic remains are typically only preserved under specific and unusual conditions: for example, extreme continuous cold, such as in arctic or glacial regions of mountains; extreme continuous dry conditions, such as desert environments; or continuous wet, anaerobic environments, such as in peat bogs. Environments where oxygen is present or where there are fluctuations in temperature or moisture tend to promote the biological and chemical processes of decay. For this reason, many organic remains (fabric, paper, leather, wood) are not commonly found on archaeological sites. When sites do occur with conditions that promote a high degree of preservation, their significance may be very high because of the information potential of the artifacts they contain. This information can be vulnerable to changes in site environment, particularly alterations in moisture, temperature, or the presence of oxygen.

6.3.2 Metal artifacts

Metal artifacts in general have a higher rate of preservation than organic artifacts, but most (other than inert metals like gold) are subject to corrosion. Corrosion refers to a family of electrochemical processes in which positively charged metallic ions go into solution in an electrolyte, leaving negatively charged particles behind (Schiffer 1987). Over time, severe corrosion can leave metal artifacts unrecognizable. Electrolytes in solution, like salts, are active agents of corrosion. Bacteria can also play a role in the corrosion of metals. The presence or lack of oxygen can affect corrosion (it's absence can retard corrosion except if sulfate-reducing bacteria are present). If different kinds of metal are in contact with each other in an electrolytic environment, the "baser" or more electronegative metal will corrode, but the other will not (e.g. if zinc and iron are buried together, the zinc will corrode leaving the iron in better condition) (Schiffer 1987). Organic remains buried with metal objects can sometimes accelerate corrosion because of the presence of chlorides or other organic acids they release into the soil. Extremely dry or extremely cold conditions can significantly retard corrosion processes, but fluctuations in environment (cycles of wet and dry for example) can accelerate corrosion. Many metals will also corrode more quickly in an acidic environment (Schiffer 1987).

6.4 Summary

Table 8 provides a summary of site, feature, and artifact types and the kinds of impacts to which they may be vulnerable. Installation CRMs can compare this table to their installation archaeological inventory to help identify the kinds of preservation issues that may be relevant for their program.

Table 8: Site Vulnerability Type

	Deposition		Features					Artifact Distribution		Artifact Preservation		
Impact	**Buried**	**Surface**	**Rock Art**	**Earthen**	**Wooden**	**Landscape**	**Masonry**	**Dense**	**Sparse**	**Organic**	**Metalic**	**Lithic/ Ceramic/ Glass**
Loss of Context		x	x	x	x	x	x					
Deformation	x							x	x			
Compaction	x							x	x	x	x	x
Dislocation	x	x			x		x	x	x			
stratigraphic mixing	x			x				x	x			
loss of volume	x	x		x				x	x			
Loss of Elements	x	x	x	x	x	x	x	x	x			
Collapse		x	x		x	x	x					
sinking	x	x		x	x	x	x					
Contamination	x	x				x		x	x	x	x	
Organic												
Chemical												
Litter												
mutilation		x	x	x	x	x	x			x	x	x
Rock art damaged/ removed		x	x									
Vandalism	x	x	x	x	x	x	x	x	x			
Bullet holes		x	x		x		x					
Graffiti/tagging		x	x		x	x	x					
Salination/efflorescence	x	x	x		x		x					
Pulverization	x	x	x				x					
Dissolution	x		x							x		
discoloration	x	x	x		x		x					
Exfoliation		x	x				x					
Chemical	x	x	x		x		x			x	x	
Oxidation	x	x	x		x		x				x	

	Deposition		Features					Artifact Distribution		Artifact Preservation		
Impact	**Buried**	**Surface**	**Rock Art**	**Earthen**	**Wooden**	**Landscape**	**Masonry**	**Dense**	**Sparse**	**Organic**	**Metalic**	**Lithic/ Ceramic/ Glass**
Cracks	x	x	x		x		x					
Fragmentation	x	x								x	x	x
superficial spots/alteration	x	x	x		x		x			x	x	x
warping	x	x			x		x			x		

7.0 Treatment Options

When threats to archaeological integrity are identified, there are a number of possible categories of treatment that may be considered, depending on the nature of the threat and the type and location of the site. Whether some form of treatment is appropriate and if so, the kind of treatment chosen will depend on identifying those aspects of the site that make it important. Furthermore, any treatment options that affect the site will need to be consistent with maintaining the military mission, doable with available resources, and reviewed by the SHPO for concurrence that the treatment approach will not itself damage the site.

7.1 Planning

The planning process can play a role in preserving archaeological sites and landscapes and avoiding cumulative adverse effects. This can involve including land use in an installation's Integrated Cultural Resources Management Plan (ICRMP), especially for land management practices like forestry or grazing that could have an impact on archaeological sites. The types, settings, and locations of archaeological sites in a management area should be assessed, and the specific land management practice adjusted, consistent with the military mission, such that it can continue without significant impacts to the sites. Appropriate management practices for agriculture, timber, and grazing should be in place to prevent erosion or other impacts to archaeological resources. Such planning would be most effective where sites are buried or durable in some way, and the land management practices are shallow/slight.

A system of monitoring changes to the landscape is vital for any maintenance plan in order to identify key issues/problems that need to be addressed or corrected. The best means of doing this is to conduct periodic condition assessments that monitor changes on a systematic basis. CRMs should consider developing programs for active archaeological site monitoring, similar to the program developed for DoD Legacy (Project #09-442) that starts with baseline observations, and systematically collects key data in subsequent years to document important changes (Versar 2010). Passive monitoring using hidden cameras has also been tested on archaeological sites (Merritt and Merritt 2011). In Britain, a study has shown the potential utility of Light Detection and Ranging (LiDAR) and compact airborne spectrographic imager (CASI) in tracking impacts to earthworks on military training lands (Barnes 2003). CASI was found to be effective in showing bare ground and levels of grazing; levels of change could be shown with LiDAR.

It is important to manage archaeological site location information carefully. Some sites may be potentially attractive targets for individuals intent on looting or acts of vandalism. Some sites types, like rock art sites, are particularly vulnerable to damage from human interaction, and some have concluded that the best strategy for their preservation is to not reveal the location of such sites (Swadley 2008). Section 9 of ARPA permits installations to withhold information concerning the nature and location of archaeological resources from the public. Section 304 of the NHPA, 16 U.S.C. §470w-3(a), goes further by requiring agencies to withhold information about the location, character, or ownership of an historic property when disclosure might cause a significant invasion of privacy, risk harm to the historic property, or impede the use of a traditional religious site by practitioners. For this reason, SHPOs keep archaeological site location information confidential, released only to professional archaeologists with a need to know. AR 200-1 requires that Army Installations "not disclose to the public information concerning the nature and location of any archaeological resource for which the excavation or removal requires a permit or other permission under ARPA or under any other provision of Federal law." Air Force Instruction (AFI) 32-7065 stipulates in requirements for ICRMPs that "archeological site locations are sensitive information. Do not release them to the general public." Elsewhere, the AFI instructs cultural resources staff to "consult with the local Staff Judge Advocate before withholding of any information pursuant to [the confidentiality provisions of ARPA and NHPA] and coordinate, through channels, with HQ USAF/ILEV." The AFI adds that installations should "take reasonable measures to maintain the confidentiality of sacred site locations." In keeping with this practice, access to site location GIS information maintained as part of an installation cultural resources management program should be restricted.

In some cases, it may be advisable to develop specific preservation plans for some identified archaeological resources. This may be particularly true of cultural landscapes with archaeological elements because of their dispersed nature. Management and treatment plans can vary in how aggressive they are about changing the existing landscape. The simplest plans would be maintenance guides to ensure ongoing repair of existing features to maintain historic continuity. A treatment plan on the other hand could involve more extensive replacement and removal of intrusive features. Regardless of intent, any plan should conform to the general principals identified in the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. The four basic treatment options that can be applied are preservation, rehabilitation, restoration, and reconstruction. Preservation is the most non-intrusive of the four treatment options and involves primarily stabilizing and protecting historic resources. Rehabilitation often introduces new improvements to cultural landscapes that already have at least some historical integrity. Rehabilitation efforts, for instance, can make a landscape more adaptable for modern purposes, while also improving or maintaining its historic appearance. Restoration and reconstruction activities are more aggressive treatments designed to transform the current landscape into a better representation of how it looked in the past, and are less commonly applied to archaeological resources. Restoration and reconstruction involves removing features not originally part or compatible with the significance of the cultural landscape and replacing with features that were once part of the historic landscape. Reconstruction often involves a complete redesign of the landscape where no or little historic features are present to return the landscape to its historic appearance.

A treatment plan should be completed based on a consideration of the current use in support of the military mission, and an analysis between conditions of the existing landscape vs. its appearance during its period of significance. The latter will determine the degree of integrity that exists, which in turn determines the intensity of available treatment options. As a general practice, removal of historic features should be avoided. Only non-historic features should be removed. In cases where the landscape has high integrity, preservation and maintenance will likely be the prescribed treatment options. The primary goal of preservation is to stabilize and maintain the existing character of the landscape in support of its current use, consistent with available resources. Annual inspections and studies should be conducted to monitor changes to the landscape, such as the health of plant life and changes within the built environment (buildings, walls, roads, agricultural features like irrigation systems). Threats to character defining elements should be removed in a manner that poses no harm to historic features. Any introduction of any new elements must match or be compatible with historic features in design, scale, color, and texture. Land-use, plant life, and other features incompatible with the historic character of the landscape should not be introduced as part of any treatment plan. An important consideration is to recognize that changes to a historic landscape during its period of significance do not detract from the integrity of the original composition. Instead, such changes illustrate the evolution of the cultural feature in a manner that does not detract from its integrity. Any efforts to restore a significant landscape to a particular historic setting and remove such features would in effect adversely affect the resource.

7.2 Hardening

In historic preservation terms, hardening refers to the protection of an archaeological site through construction of a physical barrier. It may include the intentional burial of a site, the erection of external support structures such as scaffolding, or covering the site with durable material to reduce the risk of erosion.

7.2.1 Burial

One of the simplest and most often proposed methods of hardening an archaeological site is burial. An Arizona SHPO assessment of site burial methods outlines a number of factors regarding the process (AZSHPO 2004).

1. Burial-in-place will preserve an archaeological site's contributing elements and important data values (i.e., Register-qualifying characteristics) situated within the treated area.
2. The site or portion of thereof subjected to burial-in-place will be Protected in perpetuity.
3. The Research Value of a site considered for burial-in-place must be assessed prior to treatment.
4. Preserving the site or portion thereof through burial-in-place should be more Cost-Effective than conducting data recovery excavations or implementing other options.

Site burial is attractive for its simplicity, and offering the opportunity to reduce archaeological encroachment on the military mission. But whether burial could introduce unintended consequences to an archaeological site has to be carefully considered. Adding additional soil to a site might bring about long-term changes to the site environment, for example. Fill material will likely be different in character from site soils, which could alter the amount and species of ground cover, change the attractiveness of the site as a habitat for burrowing animals, insects, and worms, or alter soil chemistry and moisture content which in turn may directly affect artifact preservation (Nickens 2000). Intentional site burial can also introduce changes associated with compaction (Thorne 1991), while changes in the ground surface may create new erosion patterns that could be a threat to other sites in the vicinity. Care must also be taken to avoid inadvertent mixing of introduced fill materials with archaeological layers below. Whether the burial method is reversible may also important to consider if potential site stake-holders could require access to the site to gather data or other purposes, the latter including those identified under the American Indian Religious Freedom Act (AIRFA).

7.2.2 Scaffolding

Scaffolding or other structural support can be used to protect exposed foundations that are significant and warrant preservation, but will deteriorate if no action is taken. Pressure-treated wood scaffolding has been successfully employed at MCB Quantico and Fort Drum on archaeological sites with exposed open-laid stone foundation features (Wagner et al. 2007). The scaffolding was designed to add support to the masonry features without altering them. Considerations in employing this kind of treatment would include whether the scaffolding would be considered to have any adverse effect on the site (such as visually detracting from a site significant for more than its information potential), and what the long-term maintenance costs of any scaffolding or supports might be. At Fort Drum, sites hardened in this way have been used as training positions, offering the possibility of an added benefit in support of the military mission.

7.2.3 Other

Other materials that may be employed in site burial or hardening include geotextiles, concrete revetment systems, and even recycled tank treads. All of these materials may be employed as elements of site burial or as part of systems designed to slow erosion. A pilot study using recycled tank treads as a method for erosion control was carried out at Fort Carson in 2001. In working with this method, the Integrated Training Area Management team at Fort Drum observed that tank treads can be difficult to work with, requiring lubricating oil or torches to separate tread elements for arrangement on the ground (Wagner et al. 2007).

In another instance, an experimental program was conducted at two prehistoric sites in the right-of-way for the Iroquois Gas Transmission Pipeline crossing portions of New York and Connecticut. Researchers covered the sites with a geotextile to prevent mixing of fill material with site stratigraphy, and covered that with a layer of 1-2 inch diameter crushed blue quarry stone in order to protect the sites from impacts from heavy equipment. Both the geotextile and overlying crushed stone were chemically inert, and sufficiently porous to allow for water flow. After a period of 3-4 months, the fill was removed and the sites were tested for evidence of alterations. Lithics from the site did not show evidence of breakage or abrasion resulting from the overburden. There was also no evidence of change in site pH, moisture, particle size count or compaction. The only change noted was in soil shear strength as measured by a soil penetrometer. Overall the costs for burial were between 10 and 25 percent less than for data recovery (Ardito 1994). While these results are encouraging, they leave unanswered such questions as the longer-term effects of burial or what the effects might be to sites with a wider variety of artifact materials.

7.3 Interpretation

Awareness is an important component of the treatment toolkit that may be used in protecting archaeological sites from risk, particularly where impacts may result from unintentional or incidental human activity. Among the best ways of raising awareness are education and site interpretation. There is both a logic and a regulatory underpinning for using site interpretation as a protection strategy. The 1988 amendments to ARPA focused more attention on management actions that must be taken to improve the protection of archeological resources (McManamon 1991). Section 10 (c) was added requiring each federal land manager to "establish a program to increase public awareness of the significance of the archaeological resources located on public lands and Indian lands and the need to protect such resources." Regulations implementing this section of the law can be found at 43 CFR 7.20, Public Awareness Programs. The object of this addition was to reach visitors using public lands with a message that archeological resources are valuable to all, that they must be properly investigated and cared for, and that they are protected legally on public lands (McManamon 2000).

As an example of implementation within DoD, AFI-7065 Section 4.13. Public Awareness directs Air Force installations to “establish awareness programs to educate and inform the public about the significance of archaeological resources on installation lands [per ARPA Section 10 (c) and 32 CFR §229.20]. Requirements for cultural resources management that includes public outreach can also be found in Marine Corps Order 5090.2A, change 2 (May 2009), chapter 8 "Cultural Resources Management". MCO 5090.2A includes the text:

> 8202. RESOURCE PROTECTION. Although inventory and evaluation of cultural resources are critical aspects of the Marine Corps cultural resources management program, as well as necessary for compliance with Federal statutes and regulations, management must also include policies and procedures for assessing the condition of known resources, avoidance or mitigation of impacts on cultural resources from Marine Corps actions or the actions of contractors or tenants working on Marine Corps installations, maintenance and treatment actions to ensure preservation or enhance the condition of cultural resources, management of the data related to cultural resources, and public outreach and education.
>
> 9. Public Outreach. Reference (b = Preserve America) encourages Federal agencies to preserve America’s heritage by actively advancing the protection, enhancement, and contemporary use of the historic properties owned by the Federal government; promoting intergovernmental cooperation and partnerships for the preservation and use of historic properties; inventorying resources; and promoting heritage tourism. A preservation awareness program must be directed to both Marine Corps personnel and external interests if it is to be effective. Education can promote awareness of important Marine Corps cultural resources projects and the rationale behind them. Special events with local and national significance offer excellent opportunities to educate the public on cultural resources preservation. Events such as Earth Day (22 April), Fourth of July, Veteran’s Day, National Historic Preservation Week (third week in May), National Public Lands Day (last Saturday in September), and local town celebrations are opportunities for the Marine Corps to help educate people about cultural resources and preservation principles.

7.3.1 On-site Interpretation

Developing on-site interpretive materials may not be a common treatment on military installations, but in some cases where funding is available, it can be a valuable tool for raising awareness about sensitive archaeological resources in heavily visited areas, as a form of alternative mitigation, or a means of educating the public about particularly important cultural resources. On DoD installations, it can also be an opportunity to highlight important chapters of military history. The literature on site interpretation often emphasizes that working with the members of the local community on preservation can help foster a sense of ownership of the resource in question, helping to preserve and protect the site, and has led to substantial reductions in unknowing destruction and casual vandalism (McManamon 2000). On-site materials can be either fixed (such as historic markers or displays), or dynamic, (such as guided tours).

On-site interpretive materials are available at the Charlesfort-Santa Elena National Historic Landmark on Marine Corps Recruit Depot Parris Island. The more than 60-acre site was the capital of Spanish La Florida from 1566 to 1587. Because of the site's great historical significance, the installation has developed a number of on-site interpretive initiatives. These have included a trail system with 26 signs describing the area's history. Interpretive brochures were also made available along the historic walking trail. The trail directs pedestrian traffic away from potentially fragile areas of the site at the same time that the educational materials describe its history. The materials developed for the Santa Elena site were among the reasons cited for awarding MCRD Parris Island the 2004 Secretary of Defense Environmental Award for Cultural Resources Management (DoD 2004b).

In certain circumstances, the significance of the site combined with a relatively inaccessible location make guided tours a good choice. This is the case with the Coso Rock Art National Register of Historic Places District and National Historic Landmark on NWS China Lake. The canyons of the Coso Mountains contain the largest concentration of petroglyphs in the western hemisphere, and include thousands of images dating as early as the Paleoindian period (NPS 2007). The petroglyphs are of great interest to scholars and the public alike. To meet the challenge of maintaining security at the site while allowing public visitation to this important area, the Navy has formed a partnership with the Maturango Museum to offer tours (http://www.maturango.org/). In a separate example, public access is also available via hiking trails to the Garden Canyon Petroglyphs on Fort Huachuca, Arizona. In a small number of cases, particularly important sites are accompanied by museums open to the public. Examples include the museum at Fort Sill (http://sill-www.army.mil/museum/) and the Parris Island Museum.

7.3.2 Off-site interpretive materials

While on-site interpretation may be useful in reasonably accessible areas, it is less clear that such an approach would be of value for sites located on remote training grounds or areas where access is restricted because of the needs of the military mission, or for other practical, safety, or security reasons. In other instances where there is a compelling reason to make information about the site available to the public, off-site interpretive or educational materials can be considered. Such off-site materials could include brochures or websites. Brochures have the advantage of being relatively low-cost, and can be distributed during special events such as Earth Day (22 April), Fourth of July, Veteran's Day, National Historic Preservation Week (third week in May), National Public Lands Day (last Saturday in September), and local town celebrations.

Such materials can be about a specific site, or they can also be about preservation issues. The DoD Legacy Program has produced a wide variety of inventive examples to serve the latter purpose. For example, faced with the problem of U.S. service members stationed in Iraq and Afghanistan inadvertently or unintentionally damaging archaeological remains, the Central Command with the aid of the DoD Legacy Program developed educational materials designed to raise awareness about archaeological preservation. Among the more creative solutions was to distribute cultural heritage awareness playing cards to personnel, with examples of site types and artifacts, accompanied by important preservation lessons.

The development of web enabled content offers the possibility of broader distribution to a wider audience at low cost than could be achieved with physical materials. Many installations have developed web-based interpretive programs related to installation history or to specific sites. DoD Legacy Program Project 03-196 produced a national guidebook for military heritage sites (DoD 2003), which includes links to websites where available. Example installation cultural resources websites accessible as of December 2011 include:

- Camp Lejeune (http://www.lejeune.usmc.mil/emd/Cultural/HOME.htm)
- MCB Quantico (http://www.quantico.usmc.mil/activities/display.aspx?PID=1695&Section=NREA)
- Parris Island (http://parrisislandmuseum.com/index.html)
- NAWS China Lake (http://www.cnic.navy.mil/ChinaLake/OperationsAndManagement/EnvironmentalSupport/CulturalResources/index.htm)
- Fort Belvoir (http://www.belvoir.army.mil/ (click on About Fort Belvoir and Historic Fort Belvoir)
- Fort Benning (http://www.cr.nps.gov/seac/benpopvl.htm).
- Fort Drum (http://www.drum.army.mil/PublicWorks/Pages/CulturalResources.aspx).

Materials used on installation history websites have included explanatory text, photographs, historical imagery, maps, and occasionally, artists' renderings. Advances in digital media are making more intensive site reconstructions a possibility. While 3D digital renderings have become commonplace for monumental sites in Europe, adoption in the United States has been relatively slow. However, there are some fine examples being carried out at Colonial Williamsburg and the 3D Colonial Philadelphia project (http://research.history.org/DHC/VW.cfm and https://www.drexel.edu/news/innovations/virtual-history-lessons.aspx). In addition to reconstructing archaeological sites in three dimensions, models of historic places can be animated to show how they may have functioned in the past. This developing technology offers the potential for a virtual experience of lost or inaccessible historic sites unlike what can be provided by more static interpretations. In addition to having strong appeal for public outreach, such content could be incorporated into digital training materials designed to help troops learn to recognize sensitive cultural resources prior to deployment to areas where such recognizing such resources are an important part of the mission.

In terms of priorities for future action, significant sites with limited access and current interpretation should be considered priorities. There are many highly significant archaeological resources on DoD lands that could warrant this level of attention, consistent with the military mission, and given available funding. As an example, a partial and informal list from Air Force installations could include:

1. NHL Rogers Dry Lake, Edwards AFB, CA
2. Homestead Cave, Hill AFB, UT,

3. Rock art at Snoopy Rockshelter, Hill AFB, UT,
4. Lower Lead Mine Hills (aka Tonka Boy Cave) cave site, Hill AFB, UT
5. Beacon Ridge Village, Hill AFB, UT,
6. Mosquito Willy's Archaeological Site, Utah Test and Training Range (UTTR), UT,
7. 16th Century British Homestead Site, Eglin AFB, FL
8. Rock Art sites, Nellis AFB, NV,
9. Intact wooden dugout canoes in swamp bogs at Avon Park AF Range, FL
10. Woodland Period (IIRC) mound site, Wright Patterson AFB, OH
11. Dry cave sites on UTTR, possibly including Hogup Cave and Jukebox Cave (can't recall if they're on or adjacent to AF lands)
12. Open Paleo-Indian sites associated with Pleistocene Lake Bonneville, UTTR, UT,
13. Rock art and spring-side habitation sites on the Barry Goldwater Range, AZ,
14. Large shell-midden sites, Vandenberg AFB, CA,
15. Late Paleo-Indian surface sites, Juniper Butte/Saylor Creek ranges, Mountain Home AFB, ID,
16. WWII wooden and concrete mockups of ships, V-1 launchers, U-Boat pens, industrial facilities, Edwards AFB, CA and Eglin AFB, FL,
17. Pueblo II village structural sites, Kirtland AFB, NM,
18. Portions of the "Portage" section of the Lewis and Clarke Trail, Malmstrom AFB, MT,
19. Plains Indian Late Prehistoric winter villages on or adjacent to FE Warren AFB, WY.

7.4 Barriers and Signage for Visitor Control

In cases where potential impacts to sites are such that physical access should be restricted where possible, techniques such as barriers, signs or landscaping may be effectively used.

7.4.1 Fencing

A physical barrier may be placed around a site to limit access. In the case of a highly visited site that is deteriorating because of foot traffic, fencing can help steer pedestrians away from the most vulnerable areas. For example, fencing was part of the proposed mitigation for an interpretive trail at Anderson AFB (Tomonari-Tuggle 2002). Rock art suffering damage from human interaction could be protected by a plexiglass barrier. Potential shortcomings of barriers include detracting from the visual setting of a site—plexiglass could make photography difficult, for example (Swadley 2008); improper installation that might damage site materials; and barriers could draw unwanted attention to a site. Physical barriers would seem to be appropriate if they do not impinge on current use needs where a site location was already subject to substantial visitation and its visual context was not a significant aspect of the site.

7.4.2 Signage

Signs are another means of both calling attention to the presence of an archaeological site to help lessen unintentional impacts and involving the public in site stewardship through education. Nickens (1993) discusses the merits and successes of this approach and notes that part of determining the usefulness of signage as a means of protecting archaeological sites is an understanding of the psychology of vandalism.

In 1987 the U.S. Army Corps of Engineers Waterways Experiment Station (WES) conducted a nationwide survey of federal land managers about the effectiveness of signage in protecting archaeological sites followed by a brief assessment of the effectiveness of signage in reducing looting at the Anthony Shoals archaeological site (Jameson and Kodack 1991). Among the questions asked was whether respondents had noticed a change in looting of resources after signage. The study concluded that signs do not usually increase on-site looting/vandalism. Among 83 responses, 64 percent reported either a decrease or no change in these activities, while only 11 percent reported an increase (Jameson and Kodack 1991).

The authors further noted that signage is an important aspect of successful ARPA prosecutions. Most prosecuting attorneys, before taking or pursuing an ARPA case, ask if the resource in question was signed; the argument of specific *versus* general intent becomes moot when the site is signed. Other protection statutes, such as 18 U.S.C. 641 (theft of government property) and 18 U.S.C 1361 (destruction of government property), which have been used in the prosecution of looters, are also much easier to enforce when a site is signed (Jameson and Kodack 1991).

7.4.3 Landscaping

Landscaping in this sense typically refers to minor alterations to the context of a site, often in the form of ornamental plantings, designed to provide a physical barrier, direct traffic away from sensitive areas, or make the site less visible or attractive.

For sites that have been subject to looting, for example, the NRCS (2006) recommends low-lying plantings to avoid giving looters a way to hide their actions. Dense shrubs could be used to steer foot traffic away from portions of a site, although planning should ensure that the plantings would not cause root damage to archaeological deposits. Well maintained environments surrounding accessible or interpreted sites may help reduce the likelihood of vandalism, yet some forms of shrubbery could provide a hiding place for looters (Swadley 2008). Plantings can also be used to screen undesirable views of recent development that might otherwise detract from a site’s integrity of feeling.

In areas with frequent foot traffic, constructing intentional trails may help in preventing development of numerous ad hoc trails that might damage a site directly or expose it to erosion. “Trails should be designed so that runoff is kept in natural channels whenever possible or dispersed broadly over the landscape using waterbars or similar structures, and the trail surface should be pervious to eliminate runoff (impervious surfaces, such as asphalt, require more runoff management)” (MacDonald 1990:16).

Eroding footpaths leading up the side of mounds or earthwork sites have been successfully replaced with stairs on some historic sites in Florida. Introduced fill has also been used effectively to limit damage from foot traffic on eroding trails (Florida Heritage 2004).

7.4.4 Combined Methods

Combining fencing, signage and landscaping may be more effective than any of these methods alone. Carlson and Briuer (1986) studied the effectiveness of various archaeological protection measures instituted prior to an increase of training intensity in the west Fort Hood training area. The study employed a variety of different protective measures including:

- Wire and signs falsely warning of environmental hazards;
- Wire, signs as above, and brush;
- Berms, road blocks and other barriers;
- Burial;
- Off limits signs
- No measures (control group)

The authors found the results somewhat inconclusive because of small sample sizes; however, they did conclude that there was some evidence that site protection measures were successful in reducing the level of impacts. Site condition re-assessments found that conditions had deteriorated at 10 to 30 percent of the sites in the west Fort Hood training area per year after training intensity was increased, but the majority did not show evidence of deterioration. Overall, protection measures including burial or a combination of barriers (signs, fences, etc.) performed better than off limits signs alone, or no protective meaures (Carlson and Briuer 1986).

7.5 Stabilization

7.5.1 Revegetation

There is a substantial literature on using plantings to manage and protect archaeological sites in many parts of the world. In the United States, specific guidance developed by the NPS and the NRCS is available (see the National Clearinghouse for Site Stabilization; http://www.cr.nps.gov/seac/stabil-clearinghouse.htm, NPS Southeast Archaeological Center (SEAC) nd). Plantings can help protect archaeological sites from wind and water erosion, and in some cases, may help prevent intentional or unintentional human impacts to sites. In general, plant roots help hold soil together, preventing it from being blown or washed away. In many ways, grasses may be preferable to trees because their root systems are smaller and less likely to damage subsurface archaeological features. Planting trees on archaeological sites is less desirable because of the potential impact of their roots, but planted away from archaeologically sensitive areas, some trees may serve as a windbreak.

The National Soil Conservation Service in Mississippi has prepared guidelines for plantings designed to help stabilize and protect archaeological sites, especially mound sites. The NRCS recommends native grass mixtures because not only do they help stabilize soil, they can improve water quality and provide habitat for wildlife. If trees must be planted, “oak species are preferred over many deep rooted, early successional species such as loblolly pine, sweetgum, yellow poplar (NRCS 2006). Trees should not be planted on earthworks or mounds. The NRCS further recommends no-till planting methods (such as a seed drill).

> After native vegetation has become established management needs to be performed every 2-3 years to promote stand growth, and maintain a proper

> wildlife habitat. The most effective maintenance method is late winter or early spring prescribed burning. This method is the most cost-effective; however, the appropriate state or federal agencies must be contacted before burns are performed. If burning is not an option, mowing vegetation with a bush hog, and spot spraying with herbicide to control specific weed species are alternative options.
> NRCS 2006.

There is some debate among preservationists about the use of trees for site protection, with some preferring forest cover, particularly for earthwork sites. Andropogon Associates (1989) argue that whatever impact tree roots are likely to have had has already taken place. Moreover, they argue, the typically acid soils of forests may actually inhibit some forms of decomposition. There is danger from tree falls uprooting portions of sites, but removing forest cover is argued to be more damaging than leaving forest cover in place since clearing may disturb underlying stratigraphy and expose the site to erosion. Some preservationists recommend that where earthworks are in forest, they should be left in forest. If in cleared forest, the site should be allowed to revert to forest. This management approach stresses the importance of a stable healthy natural environment in maintaining stable preservation conditions. This is a view echoed by Corfield (1996), who discusses sites that have reached equilibrium with their environment and the ways in which changes to that environment may alter hydrology and soil chemistry. Suggested approaches for maintaining light forest over earthworks include prescribed burning and selective clearing.

Whatever the pros and cons of grass cover *versus* forest, some form of ground cover is clearly preferable to bare ground. Table 9 summarizes soil loss rates estimated by MacDonald (1990:20-21), expressed as change in surface elevation over the course of 100 years, for several landcover/slope combinations. Notably, groundcover offers good protection from erosion, even while the effects of erosion are intensified by slope.

Table 9: Soil Loss by Slope

	Slope	
Ground Cover	3%	14%
Bare	20 cm	170 cm
fallow meadow	0.013 cm	1.6 cm
Forest	0.04 cm	0.35 cm

7.5.2 Masonry Stabilization

Although subject to many of the same impacts from natural and human threats, masonry ruins may require different approaches in terms of preservation treatment. The Dictionary of Building Preservation defines a ruin as, “the partial remains of a building or structure that was once habitable (Bucher 1996:395).” Because each ruin is unique in both its link to the past and in its current condition, the preservation of that ruin likewise depends on its particular situation. The most basic aim of conservation is to minimize intervention of the original historic fabric of the feature. Unlike buildings and structures, the conservation efforts are not needed to ensure utility, since by definition a ruin is no longer in use, but rather to prevent catastrophic loss due to severe deterioration. Any plan or program designed for the preservation of ruins should follow a system of regular inspection, preventative maintenance, and repair/reconstruction.

Regular Inspection
A program of regular inspection is essential for monitoring the condition of a ruin. Buildings and structures that become ruins follow a similar pattern of abandonment and neglect that ultimately results in structural deterioration. The process continues even after the structures become ruins and can ultimately lead to the loss of the resource altogether. A good inspection program can identify severe threats to the ruins that could destabilize it before its total collapse. It is advisable to undertake a detailed annual inspection to identify weaknesses that may need to be further monitored or corrected. Inspections should also be undertaken after severe weather or other serious events that have the potential to cause damage. Monitoring to this degree should keep a check on significant threats to the ruins. The earlier such threats are identified, the less extensive conservation efforts will need to be undertaken to stabilize the situation.

Preventative Maintenance
Preventative maintenance practices help eliminate potential threats before they become severe. Preventative maintenance can include any number of activities, such as the removal of vegetation, elimination of water penetration, and site reinforcement. Uncontrolled, invasive vegetation growth is one of the greatest threats to masonry ruins. Saplings and ivy are among the most harmful if allowed to grow uncontrolled over ruins. Over time, plant life that will grow up around a ruin can plant seedlings inside voids in the masonry. As these seedlings grow they can crack and damage masonry that will often require extensive repairs at a later stage. Removal of such threats before the problem causes significant damage to the resource should be undertaken with care to cause minimal disruption to animal habitation. For instance removal in fall and winter months will avoid any bird nestings. Vegetation should also be only removed only after the plant life has been killed. Removal of live plant life is more likely to damage a ruin than a dead plant system (Quinlan et. al. 2010).

Vegetation growth that is non-invasive and no real threat to the ruins in most cases should not be removed. In some instances vegetation can protect a ruin, especially if that vegetation caps any exposed masonry that is vulnerable to water penetration. Water penetration is another potential hazard that can lead to the deterioration of ruins. Ruins are unlike most buildings and structures that have systems like roofs, gutters, etc. to eliminate such hazards. If water is trapped inside exposed masonry, freezing and thawing cycles will likely weaken and damage that masonry over time. Any inspection of masonry ruins should examine wall tops to identify possible areas of water penetration. Sealing an exposed wall top may be a treatment option.

Ground disturbance can also affect the condition of a ruin. The continual weakening of the ground at the location of a ruin can lead to substantial collapse. Ruins located on soft clay or shifting soils are particularly vulnerable, subject to forces ranging from the natural heating and cooling of these soils to actual physical disturbance, such as nearby utility trenching. Ground disturbing activities in proximity to the ruin should be prevented if possible.

Repair and Restoration
Any repair work to an archaeological ruin that is found to be threatened or damaged should be conducted to be as nonintrusive as possible. Repairs should be only undertaken if deemed necessary for the survival of the resource. The first step in any repair program is to stabilize the ruin and prevent further deterioration. The reasons for why the ruin is unstable or deteriorating need to be understood prior to any restoration activity. Any temporary or permanent supporting apparatus should be installed in a manner so as to not damage historic materials. The first principle is to repair rather than replace. Removal of actual historic features and materials should only be undertaken as a last resort to stabilize the ruin and prevent catastrophic failure. Stone and brick masonry often require repair to ensure long term stability. If stones or brick require replacing because of severe deterioration, the replacement should be done with in-kind materials. If original materials cannot be used, then similar materials in shape, texture, and color are required. Masonry repointing should likewise use the same original mortar, but if that is not possible, mortars should match in color and texture to the original. In general, mortar should be used that is softer than the actual building materials. The use of mortar that is harder than the original could likely result in damage to the structure. As a general practice mortar should be softer than the building materials it supports. Masonry structures must be flexible because building materials will expand and contract with changes in temperature. A mortar that is stronger than the materials it holds together will not give, and may cause the masonry to crack.

7.5.3 Rock Art Treatment

Some masonry stabilization techniques may be applicable to rock art sites as well. Rock art sites can be vulnerable to plant growth just as ruins are. In particular, treating lichen growths on rock art can be very difficult. Lichens are easily killed by herbicides, but mechanical scraping of the lichen afterwards can damage the surface of the stone. Furthermore, the chemicals in the herbicides used to kill lichens can stain or contaminate rock art as well as present potential health and environmental risks. Research into lichen encroachment on rock art in Wyoming showed that the use of enzymes, previously used to remove small amounts of organic material from fragile art works, holds some promise for rock art treatment. By dissolving lichens and their filaments or hyphae, enzymes reduce the need for harmful mechanical scrubbing, while the enzymes themselves are less toxic than alternative herbicides (Silver and Wolbers 2004). In another recent approach, Bakkevig (2006) proposes a reversible method of stabilizing weathered rock art using “dissolved calcium carbonate which is precipitated in a calcification process on the weathered rock and in cracks.”

7.6 Recordation

In some cases where adverse effects to an archaeological site eligible for the NRHP for its information potential cannot be avoided, the loss of information can only be mitigated through data recovery. Data recovery in this context refers to recordation of the information that made the site eligible for the NRHP. It is always considered to be a last resort.

> Alternatives for treatment will usually be available, and care should be applied in choosing among them. Preservation in place is generally preferable to moving a property. Over time, the preferred treatment for a property may change; for example, an archeological site intended for preservation in place may begin to

erode so that a combination of archeological documentation and stabilization may be required. If a decision is made that a particular property will not be preserved in place, the need for documentation must then be considered.
Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44716).

No amount of data recovery can capture all of the information value of a site, and data collection using presently available techniques forecloses the possibility of investigation with refined methods in future years. When data recovery is necessary to prevent further loss of integrity, an installation should consult with the SHPO/THPO and develop a data recovery plan consistent with the Secretary of the Interior's Standards for Archaeological Documentation (48 FR 44716). Development of a research design in consultation with the SHPO/THPO is a necessary first step, and should consider how data collected from the site might further research questions identified as a priority by the SHPO or THPO (as appropriate).

7.7 Alternative Mitigation Strategies

Where adverse effects to archaeological sites cannot be avoided, but where data recovery is effectively impossible because it would either be prohibitively expensive or unsafe—a site contaminated with UXO, for example—it may be possible, in consultation with SHPO/THPOs and the Advisory Council on Historic Preservation, to develop alternative methods of mitigating the loss. The flexibility of this approach may be appropriate to accommodate the needs of the military mission on some installations. Examples of alternative mitigation proposed outside of DoD have included creation of public displays and other publicly available interpretive materials related to the resource being lost (Draft MOA for SR99, Alaskan Way Viaduct & Seawall Replacement Program 2008). Alternatively, syntheses of archaeological data from nearby sites, and detailed chert studies have been conducted (Kula and Beckerman 2004). In these cases, stakeholders felt that traditional data recovery excavations represented relatively poor value for the dollars expended versus what could be learned by reallocating those funds to related public outreach or research efforts.

In addition to site-specific alternatives to data recovery, other Memoranda of Agreement (MOAs) have taken a larger, landscape-oriented perspective on cumulative impacts. As an example, the BLM negotiated an alternative mitigation program MOA for energy-related development in the Permian Basin of New Mexico. The MOA developed a research program alternative to the standard approach of archaeological survey and avoidance that had been previously followed. The status quo, stakeholders felt, was returning redundant information at the same time that it was not necessarily adequately protecting important sites. The MOA allows industry participants to contribute to a research fund rather than pay for traditional survey. This has allowed archaeological effort to be focused in areas of greatest interest to regional archaeology stakeholders, and has offered significant advancements in the archaeology of southeast New Mexico that would not have otherwise been possible (Larralde and Schlanger 2010).

As with public outreach, evolving 3D modeling and virtual reality technologies offer new opportunities for creative mitigation. Recordation of historic properties has historically used two dimensional media, but 3D recordation using LiDAR instruments is now possible. With LiDAR, a laser beam is directed towards a building or object, recording the target in three dimensions with a dense point cloud. This allows for recordation that is rapid but more detailed than traditional recordation methods. The results can then be shown in three dimensions, giving the viewer an unprecedented appreciation for the recorded resource. Examples of using LiDAR technology to record and share historic sites can be found at http://archive.cyark.org/. CyArk has been working to digitally preserve important monuments around the world. A recent project is focusing on digital preservation of petroglyph sites.

7.8 Summary

Tables 10 and 11 provide a summary of the kinds of archaeological site impacts that can be anticipated on a military installation, and the categories of treatments that may be applicable to those situations. The first table lists impacts by source, the second by impact type.

Table 10: Human Activity and Archaeological Site Treatments

Table 10	Planning	Hardening	Interpret.	Fence/ Signage	Landscaping	Monitoring	Stabiliz.	Record.
Wind	x	x			x	x	x	x
Water	x	x			x	x	x	x
Fauna	x	x			x	x	x	x
Flora	x	x			x	x	x	x
Freezing/ Thawing	x					x		x
Gravity	x	x			x	x		x
Argilliturbation	x					x		x
Fire	x	x				x		x
Timber	x	x				x		x
Plowing	x	x				x		x
Grazing	x	x				x		x
Mining	x	x				x		x
Construction	x	x				x		x
Remediation	x	x				x		x
Vehicle Training	x	x	x	x	x	x		x
Pedestrian Training	x	x	x	x	x	x		x
Ordnance Training	x					x		x
Recreation	x	x	x	x	x	x		x
Looting	x	x	x	x		x		x
Vandalism	x	x	x	x		x		x

Table 11: Archaeological Site Impacts and Treatments

	Planning	Hardening	Interpret.	Fence/ Signage	Landscaping	Monitoring	Stabiliz.	Record.
Loss of Context	x		x	x	x	x		x
Deformation	x	x	x	x	x	x	x	x
Compaction	x	x	x	x	x	x	x	x
Dislocation	x	x	x	x		x	x	x
Stratigraphic Mixing	x	x	x	x	x	x	x	x
Loss of Volume	x	x	x	x	x	x	x	x
Loss of Elements	x	x	x	x	x	x	x	x
Collapse	x	x			x	x	x	x
Sinking	x	x				x	x	x
Contamination	x	x	x	x		x		x
Mutilation	x	x	x	x		x		x
Salination/Efflorescence	x					x	x	x
Pulverization	x	x	x	x		x		x
Dissolution	x					x	x	x
Discoloration	x		x	x		x	x	x
Exfoliation	x		x	x		x	x	x
Chemical	x		x	x		x	x	x
Cracks	x					x	x	x
Fragmentation	x		x	x		x		x
Superficial Spots/Alteration	x		x	x		x	x	x
Warping	x					x	x	x

8.0 Discussion and Recommendations

This report outlines many kinds of impacts whose individual and cumulative effects can cause significant deterioration of archaeological sites on DoD lands. A variety of approaches to treat or mitigate these problems have also been summarized. In order for CRMs to use this information constructively, an outline for an installation-specific approach to the information is presented, along with a means of prioritizing problems and choosing appropriate treatments.

The first step for an installation CRM will be to identify cumulative risk factors applicable for their installation. Sections 5 and 6 describe specific kinds of land use and settings that should be identifiable in an installation GIS along with the kinds of archaeological site risks that can be expected with those settings and activities. A CRM can then review their archaeological site inventory GIS and the discussion in Section 7 to see if the types of sites they have are vulnerable to identified risk factors. Where potential risks have been identified, it may be necessary to develop a periodic monitoring program to assess whether in fact recorded sites on the installation are deteriorating. If the CRM identifies significant deterioration, they can then select a treatment response as appropriate given their installation’s mission and available funds.

Because resources available to address cumulative impacts to archaeological sites are limited, it is important to be able to prioritize actions. There are many sources of decay or disruption of archaeological sites and materials, but not all of these necessarily represent the same degree of risk. Research conducted by Christopher Mathewson (in Nickens 2000) ranked the relative impact of various decay factors through discussions with interdisciplinary workshop participants. The workshop discussed physical, chemical, and biological processes that affect archaeological preservation. Participants agreed broadly that human activity and erosion represented the greatest threat to archaeological sites. Mathewson further created a matrix assessing the relative impact of different processes on specific archaeological components (Table 12), echoing the results of the workshop (Nickens 2000).

Table 12: Site Processes and Relative Impacts

SITE CONDITIONS	**Animal Bones**	**Shell**	**Plants, Ecofacts**	**Charcoal**	**Crystalline Lithics**	**Granular Lithics**	**Ceramics**	**Features**	**Soil Attributes**	**Metals**	**Context**	**Rock Art**	**Isotopic Context**
Cyclic Wet-Dry	A	A	A	A	A	A	A	A	A	A	N	A	A
Continuously Dry	E	E	E	E	N	E	N	N	N	E	N	E	E
Continuously Wet, Anaerobic	E	E	E	A	A	A	A	A	A	A	N	A	A
Continuously Wet, Aerobic	A	A	A	A	N	A	A	A	A	A	N	A	A
Cyclic Freeze-Thaw	A	A	A	A	A	A	A	A	A	N	A	A	A
Freeze	A	A	A	A	N	A	A	N	E	N	A	A	E
Thaw	N	N	N	N	N	A	N	N	A	N	A	N	A
Compression	A	A	A	A	N	N	A	A	A	N	A	N	N
Movement	N	N	N	A	N	N	N	A	A	N	A	N	N
Erosion	A	A	A	A	A	A	A	A	A	A	A	A	A
Deposition/Sedimentation	E	E	E	E	E	E	E	E	E	E	E	E	E
Microorganisms	A	N	A	A	N	N	N	N	N	A	A	A	A
Macroorganisms	A	A	A	A	N	A	N	A	A	N	A	N	N
Vegetation	N	N	N	N	N	N	N	A	A	N	A	A	N
Human Intrusion	A	A	A	A	A	A	A	A	A	A	A	A	A
Acidic Environment	A	A	E	N	N	A	N	N	A	A	N	A	A
Basic Environment	E	E	A	N	N	E	N	N	A	A	N	A	N
Oxidizing Environment	A	A	A	A	N	N	N	A	A	A	N	N	A

Notes
E = Condition Enhances Preservation/Reduces Decay

A = Condition Accelerates Decay
N = Condit ion is Neutral or Has No Effect
= Site Component s and Conditions

Using this type of impact-versus-preservation matrix, a CRM can identify resources in their installation’s inventory that are most at risk for loss of information. A useful scheme for translating these risks into chronological priorities can be found in MacDonald’s (1990, pg 28) plan for treating erosion:

Priority 1. Presently eroding sites with salvageable data:
treat immediately.
Priority 2. Sites with impending data loss within next 2 years:
plan treatment immediately and execute next FY.
Priority 3. Sites with impending data loss in 2 to 10 years:
plan treatment this FY, execute prior to data loss.
Priority 4. Sites with impending data loss in >10 years:
passive management (avoidance) currently appropriate, but reassess if site conditions change.

In addition to these prioritization criteria, installation CRMs should also consider the relative significance of archaeological sites. For example, an installation might consider developing interpretive materials for NHL archaeological sites not accessible to the public before doing so for other sites. In addition to providing the public with valuable heritage assets information per ARPA and the Preserve America Executive Order, such materials can help raise awareness about archaeological preservation issues, and help prevent deterioration of these non-renewable resources. A list of DoD NHL archaeological sites considered at risk by NPS is included in Appendix A to serve as examples of potential priority sites. Where funds are not readily available to support this work, installations may wish to establish cooperative agreements with stakeholders such as local museums or universities.

CRMs can use site treatment priority lists as the basis of goals identified in the ICRMP, and funding requests as needed.

8.1 Final recommendations

8.1.1 Recommendations for CRMs.

Installation CRMs can use the information in this report to identify archaeological sites at risk for adverse effects due to various cumulative effects. In an example review process, a CRM would:

- review Installation GIS and Sections 4 - 6 of this report to identify land use and environmental contexts applicable to the installation;
- compare identified threats from those contexts against the installation archaeological inventory;
- conduct monitoring program to assess state of sites and threats;

- identify priority issues based on identified threats and cumulative impacts;
- develop treatment plan using Section 8 as a starting point;
- consult with stakeholders, including the SHPO and Tribes; and
- implement a treatment plan as appropriate and funds are available.

8.1.2 Additional Program Recommendations:

- Make ICRMPs more integrated by referencing information on land use, land cover, and future plans available in natural resource and master planning documents.
- Develop monitoring programs to periodically assess the condition of NRHP eligible or unevaluated sites.
- Assess the risks for cumulative impacts, and include that information in the ICRMP.

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APPENDIX A

Archaeological National Historic Landmarks on DoD Land

National Historic Landmarks (NHLs) are designated by the Secretary of the Interior under the authority of the Historic Sites Act of 1935. NHLs are historic and archaeological sites, buildings, and objects which possess exceptional value as commemorating or illustrating the history of the United States. Section 110(f) of the National Historic Preservation Act (NHPA) requires that Federal agencies exercise a higher standard of care when considering undertakings that may directly and adversely affect NHLs, and to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to the NHL (Sec. 110(a)(2)(B) and Sec. 110(f)) (NPS n.d.a).

A searchable database of NHLs has been developed by Heritage Preservation Services and is available online (NPS 2011). The database includes information on the current status of threats to the integrity of the cultural resource. The four threat levels are:

- *Emergency* – recent catastrophic damage has occurred that requires immediate intervention;
- *Threatened (Priority 1)* – have suffered, or are in imminent danger of, a severe loss of integrity;
- *Watch (Priority 2)* – face impending actions or circumstances that likely will cause a loss of integrity; and
- *Blank field (Priority 3)* – there is no known current or potential threat to the landmark.

In preparation for the NPS's NHL condition assessment document issued every other year, the NHL office requests updates on NHLs from the NPS regional offices every even numbered year. These updates are added to the NHL website (Bolasny 2007).

A number of archaeological NHLs on DoD land were on the potential threat list in 2004, based on a previous Legacy report (http://www.denix.osd.mil/cr/upload/07-375_Analysis.pdf). The threat status of these archaeological NHLs was checked against the current database (NPS 2011) and is summarized in Table A-1. Information on the current threat level at each NHL is listed, the conditions assessment, the reason stated for the threat determination, and the DoD installation where the NHL is located. The table is organized in alphabetical order by state.

Table A-1: Threat Status of Archaeological NHLs on DoD Land

NHL Name	Resource Type	State	Town	DoD Installation or Agency	Threat Level in 2008 [or other year]	How Threatened
Yuchi Town Site	Site	AL	Fort Benning	Fort Benning	[Satisfactory in 2002]	None listed (NPS 2011).
Adak Army Base and Adak Naval Operating Base	District	AK	Adak Station	None. Adak Naval Air Facility closed 1997: BRAC (Alaska DEC c.2005). Navy remediating site before reverts back to US Fish and Wildlife Service (URS Corp and US Navy 2009)	Watch	No change. The recently-changed ownership is committed to economic development at the expense of the World War II installations (NPS 2011). Base added to National Priority List if contaminated sites in 1994 (Alaska DEC c.2005). Part of former base in "downtown" Adak being used under interim lease to Adak Reuse Corporation (subsidiary of The Aleut Corporation [TAC]), in land trade with US Fish and Wildlife Service (URS Corp. and US Navy 2009)
Maple Leaf (Passenger Steamer; wreck)	Site	FL	Mandarin	USACE	Not given	Specific threat not specified. Significance includes: Side wheeler vessel launched in 1851; chartered to U.S. Army in 1862; struck a Confederate mine and sank 1864, killing 4 of the crew (NPS 2011). Remains were blocking river navigation so USACE moved wreck to present position in 1882. Located in St. Johns River to west of Mandarin. Rediscovered in 1984. Buried beneath mud and well preserved. Public not permitted to dive on the wreck; artifacts are on view at the Jacksonville Museum of Science and History (NPS n.d.b)
United States Military Academy	District	NY	West Point	U.S. Military Academy	[Watch in 2004]	Erosion of the Revolutionary War earthworks has worsened, now constituting a long-term threat to their survival. Surviving cultural resources from the American Revolution last received stabilization and maintenance during the Bicentennial of the American Revolution (c. 1976). These resources are now demonstrating marked deterioration due to natural causes such as erosion and weathering, which are resulting in the loss of the distinguishing characteristics that make these resources eligible for the National Register of Historic Places. Loss of these resources would constitute an immediate adverse effect to the USMA National Historic Landmark. Rec. + changes since last report: The following tasks

NHL Name	Resource Type	State	Town	DoD Installation or Agency	Threat Level in 2008 [or other year]	How Threatened
						have been identified as necessary for the preservation of significant resources: stabilization of Redoubt 4, stabilization of Romans Battery Magazine, Stabilization of Queensboro Furnace, Flirtation Walk rehabilitation, Redoubts 1 and 2 Viewing Platforms and Stabilization, Kosziuzko's Garden Rehabilitation, Warner House Window Treatment, Stabilization of Redoubts 5,6, and 7 on Constitution Island, Stabilization of Battery Miegs and Redoubt Wyllis and associated battery, stabilization of River Batteries at Constitution Island, rehabilitation of ordnance compounds, stabilization of Chain Battery, stabilization of Warner House foundation, preservation and stabilization repairs at Fort Putnam, waterfront rehabilitation, and family housing rehabilitations. Because of staff constraints and the requirement for close supervision of these projects, projects must be phased over several fiscal years. Phasing has been established based upon levels of deterioration and anticipated loss of distinguishing characteristics displayed by the resources. Budgetary estimates for this work have been developed based on preservation and stabilization efforts currently underway for Redoubts 1 and 2 and their associated batteries (NPS 2011).
Deer Creek Site	Site	OK	Newkirk	USACE. On low bluff overlooking Arkansas River	Satisfactory	The site is fenced and protected from ground disturbing activities. It is overgrown with poison ivy and is not open to the public. There are no changes to the landmark (NPS 2011).
Charlesfort – Santa Elena Site	Site	SC	Parris Island	Marine Corps Recruit Depot Parris Island	Not specified	Not stated.
Crow Creek Site	Site	SD	Chamberlain	US Army Corps of Engineers (USACE)	Watch	There has been some bank erosion and minor looting at the landmark. There are no changes since the last reporting period [2004] (NPS 2011).
Fort Thompson Mounds	District	SD	Fort Thompson (town)	USACE	Satisfactory	There are no threats to the landmark reported at this time. No changes since the last reporting period [2004] (NPS 2011). NOTE: NRHP nomination not available online. Site "on the Crow Creek Indian Reservation" (NPS 2011]. Fort Thompson is the largest

NHL Name	Resource Type	State	Town	DoD Installation or Agency	Threat Level in 2008 [or other year]	How Threatened
						settlement on the Crow Creek Indian Reservation.
Langdeau Site	Site	SD	Lower Brule	USACE	Watch	There is bank erosion at the NHL. There are no changes to the NHL (NPS 2011). NOTE: NRHP nomination not available online. On private land.
Molstad Village	Site	SD	Mobridge	USACE	Threatened	Bank erosion is an issue with this landmark. BIA is now holding it in trust for the Cheyenne Sioux Tribe (NPS 2011). Near Oahe Reservoir/Lake Oahe (USACE 2011). USACE undertook bank stabilization in coordination with local tribes (Brodnicki 2000).
Vanderbilt Archeological Site	Site	SD	Pollock	USACE	[Satisfactory in 2004]	None listed (NPS 2011).
Marmes Rockshelter	Site	WA	Lyons Ferry	USACE	Watch	The rockshelter has been inundated by the Lower Monumental reservoir since construction of the Lower Monumental Dam in the late 1960s. Intermittent monitoring is conducted of this location. There are no reported changes to the landmark (NPS 2011). Archaeological excavations by Wash. State U. 1960s before inundation by USACE (Washington State U. 2011).
Clover Site (46CB40)	Site	WV	Lesage	USACE	[Watch in 2006]	Unauthorized plowing occurs at times. Site is surface collected and materials removed. Recommendation/change since last report: Ensure that site is not plowed and remains planted with appropriate materials to maintain ground cover to prevent further surface collecting. More frequent monitoring of the site to assess and prevent further damage and to discourage and/or control unauthorized surface collecting (NPS 2011). On high flood terrace of Ohio River within Green Bottom Wildlife Management Area.