Chapter 4

Restoration, Conservation, Maintenance, and Protection

Contents

Chapter 4

Restoration, Conservation, Maintenance, and Protection

INTRODUCTION

The United States possesses myriad striking, significant prehistoric sites and structures, restored historic houses, public buildings, monuments, bridges, parks, and landscapes. Yet it has lost many more of these important cultural resources, which were just as reflective of significant historic values and became the victims of neglect, deliberate destruction, or of conflicting community values.

Preservation of cultural resources involves restoration, conservation, and maintenance. It may require extraordinary means, such as diverting a stream bed to protect properties from severe erosion or law enforcement procedures to apprehend and prosecute looters and vandals. This chapter identifies the primary human and natural threats to cultural resources, and discusses the technologies that can be brought to bear to slow, reduce, or eliminate the damage such threats cause. Although each discipline involved in the preservation process has its own specific interests and requirements for technology, successful long-term cultural resource protection include three basic components, each of which uses a variety of technologies:

1. identification and analysis of the primary threats to cultural resources;
2. evaluation, resolution, or mitigation of specific threats; and
3. public education and involvement.

Each component must be integrated with an overall set of strategies for confronting, managing, and reducing the enormous stresses on America's cultural resource base. Public education, which is an essential part of the Nation's preservation effort, is discussed in chapter 5.

THREATS TO CULTURAL RESOURCES

U.S. cultural resources are subject to a multitude of human and natural stresses (tables 14 and 15). The United States is entering a critical period when the many forces operating to destroy important cultural resources may outweigh the efforts to preserve them for future generations. As one archaeologist noted, "The next generation cannot study or preserve what has already been destroyed."[1] For example, fewer than 10 percent of the known prehistoric Mimbres sites in southwestern New Mexico are still intact. Southeastern Utah has experienced sustained losses of its prehistoric resources. More than 60 percent of the ancient Anasazi sites of the region have been dug for ancient pots, baskets, or other salable items.[2]

Economic pressures in other areas have compelled property owners and real-estate developers to achieve the "highest and best, " use of land. That has often meant the most immediately profitable use. Until the first of several preservation tax incentives became available in 1976, the high costs of maintaining historic buildings often meant their demolition and replacement with modern, low maintenance structures that were often out of place in the neighborhood. Urban parks, which contain both landscape and structural elements, are subject to increased visitation, both

[1] Charles McGimsey, *Public Archaeology 3,* 1972. *See* also testimony in hearings on Archaeological Resources Protection Act, 1979.

[2] Carol Ann Bassett, "The Culture Thieves," Science '86, July/August 1986, pp. 22-29.

Table 14.—Human-Generated Threats to Cultural Resources[a]

Agriculture	Neglect
Beautification	Pollution (air and water)
Construction	Preservation activities
Demolition	Recreational technologies
Drilling	(e.g., off-road vehicles,
Energy generation	metal detectors, etc.)
Fencing	Rehabilitate ion or retrofitting
Fire	Site compaction
Firefighting	Timber cutting
Fire rehabilitation	Theft
Grazing	Vandalism
Mining	Visitation

SOURCE: Office of Technology Assessment.

Table 15.—Natural Threats to Cultural Resources

Climate	Freeze/thaw cycles
Salt air in coastal environments	Subsidence
	Pests
Moisture	Blight
Erosion	Fire
Earthquakes	Violent storms (tornado,
Floods	hurricane. etc.)

aNot listed in priority order

minor and major vandalism, and arson. Increased development in urban, suburban, and even rural areas, and (until quite recently) increased oil and gas exploration, have put enormous pressures on what is a finite cultural resource base.

The severity of threats to cultural resources varies depending on the type and the region of the country in which they are found. in the West and Southwest, looting and vandalism are among the most serious threats to archaeological resources. In the Midwest and East, erosion and construction projects tend to cause more damage. Underwater archaeological resources are under severe stress from salvers and uninformed sport divers.

The life expectancy of historic structures, as well as some archaeological sites and landscapes, is threatened by acidic moisture, generated by the pollutions of an urban, industrial society. Inadequate identification, visitation, inadequate managerial/maintenance policies, and malicious destruction are the greatest threats to most landscapes. Far more serious damage is caused to cultural resources by human agency, both intentional and unintentional, than by natural, environmental causes. All of these threats can be significantly reduced by the appropriate application of technology.

Human Threats

Visitation

Over time, visitor amenities, even the wear and tear of visitors' shoes, can do enormous damage to the integrity of any archaeological site, historic structure, or landscape. Managing such stresses to cultural resources requires attention to the varieties of inadvertent harm visitors do and the development of methods to mitigate them. Cultural resource managers must often balance the opposing requirements of encouraging visitors by providing amenities for their safety and comfort, and discouraging them from imposing varieties of inadvertent harm to the resource.

Occasionally, historical accuracy must be sacrificed to protect certain original features, such as flooring and staircases from wear and deterioration caused by heavy visitation.[3]

[3]For example, research revealed that the floors at the Paca House in Annapolis, MD, home of William Paca, one of the signers of the Declaration of Independence, were never covered, painted, or varnished; site interpreters, for authenticity, kept them so. However, heavy visitation is causing some wear and has necessitated the adoption of protective measures.

Photo credit: Hugh C. Miller, Nat/onal Park Service

Minute Man National Historical Park, Concord, MA. Structures such as the North Bridge are often subject to extremely heavy pedestrian traffic.

Photo credit: Lee H. Nelson, National Park Service

Photograph taken in 1965 of carrara marble capital severely eroded by environmental pollutants. Part of the Merchants Exchange, Independence National Historic Park, Philadelphia, PA, erected 1824.

Inadequate Managerial/Maintenance Practices

Managing visitation stresses, maintenance, and restoration requires continuous attention to the needs of the place being preserved. A variety of technologies, including microcomputers, are available to improve such practices and make them more cost-effective.

An Increasingly Acidic Environment

Prehistoric and historic structures and landscapes which were built before the industrial revolution, were created in an environment now altered by acid depositions. In some cases, this threat may override the separate effects of moisture, temperature, and pollutants. The effects of acid precipitation on tangible cultural resources, although experienced worldwide, are not yet well understood. Preservationists cannot wait for society, government, and/or industry to alleviate the problem, but must help to develop the materials, designs, and techniques necessary to withstand an increasingly acidic environ merit. q

Photo credit.' Hugh C. Miller, National Park Service

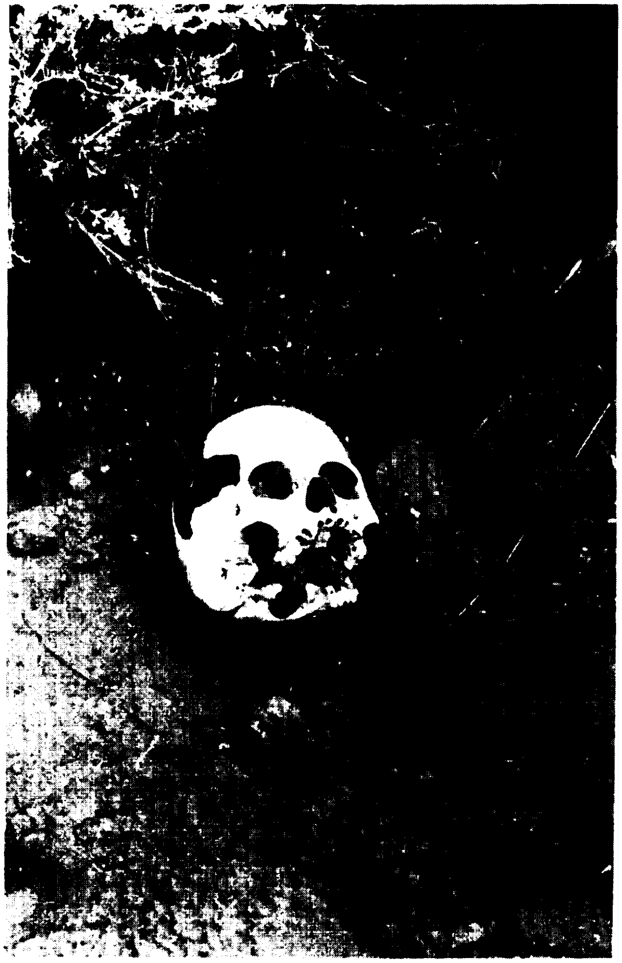
Acid rain monitor at the Eisenhower National Historical Site, part of the Gettysburg National Military Park, Gettysburg, PA.

Looting and Vandalism

Illegal activities, including looting and vandalism, are marked threats to archaeological resources, particularly on public lands in the Southwest and West. As the pressures of urbanization have increased markedly, so have looting and vandalism, in large part because of the high value placed on prehistoric Native American artifacts in national and international art markets. s Recent law enforcement investigations reveal that illegal activities on public lands are not solely the work of local individuals who maintain their own

[4]M. Del Monte and O. Vittori, "Air Pollution and Stone Decay: The Case of Venice," *Endeavor, New* Series, vol. 9, No. 3, 1985.

'Ian Graham, "Looters Rob Our Past, " *National Geographic,* April 1986, pp. 452-460; and Gillett G. Griffin, "In Defense of the Collector, " *National Geographic,* April 1986, pp. 462-465.



Fred

H m A az b
U G
m g

collections, but may also be sponsored by private museums, collectors, and dealers.[6] Looters often have the mechanical means and logistical capabilities, including four-wheel drive vehicles, two-way radios, even light planes, helicopters, and other "recreational" equipment to venture far and quickly into the hinterland. They search out, often quite knowledgeably, the sites with the greatest potential for cultural items and indiscriminately rip them apart,[7] sometimes with expensive excavation equipment such as backhoes and bulldozers.

Looters search out and destroy Indian burials because they often yield significant artifacts. They may unearth the bones, leaving them for animals and birds, and often break and scatter archaeological items of low economic value. Unfortunately, many of the discarded items can yield more information about past societies than the pots, baskets, and other collectors' items. Yet when ripped from their context, they lose most of their informational content.

Participants in OTA's Workshop on Technologies for the Physical Protection of Prehistoric and Historic Sites expressed deep concern about the destruction of U.S. prehistoric and historic sites that results from national and international trafficking in items stolen from public lands. They noted that the problem is worldwide and will require both domestic and international legal action and cooperation. The original location, or provenience, of most stolen archaeological artifacts is impossible to prove, making it extremely difficult to stem the sale of illegal artifacts.[8] The application of law enforcement technology will only slow down the loss of these items.

The Convention on Cultural Property implementation Act[9] prohibits importation of stolen cultural property documented as belonging to the inventory of a public monument, museum, or similar institution within a State that is a party to the UNESCO Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property (see *Chapter 7: Technology and Preservation Policy).* It also restricts archaeological or ethnological materials from other countries on their request and subsequent agreement by the United States.

In the United States, many people who believe that public land should be free to be exploited by individuals, contribute to the protection problem. In many areas, individuals have been collecting from sites on public lands for years.[10]

[6] Jim Robbins, "The Great Artifact Grab, " Chicago *Tribune Magazine*, Aug. 10, 1986.

[7] Bassett, op. cit.

[8] See Graham, op. cit., for an extremely rare case in which an artifact obtained illegally from Rio Azul in Guatemala was traced to that site as a result of decipherment of the Mayan glyphs inscribed on the piece.

[9] Public Law 97-446,

[10] Although southeastern Utah has been the focus of attention recently (see, for example, Bassett, op. cit.; and Robbins, op. cit., such looting is common in many other States.

Some families in southeastern Utah were even encouraged to do so earlier in the century by museum-based archaeologists and received training in how to dig and what to take out. [11] Some residents in these areas tend to be highly resistive to Federal or even State interference in their "recreational" activities. Inconsistent implementation and enforcement of national laws often increase their frustration and contempt for Federal efforts to stop il legal activities. Yet such attitudes could change if Federal managers maintained closer relationships with State and local agencies and with the general public in local communities. In particular, cooperative educational and research programs conducted on federally managed lands and facilities could be effective.

One author has noted that in addition to research on the methods for protecting cultural resources, more information about the detailed nature of human and natural causes of damage is necessary. She also suggests that behavioral research on vandalism might lead to the development of more effective strategies to protect against this highly destructive threat to U.S. cultural resources. Finally, it is important systematically to study the results of various attempts to protect cultural resources in order to improve on protective design. [12]

Other Human Threats

Although extremely serious, most of the other threats caused by humans, either intentionally or unintentionally, are subject to a variety of Federal controls. Federal and State laws and agency regulations attempt to mitigate the effects of commercial timber cutting, grazing, mining, power generation projects, and oil-and-gas activities on public lands.

Unfortunately, many of these controlled activities increase the access to public lands by pothunters and vandals, by creating new roads and tracks into remote areas. In some cases, individuals engaged in legal pursuits during the day appear to turn to looting and vandalism after work. For example, in areas of southeastern Utah where seismic tests and exploratory drilling for gas and oil have increased recently, so have the reports of damage to sites. [13] Federal managers may also inadvertently contribute to such illegal activities by failing to monitor properly the legal uses of the land.

Human disturbances and technology itself are accelerating the destruction of prehistoric and historic places. For example, off-road recreational vehicles (four-wheel drive and dirt bikes) both increase access to remote areas and tear up the surface of the soil, which then erodes much more readily as a result of wind and rain. [14] In addition, some modern building techniques and materials actually hasten the destruction of historic buildings (see below).

Most public land is subject to a variety of uses, some of which are more destructive than others. In order to make informed decisions concerning the cultural resources under their care, managers need better access to information (see also *Chapter 5: Preservation Information).* They also need to incorporate the results of research on stresses to sites into their management plans. Better information concerning the documented disturbances to sites, structures, and landscapes and mitigation strategies based on such information will also aid managers in presenting their case to others.

Studies on cultural resource protection should be published in journals and other widely distributed sources so they will be available to a wider community.

Natural Threats

Erosion

Erosion from wind and water is a significant natural threat to cultural resources. Both historic and prehistoric settlers have chosen to live as close to water sources as possible, leaving their habitats and associated belongings vulnerable to flood-

[11] See Winston B. Hurst, "The Kerr Collection Study: An Archaeological Tale of Woe, and a Study of Burial-Associated Anasazi Ceramics From the Westwater Drainage," Edge of the Cedars Museum, Blanding, UT, in manuscript.

[12] Leslie E. Wildesen, "The Study of Impacts on Archaeological Sites," *Advances in Archaeological Method and Theory 5 (New* York: Academic Press, Inc., 1982), p. 82

[13] OTA Site visit, March 1986.

[14] Wildesen, op. cit., p. 75.

Table 16.—Surficial Bank Deterioration Mechanisms

Mechanism/description
Abrasion: Solid materials carried by wind or flowing water collide with an dislodge surface soil particles. Abrasion also occurs during shiting of winter ice covers.
Bioiogical (an/ma/s): Examples are bank surface destruction during overgrazing and by animal burrows and trails.
B/o/og/ca/(vegetation): Vegetation normally is conducive to surficial stability; exceptions occur during decay of root material and by tree falls or vegetation patterns that concentrate or cause turbulence in overbank flows or streamflows.
Chamicak Water and acids in water affect cohesive and other types of particle-to-particle bonding; bank material is removed by dissolution.
Debris: Debris gouges, or scrapes material from, bank surfaces as well as causing turbulence and flow concentration.
Flow *(water):* Soil particle removal by overbank flows and streamflows is a major cause of bank surface deterioration. Quantity of flow, transport capacity, turbulence, secondary currents, and wave action (see description below) contribute to the rate and location of surficial particle removal. Seepage flows remove surface particles as well as contributing to mass bank failures.
Freeze-thaw: Cyclic temperature changes cause fracture due to excessive contraction and expansion and spalling due to successive freezing and t hawing of moisture within t he bank.
Gravlty The stable slope of a cohesionless bank corresponds to gravitational stability; for steeper slopes, surface particles roll downslope (raveling).
Human act/ens (on bank): Certain human actions attack the bank—loosening the bank surface material by farming or other mechanized operation is one example. Other actions may influence natural mechanisms—the destruction of a protective vegetation cover by livestock overgrazing is one example. Many actions are possible.
Human actions (stream channd": Examples of direct actions are dredging and sand or gravel mining of channel sediments. Examples of indirect actions are structures and vessel propeller motion that cause turbulence in the streamflow. Many actions are possible.
Ice; Ice contributes to abrasion and debris (see descriptions above). Ice jams restrict a channel and affect stream and overbank flows.
Preclpitation: Surficial destruction occurs due to impact by rain or hail as well as during periods of high streamflows and overbank flows.
Waves: Waves due to wind or stream vessel traffic cause surficial deterioration of the bank near the stream water surface.
Wet-dry: Alternate wetting and drying cause stress and chemical effects (see description above) that result in surface soil particle loosening.
Wind: Surface deterioration by wind is normally small as compared with water flow; however, waves due to wind (see description above) contribute to surficial deterioration.

SOURCE: U.S. Army Corps of Engineers, "Final Report to Congress," The Streambank Erosion Control Evaluation and Demonstration Act of 1974, Section 32, Public Law 93-251, Exhibit Vii-i.

ing and erosion. One of the most devastating forms of erosion is the failure of stream banks.[15] Table 16 presents a list of the mechanisms leading to stream bank erosion.

Moisture

Moisture from the ground and the air in rain and humidity of coastal zones is the most devastating threat to historic structures. Moisture encourages the growth of bacteria and fungi as well as insect infestation. insects, such as termites and beetles, live in wet wood and consume its cellulose, causing its disintegration. in addition, condensation; plumbing leaks from bathtubs, shower stalls, sinks, and water pipes; and improperly vented appliances can, if not treated, ruin a structure. Residences, still largely of frame construction, might constitute major conservation problems in the future. Poor building practices are leaving wooden structural and exterior members susceptible to moisture.[16] Wooden components of new construction should be properly treated with preservatives, pesticides, and fungicides.

Moisture can also be of significant concern in landscapes. For example, Monk's Mound in Ohio, the largest prehistoric earthen mound north of Mexico, has recently suffered significant damage as a result of rising moisture in the mound. Rising moisture in structures may cause significant damage to stonely. It may also adversely affect the preservation of prehistoric and historic rock art (see app. B).

[15]" Final Report to Congress, the Streambank Erosion Control Evaluation and Demonstration Act of 1984, Section 32, Public Law 93-251 ," U.S. Army Corps of Engineers, 1981, for a discussion of some of the major mechanisms and their mitigation.

[16]Harry B. Moore, *Wood Inhabiting Insects in Houses* (Washington, DC: U.S. Department of Agriculture); *Finding and Keeping a Healthy House,* Southern Forest Experiment Station, U.S. Department of Agriculture, Forest Service General Technical Report SO-1, 1973.

[17]E. Winkler, *Stone: Its Properties and Durability in Man Environment* (New York: Springer-Verlag, 1975).

[18]See the extensive discussion concerning moisture damage to rock art in Constance S. Silver, *The Rock Art of Seminole Canyon State Historical Park: Deterioration and Prospects for Conservation* (Austin, TX: Texas Parks and Wildlife Department, February 1985).

RESTORATION, CONSERVATION, AND MAINTENANCE

preservation decisions are influenced by two broad considerations. First, at the level of the site, structure, or landscape, cultural resource professionals must generally decide *before* beginning excavation or restoration, on the best conservation plan. At a broader level, managers charged with preserving cultural resources must consider the various goals of preservation and choose appropriate technologies accordingly. Is preservation for future research, for public examination and appreciation, or is it to satisfy certain legal requirements? These considerations affect the management of sites and the expenditure of funds.

Although the preservation of artifacts was not the subject of this assessment, it is nevertheless important to use the best museum technology to preserve the artifacts and other research material that is removed from a property. Some of the technologies used in conservation of artifacts are transferable to sites, structures, and landscapes. However, the applications are quite different. For one thing, artifacts in a museum can be maintained in a controlled environment, modifying light, temperature, and humidity. The much larger scale of sites, structures, and landscapes, and their outdoor settings, bring with them a set of problems not faced in conserving artifacts.[19]

Restoration of a designed landscape often involves rehabilitation of existing elements—pruning and rejuvenation of trees and bushes, dredging of ponds, reconstruction of bridges and walks. it is frequently difficult to find workers who are adequately trained to do such work to the standards required in historic settings. Many of these historic skills are being lost.

Systematic, Long-Term Maintenance

This is one of the most effective methods of slowing deterioration from natural and human agencies, because systematic maintenance (fig. 3) can prevent minor problems from becoming major ones. It is crucial to the conservation of sites and structures, or the elements of a landscape. Quality of maintenance is as important as its regularity.[20]

The designers and builders of many historic landscapes, such as parks and gardens, and historic houses, expected that they would be maintained by adequate numbers of skilled personnel. Today, especially when so many historic properties are owned and maintained by public agencies, the gardeners and other maintenance personnel may not have acquired adequate experience or training. Likewise, contracting stipulations which limit governmental agencies without in-house expertise to accepting the services of lowest bid competitors often result in substandard groundskeeping and maintenance practices.

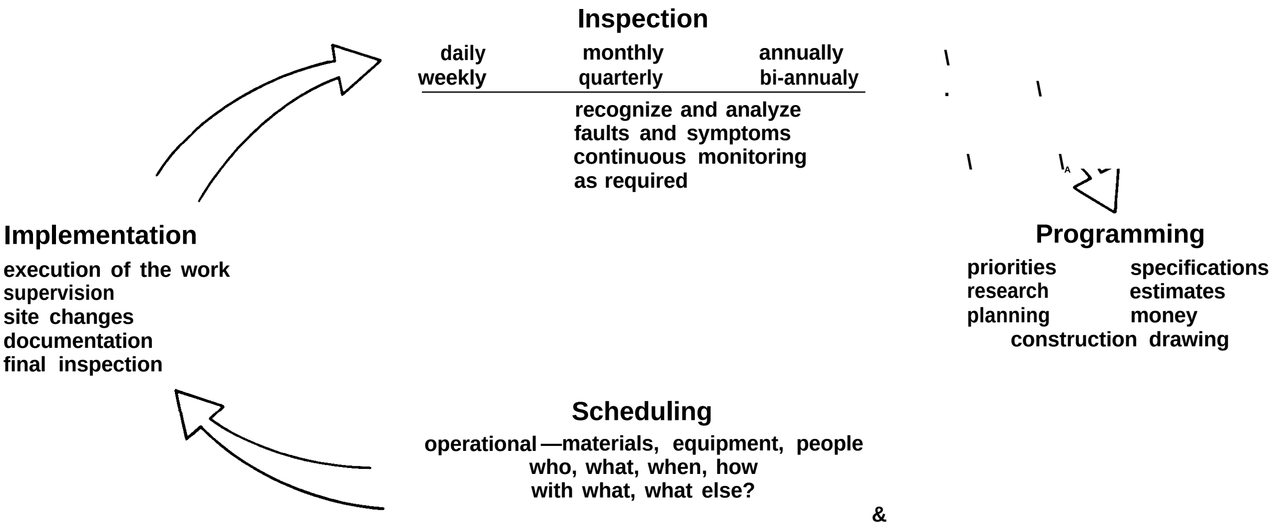
Because maintenance tends to be labor-intensive, it is important to find ways to reduce the amount of labor required.[21] Maintenance standards and plans must be developed and carried out by managers professionally trained in tending historic properties. As noted below, the increased use of personal computers and specially designed software could be extremely helpful in

[19] A striking example of this is seen in the Maya carvings from Yucatan, Mexico. Maya cities were constructed from limestone, the predominant structural material found in the Yucatan. When, in the course of excavation, the limestone is exposed to the atmosphere, it begins to deteriorate. In many cases, bas-relief carvings exposed at the turn of the century and left onsite have virtually disappeared as a result of constant exposure to the elements. By contrast, those from the same era that were stored in a museum context have been maintained in nearly the same condition in which they were found. (Peter Schmidt, Museo Regional Instituto Nacional Antropologia y Historia, Yucatan, personal communication, 1986.)

[20] *Cyclical Maintenance for Historic Buildings,* J. Henry Chambers, AIA, Interagency Historic Architectural Services Program, Office of Archaeology and Historic Preservation, National Park Service, U.S. Department of the Interior, 1976.

[21] Sleepy Hollow Restorations, in New York State, has reduced its total labor force by developing a program of maintenance that employs two levels of skills. For the basic grounds, the organization uses grounds maintenance employees with only moderate training and skills. It employs college graduates for maintaining the historic gardens, Although the latter command higher salaries, their higher skill and professional interest in historic gardens more than repays the extra investment. In the winter, when maintenance needs are less demanding, these workers carry out research projects that they can apply to improving the historic gardens (e.g., searching out the original garden plantings and determining modern sources). Because such workers generally possess higher communications skills, they are also more effective in communicating required maintenance tasks to outside contractors who trim the large trees and do other specialized work.

Figure 3.—The Maintenance Cycie



SOURCE: National Park Service.

improving the quality and quantity of maintenance.

Computer Technology

The computer can be an extremely effective tool for predicting possible effects of stresses to an area, planning for the management of maintenance, and enhancing restoration and rehabilitation.

Visitation.–By using a computer to examine the wear patterns caused by known human traffic in given areas, technicians can develop parameters of wear under a variety of conditions. Managers can then ask the computer to simulate the amount of wear different areas of the landscape or structure might sustain as a result of the same amount of traffic. Such information might then be used to predict how best to channel visitor traffic, or which areas might better handle expected park visitors.

Vandalism.—Experience with a particular historic property provides a variety of clues about which parts suffer the greatest risk of vandalism. Such information can be introduced into a computer model that can then be used to predict other areas of great risk from vandalism.

Site Management.– Maintenance planning and management computer software can assist in long-term maintenance. For example, a computerized management plan for a landscape would allow landscape managers to factor in a number of tasks on a cyclical basis. Each different species of tree, shrub, and plant requires a different treatment. Structures such as houses, barns, bridges, pavilions, and interpretive centers require yet a different set of maintenance strategies. The computer allows computation of needed labor resources based on assumptions about maintenance standards and landscape systems, and provides the capacity to match up such needs with available labor. It also enables managers to develop a schedule for maintenance that takes into account the level of education and skills of the maintenance personnel.

Expert systems (see *Chapter* 5: *Preservation Iformation)* might be especially effective for designing plans for certain maintenance tasks, especially those that call for highly specific, readily describable techniques.

Computer-Aided Design/Drafting (CADD).– This technology is aiding architects and engineers involved in historic structural restoration and rehabilitation through the Federal Government's historic preservation tax incentives program. Their proposals, supported by drawings, plans, and specifications, must undergo strict assessment for approval by the various design review groups within local preservation committees, State Historic Preservation Offices, and the National Park Service. Drawings and views in perspective are time-consuming and expensive to prepare but constitute important components of the rehabilitation certification process.

CADD software enables designers to complete three-dimensional computer models of the buildings on which they are working, simulating or rotating to any selected view of height or distance, perspective or isometric. All perspectives can be reproduced on a line plotter with or without "hidden" lines. This technology dramatically cuts the time and expense routinely associated with completing hand renderings. For example, CADD allows one practitioner to produce over a dozen drawings in 1 day. Normally, three professionals require 3 days to produce three architectural drawings.[22]

Technologies for Reducing Erosion and Stabilizing Landscapes and Archaeological Sites

As noted earlier, whether it occurs from overflowing streams, the variation in water level of reservoirs, or from wave action, erosion is one of the most serious natural threats to landscapes and to archaeological sites. "The methods available for archaeological site stabilization differ very little from those which have been used for streambank maintenance and general erosion control."[23] Comparatively little research has been carried out on the use of such methods. The following methods, among others, have been used with varying success for site stabilization:

- stone riprap,
- concrete pavement,
- gunite,
- used tire mattresses,
- overplanting,
- driftwood facing,
- sandbags and woven fabric,
- GEOWEB, and
- vegetation around underwater sites.

Although many of the above methods would be unsuitable for the long-term preservation of certain historic landscape features, the use of temporary methods such as the emplacement of certain forms of woven fabric, the use of tire mattresses, or fencing, might prove appropriate in some locations until vegetation growth resumed. The historic earthworks at Fort Foote, MD, were stabilized in this fashion.

Cultural Resources Monitoring

Monitoring of archaeological resources, structures, and landscapes is essential for their efficient management. The specific appropriate technology will differ for each type of cultural resource, but the overall goal is the same–to contribute to the protection of the resource.

As noted in Chapter 3: *Research,* because many archaeological sites are not adequately surveyed, their condition is unknown. Even known sites are seldom monitored periodically. The numbers of sites and sheer size of western landholdings render traditional patrol methods unfeasible. Remote sensing, either from the air or from ground-based cameras, may help to establish a baseline. Once a baseline condition is determined, environmental and other sensors might be used to monitor sites in acute danger, either from natural or human threats (see Protection From *Deliberate Destruction,* in this chapter). Education of tourists and the local population is also an important component in site monitoring (see *Chapter 6: Public Education).* Often volunteer help is crucial in looking after sites, especially those in out-of-the-way or difficult-to-access areas.

In historic structures, it is often necessary to monitor the moisture content or the acidity of the atmosphere in order to determine what treatment may be appropriate. For example, monitoring the condition of roofs or cracks and other signs of movement in masonry walls[24] is important in

[22] See Karen Kershaw, "Looking Back, a Historical Perspective, " *Architectural/ & Engineering Systems,* March/April 1986, pp. 34-35.

[23] Robert M. Thorne, "Preservation is a Use . . . Experimental Archaeological Site Stabilization in the Tennessee Valley, " Tennessee *Valley Authority Publications in Anthropology 40, 1985.*

[24] J. Henry Chambers, *Using Photogrammetry to Monitor Materials Deterioration and Structural Problems in Historic Buildings* (Washington, DC: U.S. Department of the Interior, National Park Service, Preservation Assistance Division, no date).

deciding when additional shoring, repair, or replacement may be necessary.

The following discussion takes up technologies and issues that are more specific to archaeology, historic structures, and prehistoric and historic landscapes. As in earlier chapters, underwater archaeology is broken out for separate treatment because of the highly specific nature of the issues related to it.

Archaeology

Comparatively little work has been done on the conservation of adobe, stone, and wood for archaeological use. However, some of the methods that are being developed specifically for historic structures are applicable to archaeological preservation (see below, discussion of technologies for structures).

Today, the Federal Government seldom restores archaeological sites after excavation, especially in climates where they have deteriorated significantly or disappeared from the surface. Such restorations must generally rely too strongly on conjecture about the site's original form and construction. In addition, they are normally extremely expensive. Instead, the excavation is "backfilled" with earth. Where feasible, sites found above ground are stabilized to prevent them from further deterioration.[25] Prime examples of such sites are the prehistoric Anasazi buildings and villages in Navajo National Monument, or Chaco Canyon National Historical Park.

The National Park Service (NPS) has conducted research on the stabilization of many different kinds of structures in many different soil conditions. Even in relatively narrow regions of the Southwest, the soils originally used as mortar or for adobe vary considerably from place to place. Appropriate mixes of portland cement (for strength and durability) and native soil (for color and elasticity) derive from testing the chemical and physical properties of the soils and developing site-specific mixes.[26] NPS now uses a chemical called Roplex, which it adds to the mortar used for stabilizing the prehistoric sandstone structures in the Southwest. Roplex extends the life of the stabilizing mortar which closely resembles the original mortar in color, texture, and consistency.

Photo credit: Ray A. Williamson

National Park Service employee inserting stabilizing mortar in sandstone wall of Pueblo Bonito, Chaco Canyon National Historical Park, NM.

Not every site can be stabilized with the resources at hand. Some sites have eroded to grade level or are reasonably protected (for example, cliff dwellings) and need little additional stabilization. Because stabilization tends to reduce their archaeological integrity, other sites may lose more of their research value by attempts at stabilizing them than if they were simply left exposed to natural forces of erosion .27

[25] It is NPS policy to preserve sites as they are when they are inherited by NPS, as opposed to just letting them deteriorate or restoring them.

[26] See, for example, Dennis Fenn and George J. Chambers, *Laboratory Assessment of Soil-Cement Mortars Used in Prehistoric Ruins Stabilization in the National Park Service* (Tucson, AZ: National Park Service Western Archeological Center, January 1978).

[27] For example, at one Anasazi site in southeast Utah, stabilizing mortar appears to have been used to fill in small ports originally in the walls of one structure. OTA site visit, June 1986.

Sites most in need of stabilization are those that are highly exposed to natural and human threats. Such judgments are often made by archaeologists and other cultural resource professionals, few of whom are experienced in analyzing the need for the treatment. Therefore, there is a requirement for basic guidelines and available stabilization options.[28]

There is no known long-term way to stabilize adobe. If left uncovered, it requires periodic maintenance. Therefore NPS has often resorted to building shelters over adobe or mud structures, such as the remains of prehistoric pit houses. Although such measures protect the structures, they are often esthetically displeasing. Much more can and should be learned about how to stabilize existing prehistoric structures. Structural engineers and architects could be of help in investigating better stabilization methods.

Site Burial

After excavation, unless structures are to be stabilized or reconstructed, sites are commonly filled with sterile soil. Such a practice tends to preserve the remaining unexcavated material. Sites have been buried by concrete or asphalt under parking lots, or by rocks, backfill, or water in efforts to save them for future research. However, the long-term effects of various site burial techniques are not well understood and should be studied.[29]

Rock Art Preservation

Prehistoric and historic rock art contain significant cultural information. For example, in California, numerous rock art panels have been studied in efforts to explore the astronomical observations and knowledge of California Indian groups.[30] In New Mexico, careful examination of the distribution of images among rock art panels along the Rio Grande has demonstrated the movement of certain ideas from Mexico into central New Mexico during the 14th and 15th centuries.[31] Relatively little effort has been expended on efforts to preserve these important cultural resources (see app. B).

Photo credit: Ray A. Williamson

Ancient Pueblo Indian petroglyph pecked on basalt outcropping south of Santa Fe, NM. The quartered circle to the right of the flute player may represent the sun. The quartered circle is a common rock art motif in the Southwest.

Site Avoidance

In many areas, this is considered the method of choice in preserving archaeological sites. Although in some cases, such a strategy is appropriate and feasible, in many other cases avoiding the site simply puts off for a few years an inevitable conflict with other legitimate uses of the land, and the necessity to make decisions about active preservation.

Underwater Archaeology

Conservation and protection of underwater cultural resources, like other underwater archaeological procedures, tend to be expensive and require extremely specialized knowledge and facilities. Concreted metal, waterlogged wood, and other organic materials such as leather or fab-

[28] Jim Trott, National Park Service, personal communication, 1986.
[29] See Thorne, op. cit., for a discussion of several methods of site burial.
[30] Tom Hoskinson and Arlene Benson (eds.), *Earth and Sky: Papers From the Northridge Conference on Archaeoastronomy* (Thousand Oaks, CA: Slów Press, 1985).

[31] Polly Schaafsma, *Indian Rock Art of the Southwest* (Albuquerque: University of New Mexico, 1980).

Photo cradit National Oceanographic and Atmospheric Administration

Concreted anchor from the *U.S.S. Monitor* (sunk Dec. 31, 1862). Anchor recovered 1977. Such a large and heavy artifact excavated from underwater constitutes a substantial conservation challenge.

ric begin almost instantaneously to deteriorate when exposed to the open air after having been submerged or buried under sediments. They must be immediately reintroduced into salt or fresh water, via holding tanks, or wet-packed for transport to permanent conservation facilities. Conservation means perpetual maintenance under controlled conditions.

In the United States there is a shortage of conservation facilities as well as a dearth of trained, competent conservation personnel to deal with the ever-increasing numbers of cultural materials being recovered from the deep. In addition, many projects are directed by non-research-oriented organizations and individuals who betray a lack of knowledge of appropriate conservation methods. The following approaches represent the range of conservation treatments available.

Full-Scale Conservation

This approach calls for the stabilization and continuing care of all waterlogged objects taken from underwater, including ship's hulls. This is the most complex and expensive method, but permits scholars and the public to examine thoroughly historic shipbuilding techniques and any culturally significant contents removed from the vessels. This approach necessitates fully staffed conservation facilities with completely controlled environments (humidity, temperature, light, etc.). Conservation processes are time-consuming and tedious and demand a long-term commitment on the part of any agency or institution that assumes the responsibility for applying them.

For example, the Swedish Government has assumed responsibility for the *Wasa,* a well-preserved 17th century Swedish warship, for the past 26 years at a cost of over $20 million. The Mary Rose Trust is in the early stages of conservation of the *Mary Rose,* a 16th century English warship. Harvard University's *Snow Squall* project (located in the Falkland Islands) is currently recovering the first 30 feet of the clipper's hull. Everyone except the trained conservator is a volunteer. The Mariner's Museum in Newport News, Virginia, has taken on the *Ronson Ship* bow in New York City using private funds, in contrast to the other groups which rely largely on public funds.[32]

Even thoroughly stabilized materials remain extremely fragile. Polyethylene glycol is the commonly used wood consolidant and is very costly. However, recent successful experiments using sucrose promise to lower some stabilization costs. Sucrose is very cheap and seems highly stable.[33]

[32]Sheli Smith, Mariner's Museum, Newport News, VA, personal communication, 1986.

[33]James M. Parent, "The Conservation of Waterlogged Wood Using Sucrose," *Proceedings of the 14th Conference on Underwater Archaeology,* Calvin Cummings (cd.) (San Marine, CA: Fathom Eight, 1986).

Combined Conservation and Documentation

This approach involves stabilizing all small, portable waterlogged cultural materials and documenting large objects such as the hull; it dramatically reduces conservation costs. Though a significant amount of study is still feasible, some technical knowledge is lost. However, these articles must still be housed in properly staffed conservation facilities. For example, the State of Maine conserved the small artifacts recovered from the Defence and made detailed drawings of the hull for only *$20,000.* The Canadian Government conserved all the small objects from the *San Juan,* molded sections of the hull, and recorded the remaining sections with drawings.[34]

Conservation Through Technology

This technique, as yet unadopted, would involve recording all small artifacts with holographic techniques and all large artifacts through molding and documentation. It would require only holding areas and seasonal conservation staffs. The host institution's commitment would be minimal because its staff can easily transport and store all information. There is a drawback to this approach in that it does not yield any tangible artifacts.

No Action

This approach leaves sites submerged or buried beneath sediments. Deterioration of shipwrecks and other objects is slow and advances in conservation technologies may significantly improve our ability to conserve artifacts taken from a submerged environment. This approach postpones the acquisition of knowledge about a site. Future technologies might enable the analysis and interpretation of certain buried underwater archaeological components in situ. The Turkish Government has left several shipwrecks at Yassi Ada uninvestigated. The State of Maine selected one ship for study after a survey of the entire Penobscot fleet. The Commonwealth of Virginia reburied the Revolutionary War period Cornwallis Cave wreck in anticipation of more information on the scuttled British fleet.

[34]Smith, op. cit.

These alternatives represent different emphases in terms of costs, commitment, and conservation facility readiness and capability. Realistic consideration of the pros and cons inherent in each of the above conservation methods should be explicitly reflected in project research plans or archaeological investigations will have only unsatisfactory databases and poorly conserved artifacts.

Historic Structures

The following reflects the current ethic governing the conservation, restoration, and maintenance of historic structures. **"Deteriorated architectural features should be repaired rather than replaced wherever possible. In the event replacement is necessary, the new material should match the material being replaced in composition, design, color, texture, and other visual qualities. "[35]**

A variety of techniques and materials can be applied to historic buildings to conserve and maintain materials and systems. They include chemicals to slow the deterioration of glass, wood, and metal; or to clean masonry; techniques for shoring up structurally weakened or unsound buildings; and paints to protect surfaces. The following issues describe some of these technologies and discuss a variety of problems preservationists face in applying them to best effect.

Both the Misapplication and Nonapplication of Existing Technologies

It is important that architects, engineers, and construction personnel be thoroughly trained in traditional building technologies and the causes of structural materials failure. It is essential that they understand the characteristics of the materials to which they are applying protective treatments.

Historic Buildings.–Well-designed old buildings are systems possessing their own metabolic processes, which have achieved a kind of symbiosis with their environment. The history of

[35]*The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings* (Washington, DC: Preservation Assistance Division, National Park Service, U.S. Department of the Interior, 1983).

the Waverly Mansion, a 19th century historic wooden house located in Mississippi, illustrates this point. The house stood vacant for over 50 years. However, because its builder had understood the effects of a hot, humid climate on wood and had designed an adequate ventilation system, the structure, even though uninhabited and unmaintained for so long, exhibited virtually no deterioration of its members.

A firm understanding of a structure's site, surroundings, and construction can prevent improper rehabilitative treatments for adaptive use. Louisiana plantation houses, whose living floors were routinely raised about 10 feet from ground level, had first floor masonry walls treated with whitewash, instead of paint, to permit passage of moisture or rising dampness. In some cases, such houses have been rehabilitated by removing the whitewash and replacing it with waterproof paint. However, the paint does not allow sufficient moisture to escape from inside the foundation and hastens the deterioration of the wooden walls and other structural members above.[36]

Modern Buildings.–The need for information on materials failures and remedies is not limited to historic structures. Even many modern buildings from the 1960s and 1970s, as well as some still under construction, exhibit potentially serious flaws that could lead to the failure of certain structural elements, notably, steel shelf or clip angles, and reinforced concrete, today's most prevalent construction material.

Many reflect poor building practices and misunderstanding of existing information; some demonstrate unsuccessful attempts at innovation. Such structures present important lessons to preservationists who can benefit from determining why they are failing, and working closely with trade and professional associations to encourage better comprehension of construction techniques, building materials, and structural systems. These buildings represent prevailing attitudes with regard to contemporary architecture and engineering that tend to place extremely low emphasis on long-term maintenance of reinforced concrete and exposed metal shelf angles. Curtain walls may pose a danger because of failing clip angles. As these buildings age, preservations will confront a growing variety of extremely high-risk building systems.

For example, Alcatraz, formerly a Federal prison, but now a National Historic Landmark, contains a cell-house (1909) constructed of porous reinforced concrete. The local marine aerosol environment is causing its reinforcement rods to corrode. Eventually the exfoliating forces[37] of the rust could cause the entire structure to self-destruct. It constitutes an almost insurmountable conservation problem. Conservationists face similar problems with the huge population of high-risk concrete structures built from the period of World War I to the present day. Besides buildings, such structures include bridge decks, elevated highways, and parking garages.

The National Bureau of Standard's Center for Building Technology, among other research groups, is directing much of its investigation and testing toward reinforced concrete structures. Such activity could significantly affect the direction of both modern and historic reinforced concrete structures design and maintenance, allowing some progress toward managing what looms as an almost intractable conservation challenges*

Historic Masonry Conservation

A major preservation problem relates to the proper identification of the various kinds of deterioration to which historic masonry, which includes every type of natural stone, brick, terra cotta, and adobe is vulnerable. Trapped moisture from the ground or atmosphere, salts, freeze-thaw climatic cycles, pollutants, abrasive cleaning, poor repair, retrofit, and rehabilitation, use of incompatible mortar in repainting, improper bedding, and weathering can pose serious threats

36Te$_{ny}$ L. Am burgey, *Assuring Long Service Life From Wood Structures,* Forest Products Laboratory, Mississippi State University.

37The expansion and contraction of trapped moisture, weathering, or chemical action such as the rusting of metal cause exfoliation of stone's surface, that is, flaking, scaling, or peeling in thin layers. See Anne E. Grimmer (compiler), *A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments* (Washington, DC: Preservation Assistance Division, National Park Service, U.S. Department of the Interior, 1984).

38*1984 Building Technology Publications,* **U.S. Department of Commerce, National Bureau of Standards, Special Publication 457-9 for the range of coverage regarding structural concrete.**

Photo cradit: Ray A. Williamson

The Reynolds Tavern, Annapolis, MD. This 18th century historic inn, which once served as the Anne Arundel County Library, has been restored and refurbished and is once again being used as an inn.

to historic masonry. Stone's natural inconsistency and layered composition can also hasten its deterioration. Adobe or sun-dried brick, prevalent in the American Southwest, is particularly susceptible to standing rainwater or splash.

How best to treat historic masonry is still highly complex and problematical. Many new products introduced into the market, such as moisture-proof coatings and consolidants, touted as cure-ails for the problem of stone deterioration are being developed, principally for new construction. They are, however, often applied inappropriately and unevenly to historic masonry and, in many cases, do substantial, even irreparable damage. Historic masonry requires breathable coatings and consolidants that allow for the migration of moisture and salts through internal spaces, cracks, and cavities to its surface. It is critical that careful testing and monitoring of the effects of new products which could be applied to historic masonry be undertaken. Preservationists firmly believe that historic buildings themselves "should not be viewed as testing grounds for untried methods. "[39]

Historic Metals Conservation

Problems associated with the deterioration of metals in America's historic buildings and structures are numerous and complicated. Over a dozen metallic materials are present in this cultural resource base, which includes nails and flashing, bridges, elaborate fences and staircases, fountains, finials, outdoor statues and monuments, structural supports, roofing, and storefronts .[40]

The conservation of zinc, lead, tin, tinplate, copper, bronze, brass, nickel, as well as wrought and cast iron present formidable challenges. Weathering or the result of exposure to the many interactions among chemical and physical elements in the atmosphere may be more damaging to historic metals than the separate effects of individual agents. The combination of humidity, temperature, salts, dirt, grime, acids, and even bird and other animal droppings threatens the integrity of structural as well as decorative or surface metallic materials. Corrosion and degradation are taking place more quickly and extensively, most dramatically because of acid precipitation. Mechanical breakdown seen as fatigue, creep, and abrasion is also a difficult conservation issue. The stress, weakening, deformation, and buckling of metals as a result of of fire have meant the loss of much of the Nation's urban landscape.

The recent restoration of the copper skin of the Statue of Liberty and the replacement of its metal skeleton, its internal support highlighted the damage wrought by the failure of architectural metals to connect. Bolted, riveted, pinned, or welded metal structural members can become disconnected by corrosion, overloading, or fatigue.

protecting metals in historic structures is ideally realized through long-term, regular maintenance coupled with sound knowledge of the behavior of architectural metals within physical environments. Trapped moisture and abrasive cleaning are as damaging to historic metals as to stone or wood. It is important to find and improve meth-

[39] Baird M. Smith, *Moisture Problems in Historic Masonry Walk-Diagnosis and Treatment* (Washington, DC: U.S. Department of the Interior, National Park Service, Preservation Assistance Division, no date).

[40] *Metals in America's Historic Buildings: Uses and Preservation Treatments,* U.S. Department of the Interior, Heritage Conservation and Recreation Service, Technical Preservation Services Division, 1980.

Photo credit: NIcolas Veloz, National Park Service

Photographs of the New Jersey Memorial, Valley Forge, PA showing staining and corrosion of bronze outdoor sculpture and subsequent cleaning. Such discoloration may signify a substantial loss of surface material.

ods for inhibiting and treating corrosion, cleaning surfaces, and to develop appropriate protective metallic, ceramic, or organic coatings. Architects should be fully aware of the load bearing capabilities of structural metals, and proper mechanical repairing strategies, such as splicing, patching, and reinforcing.

Other Major Preservation Research Challenges

Some of the other preservation research challenges are:

- the maintenance and stabilization of fragile historic structures constructed of poor quality materials and never intended to be permanent, such as slave quarters or farm outbuildings.
- the structural integrity of steel frame and curtain walls and unreinforced masonry buildings in earthquake zones. According to structural engineers, unreinforced masonry buildings are among the most dangerous structures during earthquakes. The weight of their exterior walls would mean definite separation from structural framing in the event of tremors.[41] However, they are important cultural resources and account for a sizable portion of the central business dis-

[41] *Guidelines for the Evaluation of Historic Unreinforced Brick Masonry Buildings in Earthquake Hazard Zones* (Los Angeles, CA: A. B. K., A joint Venture, 1966).

tricts and commercial centers in towns throughout the American west. Recommendations for treating them in earthquake zones has ranged from wholesale demolition to a degree of seismic upgrading and retrofit that would be prohibitively expensive and destructive of significant historic fabric.[42]

- the philosophical dilemmas relating to modern building and structural codes, public safety, and politics, a need for a realistic view of "risk and regulation" in historic preservation. Some historic buildings have been so altered to meet modern code requirements that they have been stripped of much of their significance.

Maintenance Information

Detailed information on protective treatments undertaken over the life of a structure is most important to its long-term health. A history of both interior and exterior actions enables informed conservation and maintenance. Past Federal agency maintenance and restoration records should be retained to this end. Federal records managers, many of whom have routinely discarded such records, have only recently recognized their value to preservationists.

Environmental Monitoring

There is need for improved technologies to permit monitoring of the effects of other environmental impacts to which structures are exposed. Monitoring such as that being carried out by the energy industry to determine the effects of sealing structures to prevent loss of heat, and three having been applied in Boston, Massachusetts, to assess changes in groundwater levels reveal much concerning the behavior of buildings and materials.

Building foundations, subway, and underground utility delivery systems such as sewers suffer serious deterioration if groundwater tables are lowered or raised through altered drainage patterns, water removal at new construction sites, or heavy use of deep aquifers. Below the groundwater table, soil is saturated. Untreated wooden piles, used to support the foundations of most of Boston's historic structures, have been decaying as a result of a dropping groundwater table. Such piles are permanent and stable only when they are waterlogged and can repel fungi and dry rot. New construction techniques are reducing and even eliminating the problem. For example, in the Bentonite Slurry Trench method, retaining walls placed around sites prevent the seepage of water into construction areas below the groundwater table and concomitant lowering of the local water level .43

Substitute Materials

There is a range of views within preservation concerning the use of substitute materials. In Europe many preservationists advocate that replacement materials be the same as the original. There is such aversion in much of Europe to substitute materials that preservationists reopen old stone and marble quarries to obtain replacement materials from the same sources as the originals. In the United States, however, some building seismic codes require the use of new lightweight substitute materials to replace heavy stone pieces, such as cornices. Other codes allow the use of replacement materials matching the originals only to a specific height, then require the lightweight substitutions beyond the level at which casual observers would not detect the difference.

Landscapes

Conservation and Restoration Decisions

Who determines conservation goals and decides the extent and authenticity of restoration for landscapes? Who decides which public landscape projects receive priority for preservation? These questions are of concern because few landscapes serve only one function. They also are owned or controlled by a wide variety of public and private organizations, or by individuals. Cultural landscapes, especially, generally have multiple owners.

Parks and other public spaces were created as a result of the public need for open space in ur-

[42] Michael E. Durkin, "Improving Safety in Unreinforced Masonry Build ings, " *Ekistics* 51, November/December 1984.

[43] Harl P. Aldrich, Jr., "Preserving the Foundations of Old Buildings'" *Technology and Conservation, 1979.*

ban settings. They are used by the public for a variety of recreational, social, and educational activities. Other prehistoric and historic landscapes may be subjected to a variety of stresses as a result of changing land use patterns and development, including mining, drilling, and urbanization. Local residents who wish to use a property may see its value and the goals of preservation in a much different light than preservation professionals. For example, residents might rather build a swimming pool or skating rink in a historic park than maintain a scenic view. Or, the public might complain if grassy areas in a historic battlefield were kept trimmed to historic standards, attributing the higher grass of the historic period to lack of maintenance, rather than historic authenticity.

Because restoration and conservation are generally expensive and funding for historic preservation increasingly limited, priorities must be set, taking into account local values for current use as well as those of preservation professionals on the significance and degree of deterioration of the landscape. In addition to seeking advice from the local community, the landscape architect and other preservation professionals may have to educate the community about the long-term value of preserving the local landscape (see *Chapter 6: Public Education).*

Landscape Management

Landscapes change so rapidly that management becomes almost as important as restoration. Managing the growth of vegetation is a particularly important issue. For example, rampant species, such as honeysuckle and poison ivy, must be controlled without doing harm to other species or other parts of the environment. There is a strong need to find alternatives to herbicides and pesticides. NPS, for example, has banned the use of both except as a last resort. Such special cases require extensive documentation to support the need for chemicals.

Horticultural or Botanical Technologies

Authentic restoration and conservation of historic landscapes depends on the ability to identify, locate, and use plants appropriate to the historical period of interest. Landscape restorers and managers need inventories of plants grown in a region or area at different periods of history, and sources from which those plants may be obtained. In turn, the restored landscapes themselves can become an important repository for historic species and thereby assist the maintenance of biological diversity within the United States.[44]

The United States is losing important collections of historic plant materials. Yet we often are not fully aware of which plants growing today in historic landscapes are authentic historic materials. England has met such problems in part by insisting that historic gardens and other historic landscapes be replanted using historic species, even if it means that the landscape managers may have to defer certain plantings because plant stock is unavailable at the time they wish to plant.

Although many species may still remain in private collections and smaller commercial nurseries, there is inadequate knowledge of what exists and little control over the disposition of such stock. It may be necessary to establish arboretums designed specifically to save, nurture, and propagate historic species. Because of the regional nature of plant hardiness and adaptability, such arboretums would have to be regional in scope. Sleepy Hollow Restorations has already started searching out and growing historic plants; Monticello recently announced that it was establishing a historic plant center. However, a central clearinghouse for historical horticultural and botanical information, with a computer accessible database, would also be important in increasing our ability to restore, conserve, and maintain historic landscapes.

It is also important to maintain centers where a number of different specialists are working on landscape problems. For example, the National Park Service's National Capitol Regional Center for Urban Ecology maintains a staff of experts in agronomy, urban soils, and urban wildlife.

[44] See OTA's background papers entitled *Grassroots Conservation of Biological Diversity in the United States, Background Paper #1, OTA-BP-F-38* (Washington, DC: February 1986; and *Assessing Biological Diversity in the United States: Data Considerations,* Background Paper # 2, OTA-BP-F-39 (Washington, DC: March 1986), for a discussion of biological diversity. Both papers are available from the U.S. Government Printing Office, Washington, DC.

PROTECTION FROM DELIBERATE DESTRUCTION

Although education is one of the most effective deterrents to deliberate destruction of cultural resources (see *Chapter 6: Public Education),* a variety of other protective measures are necessary to conserve significant parts of our heritage for future generations to appreciate and learn from.[45]

Technologies for Security

Detailed Inventory of Cultural Resources

Detailed inventory and systematic monitoring of sites are two of the best available protective measures. For other measures to work effectively, agencies need to know what resources they have. Yet, the larger land managing agencies in the west[46] have inventoried relatively few of the archaeological resources, historic structures, and landscapes they manage. In most cases, archaeological sites on public lands are found because development is proposed, land-exchange with a non-Federal institution is initiated, or cases of destruction are discovered.

Further, most agencies have not instituted a program of systematic inspection and routine maintenance of their cultural resources. A number of OTA workshop participants pointed out that Federal agencies tend to respond to threats to cultural resources in reaction to a clear immediate danger rather than planning ahead for potential problems.

Comprehensive, systematic, and complete inventories of all Federal lands would be cost-prohibitive, because of the extensive area involved. However, many areas, more restricted in size, but currently unsurveyed, have high potential for containing important cultural resources. These areas, the likely targets of pothunting and other vandalism, should be better known to agency specialists and managed for their cultural resource values. The appropriate use of predictive locational modeling techniques would be especially useful (see *Chapter* **3:** *Research).* When law enforcement personnel have requested lists of sites that should be monitored, the sites tend to be those that have already sustained damage. Those untouched sites that are unknown to the agency may contain much more information of scientific value than those that have been damaged. Yet, being unknown, they are left vulnerable to potential looters, who find greater time (and the economic incentive) to search them out than do agency archaeologists.

Protective Barriers, Including Fences, Gates, and Boulders To Restrict Access to Sites

The Bureau of Land Management (BLM) has found that fencing and placing signs at Pony Express Stations in western Nevada has virtually eliminated vandalism over the past 8 years. In another example, BLM's installation of fencing surrounding the site of several Anasazi towers overlooking Comb Ridge in southeast Utah seems to have reduced the incidence of vandalism in recent years, However, it also reduces the visual quality of the site.[47] In addition, in certain cases, fencing and signs may attract vandalism by calling attention to the sites, so such methods must be used in ways appropriate to the terrain and the need for protection.

Burying Archaeological Sites

Methods include using top soil, wire mesh, rock asphalt, or concrete to make sites less visible and accessible. Although such methods are often effective in protecting sites from vandals and looters, little research has been done on the effects of site burial on the long-term condition of the buried resource.[48]

[45] See especially, Paul R. Nickens, Signa L. Larralde, and Gordon C. Tucker, Jr., "A Survey of Vandalism to Archaeological Resources in Southwestern Colorado," *Bureau of Land Management Cultural Resources Series 11* (Denver, CO: Bureau of Land Management Colorado State Office, 1981); and Dee F. Green and Pony Davis, *Cultural Resources Law Enforcement: An Emerging Science* (Albuquerque, NM: U.S. Department of Agriculture, Forest Service, Southwest Region, 1981).

[46] Ruthann Knudson, "Contemporary Cultural Resource Managemerit," *American Archaeology Past and Future,* D. Meltzer, D. Fowler, and J. Sabloff (eds.) (Washington, DC: Smithsonian Press, 1986)

[47] OTA site visit, June 1986.

[48] Ibid.

red Wi

E mp B a d Ma ag m g U b g d m
P b d w d a d e b

Use of Interpretive Signs

Interpretive signs have the effect of indicating to the visitor that someone cares about the site or structure. In addition to giving some information about the site, such signs may include warnings of penalties for vandalism and theft. New, inexpensive, vandal-resistant materials have enhanced the effectiveness of signs and messages.

Individuals have had good results in protecting sites by placing informal interpretive notes to explain the meaning such sites have to individuals and why they should not be disturbed or damaged. They are discovered, read, and sometimes added to by other visitors.[49] New plastics make possible the development of nearly indestructible tags that could be written on and placed on sites for future visitors.

[49] Fred Blackburn, White Mesa Institute, personal communication, 1984.

Propagation of Vegetation, Including Noxious Weeds

Planting or encouraging such weeds as poison ivy and poison oak on site surfaces as well as plants covering underwater sites, keeps most people away, and reduces not only vandalism and looting, but also damage as a result of visitor traffic. This is particularly effective, but only for sites where the environmental conditions will support the growth of such plants. Nettles are effective protectors at Plains Indians' bison jump sites.

Permanently Affixing Large Historic Artifacts or Monuments

Bolting, cementing, or otherwise attaching artifacts or monuments to the Earth tend to be expensive, but such methods are generally effective in preventing theft and major vandalism.

Law Enforcement

Measures such as those just discussed, that either restrict access to sites or warn the potential looter of the legal penalties, have been partially successful in protecting sites. However, determined pothunters or vandals can penetrate nearly any obstacle, making law enforcement measures necessary. In many respects, their methods and rationale are similar to wildlife poachers and they can be apprehended in similar ways. Catching looters and vandals committing a crime is primarily a matter of happenstance, although law enforcement officials have had some limited success using monitoring equipment. The following techniques are used by cultural resource managers and law enforcement officials.

Regular and Irregular Patrols by Agency Personnel

This remains the most effective way to protect cultural resources, though it can be quite expensive, especially over large areas. Evening, weekend, and holiday coverage (when it is generally most necessary), is especially expensive. In addition, law enforcement officers have other duties in addition to protecting cultural resources, and are often assigned other caseload work, which reduces their ability to protect cultural resources.

Informants and Secret Witnesses

Individuals who have witnessed or participated in looting or vandalism may for a variety of reasons be willing to give information to law enforcement officials that leads to convictions on the general charge of destroying government property or for ARPA violations.[50] Informal, noncommercial "pothunters" may be the people most likely to become informants. Obtaining their help will require a change in attitudes among Federal agency officials and archaeologists.[51]

Sting Operations

In certain, well-defined cases, it may be possible to catch looters or middlemen by conducting a "sting" operation for stolen artifacts.

Unarmed Rangers

Prospect Park, in New York, has successfully used unarmed, uniformed rangers to patrol the park. They have the power to issue summonses for "quality of life" violations,[52]

Adopt-a-Site

Local residents are often willing to monitor sites or structures, especially rural ones, on a regular basis and report suspicious activity to law enforcement officials. They become the eyes and ears of the agency in the area. In return, however, such individuals should be kept informed about the results of their work and about agency interest in the sites.

Electronic Monitoring Devices

Much of this technology has been developed for the Immigration and Naturalization Service, the Department of Defense, or to serve other national needs. in the preservation community, the use of these devices is increasing as technologies evolve, and become cheaper and better known to it. Both magnetic and seismic intrusion detectors are available. However, they are still quite expensive, and require trained personnel to maintain and use them. Furthermore, in remote areas, law enforcement officials often cannot reach the site quickly enough to be effective even when intruders have been detected by sensors. In addition, such devices pick up legitimate visitors who are there to sightsee or study the site, as well as those with less benign intentions.

Still, such devices can be effective in providing officials with information concerning patterns and cycles of unwanted intrusions at high value sites, thus enabling them to position personnel nearby at critical times. In other words, they must be used in a coordinated fashion.

---

50 Archaeological Resources Protection Act of 1979, Public Law 96-95, Sees. 6 and 7.

51 See, for example, the discussion in Thomas F. King, "The Pothunter as an Ally, Not an Enemy, " *Early Man,* Summer 1982, pp. 38-40.

52 Tupper Thomas and Paul C. Berizzi, "Prospect park: Rebuilding the Past for the Future, " *Parks and Recreation,* June 1985, pp. 24-30.

Remote Cameras

Photographic or video cameras that can survey a scene and can be stat-ted by electronic sensors may be extremely effective in gathering needed evidence on looting or vandalism at selected sites. These devices are also expensive and generally vulnerable to destruction by the very looters and vandals they are attempting to monitor.

Listening Devices

Listening devices are available and relatively inexpensive compared to video, yet they are not used because they may violate first amendment rights.

Alarm Systems

Both fire alarm and break-in alarm systems are generally used in historic structures. To be most effective, they must be simple to use and to maintain. Otherwise, they may be ignored or improperly used.