Archaeological Impact Screenings Reference Guide

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Introduction

This report identifies some common impacts that occur at archaeological sites; describes certain types of activities that may cause these impacts within national parks and national historic sites; and discusses various approaches used to mitigate these impacts. This report can serve as a reference guide to cultural resource managers and those responsible for the design and implementation of projects that may affect cultural resources. It outlines the distinction between the impact and its cause. With an understanding of the different impacts and how they affect cultural resources, it will be possible to make better assessments of impacts caused by a variety of processes. Grazing animals, vehicle traffic and pedestrian traffic can cause soil compaction. Assessing the degree of impact and the effect of the impact on cultural resources have to be determined on a case-by-case basis, as do the mitigative actions to be applied. This report presents information on many of the more common methods of site protection that have been practised and studied, and discusses some of the advantages and disadvantages of each. Many of the approaches to site preservation require careful study and implementation to achieve the desired result.

Site preservation

Cultural resources are limited, unique and rapidly disappearing. Threatened sites have generally been dealt with in one of two ways. Actions have tended to be either excavation or some measure to conserve the site in situ. The conservation approach stresses the need for protection, preservation and management of cultural resources so they will be available to future generations. In contrast to this is the salvage ethic which emphasizes the recovery of archaeological material from threatened sites. While the conservation approach does not preclude all excavation, it sees the preservation of a site under threat as the preferred option wherever it is feasible (Nickens 1991:52).

The Parks Canada Cultural Resource Management Policy (Parks Canada 1994:103) recognizes that cultural resources have a value associated with being part of a larger entity, that of the site or place. That value, the contextual integrity of cultural resources, needs to be preserved through in situ preservation. For many years, archaeology within Parks Canada has been guided by the ethic of in situ preservation of cultural resources recognizing that cultural remains are fragile, finite, and non-renewable and therefore need to be conserved. It is another principle of the Cultural Resource Management policy that the greatest public benefit will come from the protection of cultural resources and respecting their physical integrity (Parks Canada 1994:104).

Archaeological excavation as a mitigative measure has been over-used as a method to preserve data threatened by development. While recovered archaeological data can help to inform us about past cultures, the site is destroyed in the process. Preserving the site in situ is often less costly than excavation and storage, and leaves the site available for future investigation.

From the perspective of in situ preservation, excavation should only be employed as a last resort when all other options for protection have been exhausted. Even then, it should only take place after a number of preliminary investigations have been made, including the completion of a cultural resource inventory and evaluation. Every effort should be made to prevent the destruction of the site and only if that destruction is found to be uncontrollable should excavation be considered. Actions that reduce the potential for long-term conservation of the resource should be avoided (Parks Canada 1994:105).

Mitigation summary

Site avoidance is frequently used as a strategy for site preservation, though there are reasons to be critical of the approach. Thorne, Fay and Hester (1987:2) are among those critics pointing out how the process has been abused. It is not uncommon that an inventory is conducted to determine areas of sensitivity, and then development plans modified only as needed to avoid directly impacting the sites. Frequently such an approach only considers the primary impacts and is motivated by a desire to avoid the expense of archaeological excavation, ignoring long-term site protection issues and the secondary or tertiary impacts the development might have.

Consider the example of a road development. The right of way is moved from its originally proposed route to avoid direct impact to an archaeological site. The change in location, however, does not address the potential for disturbance from activities associated with the road construction through the movement of heavy equipment over the site, the dumping of materials or the activities of work crews. Once the roadway is completed there can be additional impacts resulting from visitors (foot traffic, vandalism, pot hunting) as a previously remote site is now easily accessible. The road could also be responsible for changes in the local environment which can affect the preservation of the site. For example, changes to the drainage patterns or loss of vegetation can cause erosion to spread into the site area, resulting in loss of artifacts and features, and eating away at the integrity of the site and its context.

Thus simply avoiding the primary impact without considering the potential secondary and tertiary impacts to the site does not meet the objectives of site preservation. This potential for indirect impacts too often goes unrecognized. There is an assumption that if the direct impacts have been avoided there will be no consequences to the site as a result of the development. Seldom does any subsequent post-impact or long-term monitoring follow developments where this form of mitigation has been used, resulting in the untested assumption that site avoidance is a valid method of site preservation (Thorne, Fay and Hester 1987:2). While site avoidance provides a short-term measure of protection, it does nothing for the resource over the long term and does not address indirect, secondary or natural impacts that may continue to act on the resource.

When considering the stabilization of standing structures, it is important to understand an archaeological component may be adversely affected by the stabilization effort if it is not taken into consideration. Repairs to standing structures often include work on foundations, sills and joists, and therefore require excavation into archaeological strata associated with the structure. Equal consideration should be given to the buried cultural components lying below the structure when planning the project (Thorne, Fay and Hester 1987:15).

Nickens (1991:56) is another advocate for the preservation of sites through an active strategy of site protection rather than the more common alternatives of avoidance or excavation. He recognizes that in situ preservation of sites is usually a more cost-effective approach than controlled excavation and its associated expenses of reporting, analysis and curation, though he admits the recovery of data through excavation may be the best solution under certain conditions. Among other advantages, preservation allows sites to be excavated with better tools and different research interests in the future.

Impacts and effects summary

Each ground disturbance activity has the potential to damage, degrade, or destroy archaeological and historic resources. These disturbances can be caused by vehicular, human or livestock traffic on natural ground surfaces; the construction of park or visitor facilities (including camping or picnic sites, signage, docks, privies); installation of above or below ground utility lines; development or maintenance of trails, fire breaks or roadways; and controlled burning. A number of these impacts will be dealt with below.

There can also be indirect impacts associated with these activities, such as loss of vegetation cover or organic soils, erosion and the unauthorized collection of artifacts. These direct and indirect impacts can alter or destroy cultural resources and their contextual integrity, or cause their removal. It is not sufficient to simply look at an impact in isolation from known previous or anticipated future impacts. The cumulative effect of all impacts needs to be taken into consideration as each has the potential to be enhanced by past and future impacts to the same resource base. Much of the impact will likely occur in areas already developed or those subject to visitor use.

Definitions

Impacts

Wildesen (1982:54) defines an impact as a measurable change in a characteristic or property of an archaeological site. Impacts can be direct or indirect, discreet or continuous. A **direct impact** is caused by an action that occurs at the same time and place as the impact. An **indirect impact** is also caused by an action but occurs later or at a location removed from the site of the action. The loss of artifacts from a site may be the direct result of unauthorized collection by site visitors and an indirect result of a trail development which allowed easier access to the site. A **discreet impact** occurs once, while a **continuous impact** is recurring. The removal of a site during construction of a visitor reception centre may be a discreet impact, while a continuous impact may occur as artifacts present at or near the surface are repeatedly damaged and moved by ongoing maintenance of the grounds surrounding the centre.

Agents

The agents of impact are the actions that can result in impacts to cultural resources. Plowing, road construction and hiking are examples of potential impact agents that may result in the transferal of artifacts, alteration of sediments by compaction, or removal of both artifacts and sediments by erosion (Wildesen 1982:54). There are also natural agents of impact such as wind, waves or currents which can cause site erosion.

Effects
An effect is a judgment about an impact as it relates to the archaeological values of the site. Impacts are determined by the observation, measurement and description of physical changes while effects are determined through reference to a set of standards. Impacts can be quantified while effects are either present or absent. In order to determine the presence of effects, there must be thresholds for impacts which allow for the identification of effects once the threshold is crossed (Wildesen 1982:54-55).

Impact Types
In developing a successful preservation strategy it is important to understand the impacting force. Impacts can be classified into a relatively small number of types (burial, removal, transferal, alteration) under which more specific terms may be subsumed (Wildesen 1982:53-55).

Burial
Burial refers to the covering of cultural resources. While archaeological sites are typically found to occur in a buried state, and burial is often a prescribed measure for site protection, it does constitute a measurable change in the resource and its effects need to be considered.

Removal
The removal of cultural resources may be intentional as with pot hunting or unintentional as is the case with erosion or mechanical earth-moving activities. In either case the result is the total loss of the resource.

Alteration
Alteration can take many different forms. In some cases the alteration may not be significant to the resource but in other cases it may be very detrimental. Different materials may have different tolerances to the types of alterations that occur. All archaeological sites are undergoing changes. The specific changes and the speed with which they occur will be important aspects to consider in determining the effects of a given alteration on a resource. Two types of alteration are compaction and burning.

Compaction
Soil compaction is a common impact associated with camping and trail use in national parks. It can occur as a result of pedestrian, vehicular or animal traffic, and has the potential to alter the contextual integrity of the site, the nature of the sediments containing archaeological resources and the inferences that can be drawn from them. It may also damage exposed or shallow buried artifacts, alter their spatial relationships or cause previously buried artifacts to become exposed. Damage from compaction is a particular problem with more fragile objects such as bone or ceramic. The effects of compaction on soils can include reduced porosity; chemical alterations; changes in moisture content, temperature and microbes inhabiting the soil; and the loss of surface organic horizons. The reduction in soil moisture capacity can lead to increased runoff.

Among the factors that determine the amount of compaction that will occur are the nature of the impact agent; the distribution of the compacting activity (concentrated or dispersed); the number of impact events; and the nature of the site sediments and enclosed archaeological materials. An appreciation of these factors are required in order to determine what degree of impact will constitute an adverse effect on a cultural resource (Wildesen 1982:64).

Heavy visitor use at campgrounds and trails has repeatedly resulted in increased compaction with similar effects resulting from grazing cattle (Wildesen 1982:63). The amount of use, along with the type and amount of initial vegetation cover, soil moisture, initial bulk density and soil texture, are all factors in determining the amount of compaction that can occur. Some studies suggest compaction amounts level off after several years of such use. The degree of compaction varies with depth. In one study, maximum compaction was found to occur in a zone lying between four and 16 inches below surface (Wildesen 1982:63).

Moist soils with variation in particle size and containing little organic matter are more prone to compaction. Organic content can protect soils from compaction, but as organic matter is often removed through trampling, the underlying mineral soils become more exposed and prone to compaction. Compaction decreases pore space and moisture content, and reduces the capacity of the soil to absorb moisture, increasing the potential for runoff and erosion. The erosion potential increases in soils with little variation in particle size and particularly those with high amounts of silt or fine sand.

Burning

Fire can have direct impacts on cultural resources and can also interact with other impact agents to multiply the effects. It can destroy organic matter and alter the chemical properties of soils; enhance erosion potential, particularly in arid environments; and may increase the tendency toward compaction. The intensity of the fire, proportion of vegetation destroyed and organic matter consumed, degree of soil heating, and frequency of occurrence are factors which influence changes in the physical properties and erosion potential of the soil. The impacts are also dependent upon the local conditions including those of the soil, forest floor, topography and climate (Wildesen 1982:68).

Transferal

Transferal refers to the displacement of material from its previous context. The effect that a displacement will have on a resource needs to be evaluated with consideration to the degree of movement and the effect on the integrity of the site and its interpretive value. Often the effect will vary with the assessed research or heritage value of the resource. The slight movement of flakes within a lithic scatter which is valued only for showing evidence of human activity would likely not have a significant effect, whereas the same impact could have a very significant effect if the site was valued for its potential to reveal detailed information about artifact patterning (Wildesen 1982:58-59).

Artifacts exposed on the surface often indicate the presence of a larger site with buried resources. Such exposures are vulnerable to damage that diminishes their integrity with the remainder of the site that may lie below the surface. The strength of the relationship between the surface and subsurface components of a site depends on the degree of impact that the exposure may have suffered and the specifics of these impacts, such as the degree or direction of the displacement. In Wildesen's review of studies related to impacts to archaeological sites, he found a significant loss of surface artifacts due to surface disturbance was not necessarily replaced with artifacts from the subsurface zone, which could be detrimental to future site detection (Wildesen 1982:56, 58-59).

While the effects of transference impacts caused by ground disturbance activities such as grazing and plowing on archaeological sites are often extensive, they may not be as severe as was previously believed. A number of studies have suggested that even with exposure to such impact agents, spatial relationships defining discreet activity areas are likely to be preserved over long periods of time (Wildesen 1982:57). There are environmental factors that may influence the degree of movement. High moisture levels, for example, may affect the degree of artifact movement caused by machinery, hikers or animals as they inadvertently transport artifacts large distances in wet soil adhering to tires or feet (Wildesen 1982:57).

Impact Agents

Erosion

Erosion is a natural process that can result in the damage, destabilization, or total loss of cultural resources and their soil matrix. While erosion can be a natural process, certain human actions may create the conditions necessary for erosion to take place. Wildesen (1982:64-65) refers to the inherent properties of a site that may make it subject to erosion from natural causes as **erosion hazard**, and the effect of human activities on the site as **erosion potential**. With an understanding of the natural conditions that lend themselves to the development of erosion and the potential for human actions to trigger or enhance erosion, a variety of equations have been developed. These equations can be used to estimate the erosion potential of certain human activities including agricultural practises, skid trails, roads, landings, burns and grazing.

Any project that includes clearing can increase the likelihood or severity of soil erosion by altering the soil structure and removing vegetation cover. These conditions destabilize the soil, increase the impact of rain and reduce infiltration rates. The effects of these impacts along roads are often more severe due to the nature of their construction which includes greater slopes along the edges of the road, a tendency to intercept the flow of subsurface water, and the concentration of the overland water flow along the road and its associated channels (Wildesen 1982:64-65).

In the case of roadways, it is likely the greatest amount of erosion will occur immediately after construction and will gradually stabilize over a period of years. The actual amount of erosion is dependent on both the natural conditions which form the erosion hazard and the erosion potential from human activities at the site. When evaluating the potential impacts resulting from an activity, it is necessary to consider the entire project and not just its ultimate goal to ensure the potential for indirect impacts are addressed. For example, to gain access to an area to complete a project may require the clearing of a temporary road or track. While this temporary road may not be considered an objective of the project, it is still part of the project and needs to be considered in that context (Wildesen 1982:64-65).

Vandalism
The term vandalism covers a range of depreciative behaviour toward cultural resources and may include the following actions (Nickens 1993:7-8):

- unauthorized excavation (pot hunting)
- carving, scratching, chipping and defacement
- surface collection of artifacts
- marking, removing, tracing or casting, and shooting at rock art
- theft of artifacts from structures
- stripping boards
- removal or dismantlement of portions of a structure
- arson
- climbing or walking on resources
- off-road vehicle use in sensitive areas
- rearrangement of resources
- breaking artifacts
- knocking structures over
- use as firewood
- throwing rocks into excavated ruins
- handling and touching.

Vandalism is one of the major causes of impacts to archaeological sites and is of serious concern given the degree of impact that can be caused and the willful nature of the damage. Many studies have looked at the issue and have found that some types of sites are more prone to vandalism than others, and certain factors appear to increase the vulnerability of a site. Sites that are particularly vulnerable include rock art sites, open camps or chipping stations, stone walled dwellings, historic buildings, rock shelters and caves. Factors found to increase the vulnerability of a site to vandalism include public awareness of the site, signs of previous vandalism, high visitor use, and obvious deterioration (Wildesen 1982:68).

The motives for the vandalism of cultural resources, including looting, are various. They include the desire to acquire artifacts, ignorance (of the law or of the destruction caused), curiosity, recreation, profit, showing off, rebellion and carelessness. The rate of vandalism is found to be highest where there is an awareness of the presence of cultural resources, and where access to the site is easy and law enforcement lacking. Vandalism rates are lower at sites with few resources and effective law enforcement. The vandalism of cultural resources is different from other sorts of vandalism as collecting is often a primary motive, rather than simple destruction. The perpetrators are often older and more methodical, and may use sophisticated techniques to recover artifacts while avoiding detection (Wildesen 1982:69).

Effects associated with unauthorized artifact collecting include the removal of whole finished tools and the destruction of site context. This is likely to leave the site with greatly diminished resources and interpretive value. Even if the collected artifacts could be recovered, their archaeological significance has been reduced due to their lack of context. A review of the collections made by artifact hunters may be of some value in revealing patterns in collecting behaviour and supplement any information available for a site (Schiffer and Gumerman 1977:297-298).

Mowing

The use of large mowing machines can result in the compaction of the soil matrix which can in turn alter or destroy archaeological features. Mowing can also break artifacts near the surface or disturb them from their location. Mowing also reduces the vegetation cover which can leave artifacts more vulnerable to impacts (MacDonald 1990:16).

Livestock grazing

The direct impacts from livestock include the trampling of artifacts, the mixing of cultural materials, and the damage or displacement of features, structural remains or their components. Indirect impacts may include the loss of vegetation and accelerating site erosion, and impacts associated with the construction of facilities for the animals (United States Department of the Interior 1999:3.12).

Off-road vehicles

Accessibility is a major factor contributing to vandalism and the use of off-road vehicles is a concern in this regard. They allow for easier access to sites which has been shown to be a major factor contributing to vandalism, and can also cause compaction and erosion damage to archaeological resources and the disturbance of their protective vegetation both directly and in conjunction with the natural erosional forces of wind and rain. Soil compaction on trails used by off-road vehicles can be severe, reaching depths of up to one metre (Wildesen 1982:69).

Campgrounds and trails

The development of recreational facilities such as trails, interpretive nodes, and camping and picnic sites has a direct impact on archaeological resources present in the area excavated or cleared. Such developments may destroy artifacts, features, and their associations with each other and their surrounding soil matrix. The indirect impacts from foot traffic on and around these facilities will likely lead to erosion and soil compaction. With improved access and an increase in the number of visitors, the unauthorized collection of artifacts is also likely to increase. Unauthorized collecting of artifacts is related to visitor access and often occurs within a quarter-mile of recreational sites (United States Department of the Interior 1999:3.13-3.14).

Factors governing the selection of hiking and camping locations are often persistent through time, resulting in campgrounds and modern trails being located on or adjacent to those used in the past. This effect has been recognized as being a particular problem with trails situated along beach ridges and eskers and on well-drained landforms situated close to water sources. Complicating the effect is that the soils associated with these well-drained locations are often thinner and more susceptible to erosion associated with visitor use. In the absence of restrictions on camping location, site use or designated trails in such areas, the likelihood of damage to cultural resources can be quite high.

When camping is uncontrolled it tends to occur in areas that have less vegetation cover. The reduced cover is possibly due to poor quality, shallow or infertile soils which makes them more sensitive to impact. The effects of camping and foot traffic on the archaeological remains can be significant not only for their direct impact but also because they increase the tendency for natural impacts such as erosion to occur. With designated campsites and trails, the problem is readily solved by moving a camp or rerouting the trail away from sensitive areas. Less easily solved are problems of damage associated with unrestricted camping or trail use (Lynott 1991:83).

Foot traffic on a site can damage artifacts and features both directly and through soil compaction, and cause both horizontal and vertical displacement. Shoreline and stream bank areas are often selected as camping and hiking areas, and where these areas are impacted by erosion they are more likely to include exposed resources, making them more susceptible to impacts from foot traffic. Trails can also increase the likelihood or severity of damage from erosion as pedestrian impacts speed up the process. Trails should be designed so runoff is kept in natural channels or dispersed broadly over the landscape using waterbars or similar structures and not directed onto archaeological sites. Trail surfaces should be pervious to eliminate runoff. Development of recreational trails should be carried out with caution to ensure they do not provide easy access to sites, leading to increased vandalism (MacDonald 1990:16).

Infrastructure development

Direct impacts from the development of park infrastructure often occur as a result of clearing operations, drilling, cutting, trenching and other forms of excavation. Roads bring additional traffic to the area, putting more stress on adjacent areas made accessible by the development. Indirect impacts from increased visitation may include a loss of vegetation cover and organic soil layers, erosion and pot hunting.

Undertaking developments in previously unused areas where the resource potential is not adequately known may lead to the discovery of previously unrecorded sites. A survey of the proposed work should be undertaken prior to any such development and may be useful in finding the best route to follow to avoid impacts. All clearing and excavation activities should be closely monitored during the development in order that any unforeseen impacts can be mitigated and unanticipated sites recorded (United States Department of the Interior 1999:3.11-3.12).

Predicting, Monitoring and Recording Impacts

To mitigate impacts effectively it is necessary to be able to predict and assess the potential for impacts to cultural resources and measure the results of mitigative action. Simply identifying impact agents and impact types is not sufficient. Impacts need to be quantified. Describing impacts using terms such as extensive, severe, considerable or minimal without defining what they mean does little to assist in devising mitigative strategies. Typical measurements include the extent, severity, duration and rapidity of the impact (Wildesen 1982:75).

Predicting

Predicting impacts to cultural resources within Parks Canada can be difficult. Cultural resources are frequently hidden from view and are often only discovered as a result of being disturbed. To minimize the potential for damage every effort should be made to ensure that all potential impacts to cultural resources are identified at the planning stage, and steps taken to avoid or mitigate those impacts. Advantage should also be made of every ground disturbance activity to record any previously undiscovered resources that may be encountered during the project. Such activities have the potential for revealing cultural resources and should include an impact monitoring program.

To improve predictive capability it is necessary to identify current destructive processes and study their effects on cultural resources. Effects already documented can be used to demonstrate the consequences of similar impacts or their agents. Where mitigative actions have been taken, the effects of these actions on the impacts should be recorded and an assessment made to better inform decisions regarding subsequent mitigative actions (Schiffer and Gumerman 1977:298-99).

Frequently the factors that determined site location in the past such as proximity to water, accessibility, transportation and topographic features are still valid today, leading to conflicts between in situ heritage resources and development needs. Such conflicts are common and, due to inadequate screening measures, are often not discovered until development is underway (Lynott 1991:82).

Predicting development impacts

For the sake of better impact assessments of project proposals it is necessary to document the relationship between the effects and impacts and the specific impact agents. The accurate forecasting of impacts can only occur when impact agents associated with a project have been identified and their impact potential assessed. This includes not only construction activities but those that occur at the planning and operating stages. It is also necessary to understand the nature and significance of the archaeological resources and the effects potential impacts can have on those resources (Schiffer and Gumerman 1977:292).

Three conditions must be met before the impacts of any given project on a cultural resource can be accurately forecast:

- the impacts of all activities that occur during a project's planning, construction and operating stages are delineated
- the nature and significance of the archaeological resources are known for all affected areas
- the relationships are understood between all expected impacts and the archaeological resources.

As previously mentioned, it is important to consider both the direct and indirect impacts that can result from any given project. Direct impacts are the immediate physical consequences of a project's planning, construction or use. Indirect impacts are those not directly caused by the project but would not have occurred otherwise. These are often more difficult to predict.

As an example, the construction of a pit toilet can have a direct impact from digging the hole but the creation of any new road or trail required to get to the construction site needs to be considered as a secondary impact, as does the impact that may result from any surface collecting by the construction crew. Tertiary impacts must be anticipated to arise from the ultimate use of the privy and be given due consideration. There will likely be increased foot traffic in the area around the privy, and along the formal or informal trails leading to it. This may result in a loss of surface vegetation and organic soils, soil compaction and erosion.

It is also necessary to identify the degree and extent of impact these activities might cause and what effect they might have on the cultural resources. In order to answer these questions one needs to know the nature of the resources and their distribution; the specific locations of sites relative to the area of impact; and details on the various components of the construction and operation of the facility, including the degree, extent and duration of impact.

Planning stage
In assessing the impact potential of construction projects it is important to be aware that impacts can occur at any stage of a project beginning with the planning stage. For instance, it is not uncommon for a road to be constructed to allow a survey crew to access the site or for there to be geotechnical test drilling undertaken at this stage of a project (Schiffer and Gumerman 1977:293).

Construction stage
Construction stage impacts can be divided into three categories: **primary**; **secondary**; and **tertiary**. Primary impacts are those generated by the project's principal goal, while secondary impacts are those connected with the support activities. Tertiary impacts are related to the project but are neither part of the principal goal nor connected with the support activities. The collecting of artifacts by construction workers would be an example of a tertiary impact. Determining all of the impacts that may result from a project can be very difficult. It may be possible to derive the primary impacts from construction plans, but one must be familiar with common construction practises to determine the likely secondary and tertiary impacts of the project (Schiffer and Gumerman 1977:294).

Operating stage
The impacts occurring at the operating stage can also be divided into **primary**, **secondary** and **tertiary**. To take camping as an example, the primary impacts would be those caused by the activity of camping. The secondary impacts usually result from other intended or expected uses of the facility. The unauthorized collection of artifacts from a site made possible by the location of a nearby campsite is a secondary effect because it is a reasonable expectation that with greater access to archaeological sites, the incidences of looting will increase. Tertiary impacts are not caused by the use of the facility at all, but do occur as the result of its presence. Simply increasing the number of campsites available in a park may result in more visitors to various locations within the park, increasing the degree or likelihood of visitor impacts.

Monitoring

Monitoring is essential to determine the significance of identified impacts and their responses to various conditions, activities and mitigative measures. Monitoring must be performed on a routine basis recording the same information in a standard and repeatable manner so results can be reliably compared. Several criteria should be used for each activity and type of impact being monitored. Any monitoring program should be subject to a periodic review to ensure that the information being recorded is the most relevant to the situation being monitored (Sack 2000:6.2).

Recording surface disturbances

Even relatively shallow impacts can disturb archaeological strata and hamper site interpretation. Such impacts can be measured in terms of their extent and severity in order to assess the degree of damage. **Extent** can be recorded as a percentage of the area which has been impacted. **Severity** can be recorded as a depth or by indicating whether or not some threshold has been crossed such as whether the leaf litter, A horizon or B horizon has been disturbed (Wildesen 1982:65). **Duration** may be expressed as being either temporary or permanent, or by indicating a measured amount of time. The character of the impact (rapidity of onset, reversibility, interaction with other impacts) should also be stated. Determining whether or not the impacts are intentional may also be of help in devising a strategy to deal with the problem. Wildesen (1982:66) provides some example of how to measure the degree of severity of surface disturbances.

Category	Definition
severe	removal of litter disturbance of soil > 2.5 cm deep
	removal of litter, A horizon, and a portion of the B horizon; burial of the soil surface by at least 0.25 m of soil material; or severe compaction of the mineral soil
	where A horizons are disrupted sufficiently to expose B horizons
	surface soil removed and subsoil exposed
moderate	removal of litter, soil disturbed to < 2.5 cm depth
slight	no removal of litter
	litter disrupted sufficiently to expose, partly or wholly, mineral soil
	litter removed, soil exposed; litter and soil mixed 50-50; soil on top of litter or slash
	undisturbed litter and topsoil still in place
	litter; no compaction

Some additional categories of data applicable to the recording of soil compaction are also recommended. Sack (2000:6.2) suggests that some of the measurements to be taken include soil temperature, moisture, depth of organic layer, pH, extent of bare soil, presence of tracks and recording of exposed cultural resources.

Assessing significance

The assessment of significance of individual cultural resources is an important step in setting priorities and assessing the effects of impact. Schiffer and Gumerman (1972:299-300) identify two types of significance, **potential** and **actual**. Every resource has the potential to be significant, as significance depends on the questions being asked, and these can change over time. The actual significance of an object is that which is presently known and identified. In a values-based conservation system, effects vary with the actual significance of the resource.

Mitigating Impacts

Archaeological sites are subject to the natural processes of decay and are frequently prone to more sudden or obvious impact events such as erosion. In some cases intervention is warranted to slow the deterioration of significant resources, though frequently it is simply accepted as inevitable, outside of our awareness or beyond our control. However, an impact to a site that is a direct result of a human action or process, or of a natural process that has been amplified or accelerated by a human action or process, is within our capacity to control and some action ought to be taken to avoid or minimize its effect (Wildesen 1982:75).

In situations where impacts are expected, such as with development or visitation, a check should be made of known resources in the proposed area and their locations avoided. Consideration should be given to conducting additional research into the proposed impact area based upon the degree of impact proposed and the extent of knowledge about the area’s cultural resources. The decision to proceed with a project that has the potential to impact on cultural resources should not be made without some data to evaluate the effects of expected impacts.

Some sites may be known only from an informant’s report or historical documentation. In such cases, the locations of cultural resources may not be known with sufficient accuracy to plan appropriate mitigation without further investigation. If no prior survey has been conducted in the area or if the available data is insufficient to make an adequate assessment of the impact potential, then a pre-impact investigation should be performed. All projects with subsurface impacts must take place well away from known cultural resources, and include measures to ensure that any indirect impacts from the development or its operation do not affect the resources.

Surface erosion

Thorne, Fay and Hester (1987:14) observe that as erosion is one of the primary impacts on archaeological sites, many of the approaches to site preservation are generally the same as those used to stabilize or prevent erosion. The main difference is the additional consideration of the effects of the stabilization measures on the cultural remains. The measures taken must give careful consideration to the resources and ensure that no additional damage will be caused by actions taken to protect them. To accomplish this it is necessary to have a good understanding of the potential impacts and effects of the preservation techniques, including chemical changes to the site matrix and resources, added weight on the site, and changes in site drainage and erosion patterns.

Increasing vegetation cover can strengthen the soil and reduce the stress caused by water on ground surfaces. Other measures to reduce water on site erosion include increasing the infiltration capacity of the ground surface, dissipation of rain energy or overland flow, and decreasing the slope of the ground surface or its effective slope length (MacDonald 1990:28).

Some less successful stabilization techniques have included the use of sandbags. At Golden Gate National Park, sand bags used in combination with jute netting and plantings met with mixed results as the sand bags deteriorated within four years due to weathering and pedestrian traffic. Fortunately the plantings managed to become established during that period. At Channel Islands National Park, sand bags actually accelerated the windblown undercutting of vertical faces (Lynott 1991:89, 91).

Stabilization measures that deal with erosion can be divided into two categories—horizontal and vertical; or those that deal with bank edge erosion and those that don't. While the forces acting on the site are essentially the same, the severity of their impact is likely different. There are many different techniques that can be used for site stabilization, but the technique chosen must be suited to the specific properties of the site being protected, including the cultural resources and their environment. It is not sufficient to simply address the erosion problem without considering the suitability of the technique to the local environment as well as to the specific cultural resources that are to be protected (Thorne, Fay and Hester 1987:14).

For example, while revegetation can be an effective method of preventing erosion, it is important to consider that different plant species require different environmental conditions in order to thrive. The range of species suitable in the south would not likely have any application in an arctic environment. It is also important to be aware of the effects that different types of plants can have on buried resources (Thorne, Fay and Hester 1987:15). The root systems of plants can interfere with buried resources, causing breakage or movement, destroying artifacts and context. Roots can also impair the reliability of samples for radiocarbon dating.

Each resource must be evaluated prior to the selection of a stabilization measure. Attempts to implement stock solutions to common site stabilization problems should be avoided. Each situation is different and requires a thorough understanding of the resource properties and the range of impact agents before appropriate methods of protection can be determined. The level of protection afforded a resource may vary with the physical characteristics and significance of the resource being affected.

As site preservation is a relatively new concern, many of the preservation measures being used have not been fully evaluated. Users should be cautious in implementing any of these approaches to site stabilization and it is suggested that sites be monitored to evaluate the effectiveness or negative consequences of these procedures.

Pedestrian and vandalism control

Despite laws and regulations prohibiting the collection or damage of heritage resources, these types of impacts continue to be a problem. In advance of taking any preventative action, the scope of the problem should be determined through the establishment of a resource inventory and an assessment of the present impacts. This will help to establish priorities and determine the best way to address the problem. A monitoring program will allow for the effectiveness of the actions to be determined and modifications in the protective strategy.

The techniques employed to control vandalism and pedestrian impacts on archaeological sites are frequently the same techniques commonly used to control access and movement in other situations. These generally consist of a communications strategy, including signage and fencing or other means of restricting access. Site burial can be an effective barrier but it is more expensive and possibly more damaging than what can be achieved with simple fencing or signage.

While fencing will not necessarily keep out those who are most determined, it will act as a deterrent to the casual visitor. Depending on the resource and nature of the impacts occurring, this may or may not afford adequate protection. The effectiveness of fencing can be improved if it is used in conjunction with other forms of protection such as surveillance and enforcement (Thorne, Fay and Hester 1987:59-64).

Measures such as fencing and signage may call attention to the presence of the site, but if protection from looting is a concern it may still be better than leaving the site unprotected. It does present a deterrent and looters are usually well aware of site locations. Signage can also be useful in the enforcement of laws and regulations, and the prosecution of looters after the fact. Like fences, the effectiveness of signs can be improved when they are combined with other protective measures such as patrolling (Thorne, Fay and Hester 1987:59-64).

Other more intensive site protection measures include the burying of chain link fencing on top of a site to create a form of reinforced site burial. This is less visually intrusive than fencing, and avoids the danger of calling attention to the site while also making it more resistant to casual looters. This is not considered to be a very effective deterrent to serious looters however, and it is a relatively costly measure to implement. There is also the need to consider the risk to the resource presented by the process. As with any site burial, the fill material would require careful selection and application (Thorne, Fay and Hester 1987:59-64).

Deadfall or driftwood barriers can also provide effective site protection that, depending on the site location, may be constructed using local materials. The size and quantity of the driftwood or deadfall available will determine the density of the cover that can be constructed and its effectiveness in discouraging vandals or looters. The larger the barrier, the more effective it may be in removing the site from view. Another advantage to such barriers is they may also trap soils and provide an environment conducive to revegetation (Thorne, Fay and Hester 1987:59-64).

Signage as a resource protection measure

The effectiveness of signage as a method to control willful or inadvertent visitor damage to archaeological resources has been a subject of debate. Some argue that signage calls attention to the resource, making it more of a target for vandalism. On the other hand signs indicate the importance of the resource and may deter those not aware of the seriousness of or restrictions against vandalism. Signs can also be used to warn would-be offenders of the consequences should they be prosecuted for such actions, and thus make convictions easier to obtain (Nickens 1993:2).

Resource protection through communication

One strategy for reducing vandalism is to present messages that state the regulations governing site use and the need for preservation of cultural resources. The objective is to inform the public that damaging cultural resources is both illegal and detrimental to the archaeological record. This approach attempts to create an awareness of the threatened state of the resource and its importance, while informing visitors of their responsibilities to the resource and warning of the consequences of its misuse (Nickens 1993:16).

Nickens (1993:17-18) identifies three different approaches to the communication of these messages. The first focuses on the behaviour rather than on the causes of or attitudes behind the behaviour. The methods include the use of prompts to suggest proper behaviour, manipulation of the environment that make improper behaviour more difficult, or a system of rewards and punishments. The second tries to modify the attitudes behind vandalism by making a persuasive argument for why such attitudes should be changed. In this case the approach can have an effect that extends beyond a particular site or resource to change one's attitudes toward all cultural resources. The third approach does not try to inform the reader of the resource or its risk but tries to persuade the reader to modify the behaviour through an appeal for respect for an outside authority. The message may be from an expert or a well-known and respected individual with no natural connection to the resource.

Human reactions and limitations

Persuasive communication is more effective in changing certain types of behaviour than others. It can be highly effective in reducing damaging behaviour that is unintentional or uninformed, though it is less effective against willful acts of vandalism. It is also not likely to be very effective against vandalism to a resource that is already in a distressed state due to natural factors or previous vandalism. Vandalism resulting from peer pressure is also difficult to control through persuasive communication (Nickens 1993:18-19).

There is a hypothesis that some people will respond well to the fear of punishment, while others will more readily respond to inducements of personal benefit. Other approaches appeal to a person's feelings for how one's actions may affect others, or to one's ability to make an informed moral or ethical choice. A sign that can reach people at each of these levels is likely to be more effective than one that carries only a single type of message (Nickens 1993:19-22).

Signs may not always have the desired effect. A sign that lists all of the things that are not allowed will detract from the visitor's experience, and could lead to resentment and additional vandalism. Signs which prohibit visitors from entering an area can actually lead to increased visitation as visitors are drawn to the area out of curiosity. This can lead to increased damage in cases where the restricted area is not clearly marked or protected. A sign which simply identifies a fine for damaging rock art may not be an effective way to stop people from touching the art if visitors do not associate touching with damage or think that the stated penalty is out of proportion with the potential damage that may be caused by their actions (Nickens 1993:29-31).

Advantages and disadvantages

There are both advantages and disadvantages to the use of signs (Nickens 1993:23). Some of the advantages are:

- they are relatively inexpensive to install and maintain
- signs are self-pacing
- signs are static and always in the appropriate place.

Some disadvantages are:

- signs are passive, requiring time and effort
- visitors cannot ask for additional information or clarification
- signs may draw attention to fragile resources
- they are vulnerable to damage which may encourage further damage to the resource being protected.

Case studies

In the various studies consulted by Nickens (1993:24) on the use of signs as a protective measure, none indicated that they did not work. A study commissioned by the United States Bureau of Land Management regarding vandalism of prehistoric sites in southwest Colorado interviewed local artifact collectors and concluded that 50% of the respondents who had seen signs had been discouraged from collecting. On the other hand 25% of respondents said the signs had made them aware of sites they had not previously known about. This study indicates that signs promote awareness of the law and assist in its enforcement and the protection of resources. While signs may not deter all collectors, they probably have a positive effect on new residents or visitors.

At Wupatki National Monument a study found that the intent of the signage was often ignored in favour of an interpretation more suited to the intentions of the visitor. A message such as “Please stay off the walls” may be taken to refer to specific walls in the immediate vicinity of the sign rather than to those of the entire site; or may lead people to jump over walls rather than staying away from them completely. Such problems were more apparent at the main site, while outside of this area similar types of signs seemed to work well. The study showed this type of sign worked best when used in conjunction with developed trails and a trail guide. Smaller signs were more effective than large signs as long messages were often ignored (Nickens 1993:24-25).

Signs in conjunction with barriers were successfully used to protect archaeological sites from military exercises at Fort Hood. This signage did not reveal the real reason why an area was off limits. In one case a radioactive hazard was indicated, in the other the sign simply said “off limits”. It is not clear from this study whether the signage or the fencing was responsible for preserving the site, nor is it clear that the results would have been the same had the area been open to use by the general public (Nickens 1993:25-27).

Signs were used with a program of monitoring and enforcement in the protection of archaeological sites with a history of vandalism and looting within the U.S. Army Engineer District of Portland. The message on the signs stated that looting of sites was illegal and cited the applicable federal and state laws, identified the penalty, and stated the area was under surveillance. Of the 13 areas signed, unauthorized excavations continued at five and only one continued to suffer major impacts (Nickens 1993:27-28).

Examples of some solutions tried in the past include a case at Golden Gate National Recreation Area in California where informal trails and illegal camping was impacting on a historic midden. This problem was dealt with by removing some of the vegetation surrounding the site to make the area more visible to law enforcement patrols and less desirable for illegal camping. Turf stabilization matting was installed and allowed natural vegetation to become re-established which seems to have prevented further impacts from occurring. Other options to control visitor movement include the strategic placement of thorny vegetation. This approach has been successfully used in some areas including Grand Canyon National Park to keep visitors on the designated path (Lynott 1991:83).

The use of signage as a protective measure has been studied in Australia as well. There it was found that the number of visitors who would deliberately touch the rock art could be reduced by 60% via a simple instructional sign without the use of an official insignia or stated consequences for such actions. The signs were found to have been particularly effective with children, a high risk group for that behaviour. Official warning signs stating fines and suggesting the area was monitored were also successful (Nickens 1993:29-31).

Implementing a resource protection signage program
Development of a resource protection signage program should take the following actions:

- analyze the resource
- analyze the impact source
- develop objectives
- determine sign logistics
- create message and evaluate potential effectiveness
- implement the program
- monitor the effects.

with an appreciation of the following principles:

- signs can be effective in reducing behaviour damaging to cultural resources but the degree of effectiveness depends upon having an understanding of the problem and its origins
- potential exists for increase in impacts due to signage calling attention to the resource
- an evaluation of the proposed program prior to and following implementation is necessary for best results
- not everyone will respond equally to the same message
- devise the message appropriately to the situation and include more than one message if necessary
- signs are more effective when used in combination with other protection measures such as surveillance, stabilization, interpretation or education
- systematic monitoring of the results are needed to determine the effectiveness of the approach to the situation (Nickens 1993:80).

Resource analysis
An analysis of the resource will include a detailed examination of current and past impacts and the vulnerability of the site to further impacts. Such an analysis will allow actions to be focused on sites that are most at risk. The analysis will examine both site and protection factors (Nickens 1993:81-82).

Site factors	**Protection factors**
accessibility	site awareness
density	conspicuousness
visibility	artifact value
condition	present activity
	level of protection
	public support

Each factor is evaluated using a common scale that is applied in the same manner to each site. Each factor can also be given a weighting to indicate its relative importance to the analysis. The value of the factor for a given site multiplied by the factor's weighting gives the score for that factor for that site. The combined value of all scores for all factors will give a value that can be used to rank all sites in an area to determine the priorities. Sites should be reassessed frequently to remain current with the changing condition of the resource.

Analyzing the source of impacts
In order to apply an effective solution using signage, it is necessary to know as much as possible about the target audience for the signage. The number and type of visitors, their reasons for visiting the site, method of access and length of stay all need to be considered along with local attitudes toward the resource, heritage preservation or government (Nickens 1993:82-83).

Develop objectives
Nickens recommends that the specific objectives of a signage program include both protection and interpretation. There should be a learning element in the message that visitors will remember after they leave the site. The message may try to reach people at a behavioural level to change the way they act, or at an emotional level to change the way they feel about resource preservation. The objectives of the program need to be articulated so they can be kept in mind throughout its implementation, and will likely include some of the following (Nickens 1993:78-79, 83-84):

- reduce potential for damage and destruction of cultural resources through inadvertent or deliberate acts
- bring awareness of rules and regulations to the general public
- enhance understanding and appreciation of the heritage resource.

Logistical considerations
There are a number of logistical considerations associated with a signage program (Nickens 1993:84-85):

- placement
- number
- duration
- variety
- relationship to other protective measures.

Creating the message and evaluating its effectiveness
Field testing of signage can be beneficial in selecting the best approach. For resource protection variables to be considered include the format of the message and the objectives of the target audience. An effective message must reach its target. It is also necessary to have a good understanding of the resource being protected, including its current condition and susceptibility to impacts. The implementation of a successful program requires some preliminary research in order to assess the variables and develop and test solutions (Nickens 1993:42-43, 85). The following points should be kept in mind when developing the message:

- what is the scope of the message
- does it address the objectives
- is the message clear about what is protected and what actions are prohibited
- should contact information be included
- should the message be evaluated in-house, by a visitor panel, by experts or by other stakeholders?

Monitoring
Monitoring of the condition and effectiveness of the signage will be required. Effective monitoring requires that comparisons be made between previous conditions or activities and those after the installation of the signage. Regular monitoring making use of an established

method of recording will help to evaluate the effectiveness of the signage program over the long term (Nickens 1993:89).

Summary

To have the best potential for success, the signage should be specific to the situation. The careful evaluation of resource conditions and vulnerability along with management requirements is a necessary step. Systematic monitoring of the signage, the resource and the impacts are essential for evaluating the effectiveness of the program (Nickens 1993:29-31, 89). In summary:

- putting preservation messages in interpretive signs is cheap and effective
- signs should contain few words and be free of jargon
- they should use pictures or diagrams and be well located
- visitors are more likely to read longer signs away from the actual resource while shorter messages are preferred at the site location
- signage works best as part of a co-ordinated protection strategy which may include visitor centres, self-guided tours, maps and brochures, paths, walkways and barriers.

Recreational facilities and use

Sites sensitive to impact from recreation use or those located near such facilities should be monitored more frequently and methodically. To deal with site degradation, restrictions on the numbers of visitors allowed or total site closure may be necessary. Where facility use has resulted in impact to cultural resources, additional protection should be provided such as restricting camping to areas away from cultural resources. Facilities should not be developed in areas known to contain sensitive cultural resources and surveys should be conducted prior to development to determine if such resources exist in the area (United States Department of the Interior 1999:3.13-3.14).

Restrictions of various kinds may be used to try to mitigate impacts caused by visitor use. Such restrictions may include the numbers of visitors allowed in an area, the area available to visitor use, the duration or season of visit. Signs may also be used to help control the spread of disturbance by providing an increased awareness of the resource and the need for protective measures. Fences may be used to restrict access to sensitive resources. In areas currently in use and showing signs of impact, concentrating visitor use in smaller areas may help to keep the destruction from spreading further (United States Department of the Interior 1999:3.13-3.14).

The *Best Practices for Parks Canada Trails* (Parks Canada 1996) sets out a series of guiding principles and procedures specific to the protection of cultural resources. These are to be observed during all stages of facility development and use, from design and construction to operations and maintenance. The effectiveness of any mitigative measure is dependent on having a good knowledge of the area, its resources, significance and sensitivities. These principles and procedures can be applied to a wide range of situations and include:

- gather and assess baseline information on cultural resources

- set out and monitor resource protection standards and indicators
- establish limits of acceptable change and operate within them
- apply principles and practices of cultural resource management
- assess and mitigate cumulative effects of trail-related activities, services and facilities
- assess and mitigate effect of closures or rehabilitation in one area on adjacent areas
- ensure resource protection through the use of a range of direct (zoning, rationing use) and indirect (facility design, orientation) strategies
- consider controlled access as a means of resource protection
- monitor trail activities to ensure continuation of ecological integrity.

Infrastructure development

While the practise of managing archaeological resources by simply avoiding any disturbance to them is popular, it is not considered to be the best approach as it often avoids answering questions regarding the nature of the archaeological resource affected and the purpose for which it is being managed (Wildesen 1982:79).

Effective cultural resource management requires that sufficient resource data be available or acquired through test excavation, field mapping, collections analysis or comparisons with other local sites. The management goals must also be well defined. They may be scientific goals or ones of public interpretation or preservation. The goals will help define the threshold of concern as the nature of the effect is in part determined by the expected use of a resource. In some cases such as where research goals are important, small impacts may be seen as beneficial as they allow the opportunity for site discovery or investigation. In other cases where preservation is the primary goal, there may be no perceived benefit to any degree of impact (Wildesen 1982:79).

Once a concern regarding impact to an archaeological resource has been identified, each component of the impacting agent needs to be examined to determine the type, degree, extent and duration of specific potential impacts. The nature of the archaeological resource, its value and management objectives for it also need to be identified. With this information it should be possible to determine the threshold of concern. The next step is to develop a variety of measures that might be taken to reduce the impacts below the threshold. This could include changing the type of impact or reducing its degree, extent or duration. From here it should be possible to choose a strategy that seems to achieve the objectives of both the archaeological and development interests from among the alternatives identified (Wildesen 1982:79).

Wildesen refers to this as value conservation. In this approach it is the predetermined values of the archaeological site that are to be conserved. Though not eliminating impacts through development, these values can be preserved through the establishment of a threshold of concern. This is seen as a better alternative than having to decide between the total removal of a site or the loss of development opportunities. It seeks to find zones of compatibility, but to be done properly it requires detailed knowledge about both the resource and the expected impacts (Wildesen 1982:79).

There are a variety of innovative approaches to site development that reduce the impact to cultural resources and may even be less costly to implement then more traditional methods. One example tried within Parks Canada is the use of horizontal boring instead of trenching for the installation of utility lines.

Horizontal boring was successfully used in place of traditional trenching during the installation of a water line at Motherwell Homestead National Historic Site (Hems 1995:5-6). In order to protect the historic structures from fire, a new water line had to be brought into the historic zone of the site. A common approach would have been to excavate a trench 2.75 metres deep along the entire path of the water line, cutting through undisturbed cultural deposits in the process. This would have had a significant impact on the site and would most likely have affected in situ cultural resources and diminish the integrity of the site.

Instead only four holes were required, one at either end of the water line and at a turn and hydrant junction. In the unexcavated sections, the pipe ran through deeply buried natural strata, completely avoiding the overlying cultural layers between the holes. Rather than a series of shovel tests along the route of the water line, controlled archaeological excavations were carried out at each of the holes.

This approach reduced the amount of impact substantially, limiting the potential effects on the cultural resources. It also resulted in savings in the operational costs associated with filling the trenches and resodding the area as well as costs of archaeological monitoring, recording, processing and long-term storage of recovered artifacts.

Specific Mitigative Actions

Soil burial

Site burial or capping with culturally sterile soil has a number of benefits and can provide protection to an exposed site as well as a base for revegetation. Intentional site burial mimics the natural process of soil deposition that has been responsible for the preservation of archaeological sites throughout history, and suffers from many of the same problems. Not all archaeological materials found in a site will respond equally to changes in a buried environment. The differential preservation of buried artifacts are a natural fact that archaeologists have always had to deal with. In the case of site burial as an intervention and protection strategy, however, archaeologists have to choose which materials will be preserved and which will not. While being able to choose the preservation environment gives archaeologists some control over which artifacts will be preserved, it also comes with a great deal of responsibility to make good decisions (Thorne 1989).

Any site stabilization program needs to take into consideration that each site is different and can include a wide range of materials within it. It is necessary to evaluate the constituents that make up the site compare the potential impacts against the potential for site preservation and assess the benefits of any mitigation measure before choosing any specific methods to be followed in the preservation strategy (Thorne 1989).

It is important to consider the potential for damage from soil burial and ensure that no inadvertent site damage will occur as a result of compaction from soil or equipment, or from changes site burial may cause in the water regime or soil chemistry. All measures taken to protect a site need to be monitored so that any periodic maintenance required can be performed and the success of the strategy can be assessed and modifications made if necessary in future attempts (MacDonald 1990:29).

Thorne (1989) recommends that a multidisciplinary team consisting of an archaeologist, geologist and engineer be employed in the design of any site stabilization program employing burial. The role of the archaeologist would be to determine the classes of artifacts present and those which need to be preserved and those which may be left unprotected. The geologist will advise on what type of fill materials would be suitable to achieve the preservation goals identified by the archaeologist. The engineer will be required to devise the means of implementing the burial using the materials recommended by the geologist, but must also have an understanding of how the burial will affect the hydraulic properties of the site and ultimately its contents. Other factors to be considered by the engineer are the possible impacts to the site from the use of heavy equipment or the weight of the fill layer.

Advantages and disadvantages

Burial has the potential to preserve artifacts and other archaeological materials as well as their spatial relationships. This is particularly important as context is often crucial to the development of archaeological interpretations. Burial offers a good measure of protection from vandalism as well as removing an exposed site from view, making access to artifacts more difficult. It can also be employed in the protection of sites from development impacts, and can even allow for other uses of the site to continue above the protection layer. Burial offers the potential for site loss to be eliminated through the creation of new land surface, and can also shift the frost zone above cultural levels to protect sites from freeze/thaw cycles. When used in conjunction with revegetation it can protect against site loss due to erosion (Thorne 1989).

There is the possibility that burial will cause damage both to the archaeological material as well as to those contextual relationships. Different materials respond differently to changes in their environment that can result from site burial. This makes the execution of a successful site preservation program through site burial more difficult. Depending on the materials and environments involved, site burial can create conditions that will accelerate decay, enhance preservation or have a neutral effect on preservation (Mathewson, Gonzalez and Eblen 1992:10).

Compaction and geochemical change

There are two major types of impacts that may result from the burial of an archaeological site: **compaction** and **geochemical change**. Compaction of the archaeological layer can be caused by either the weight of the material used to cover it or the equipment used in the process. Compaction can damage artifacts and ecofacts or increase the density of the sediments, limiting the archaeological data that can be derived. Artifacts with low material strength such as ceramics and bone are most vulnerable to damage from compaction. The degree of compaction is dependent upon a number of factors including the texture of the buried soil (proportion of sand, silt and clay and degree of cementation), its moisture, density and structure, and the weight, texture and thickness of the covering (Waters 1989:124-25).

The burial of an exposed surface site will certainly change its geochemical environment and may reduce the effect of a variety of natural processes covering the biological (faunalturbation and floralturbation), physical (cryoturbation, crystalturbation and argilliturbation), and geochemical (soil formation). While this generally represents a positive effect on cultural resources, new impacts may also be introduced. If the covering was not thick enough to remove the site from the zone of soil formation, burial could place it in a zone where translocated soluble salts accumulate, adversely affecting the preservation of organic and fragile material remains. In a cold region, shallow burial may be sufficient to move a site from a freeze-thaw to a permafrost zone (Waters 1989:124-25).

The conditions for site erosion could be enhanced by site burial if it increases the slope of the landscape. It is necessary to be cautious in implementing any site burial strategy for resource protection to ensure that the benefits to be realized by such actions outweigh the potential for damage. Good decision making in this regard requires a lot of knowledge about the local environment and condition of the site as well as the potential results of any mitigative action (Waters 1989:124-25). A solid understanding of how to make those mitigative actions achieve a desired effect is also required.

Environmental effects on archaeological materials

Thorne, Fay and Hester (1987:18, 24) make a distinction between shallow and deep site burial as a stabilization measure. The difference in the effects of a thin soil covering versus that of burial under roads or levees can be significant. Studies have shown there are morphological changes that occur to artifacts as a result of deep site burial, discussed below.

Soil chemistry has different effects on different archaeological materials which are useful for dating purposes. Charcoal is one of the most important sample materials found on an archaeological site and is very sensitive to changes in pH. A change in the soil from weakly acidic to weakly alkaline, for example, would represent a severe impact to charcoal preservation (Mathewson 1989:130-32).

Wood, as well as being a common material used in the manufacture of artifacts, can also be used for dating purposes. In arid environments it can be preserved in well-drained sandy soils or in a surface or near-surface context, though deterioration through weathering can be a problem. It is also quite stable in buried anaerobic environments including clayey soils with an acidic pH. Wood is not well preserved in humid conditions or when subjected to wet/dry cycles. It can be subject to damage from roots and deterioration from humic acids if shallowly buried (Mathewson 1989:130-32).

Ceramics, particularly those fired at low temperatures (500 to 700 degrees C), are very sensitive to environmental conditions after burial. Soluble salts within the ceramic object can dissolve and recrystallize repeatedly with changes in humidity. Eventually these salts reach the surface where crystallization become more extensive causing exfoliation, cracking or breakage of the object. Similar types of destruction can occur from the crystallization of invading carbonic solutions or the rehydration of incompletely destroyed clay minerals (Mathewson, Gonzalez and Eblen 1992:17).

Bone is easily warped by compaction, moisture and heat, and decomposes with prolonged contact with water. It can become sponge-like in waterlogged sites. In salty environments bone can absorb salts which can crystalize and damage the bone. In arid environments the bone can become dry and brittle and eventually fragment. Bone is best preserved in an environment not subject to alternating periods of dryness and moisture, or freezing and thawing. Both of these conditions act to create differential stresses which can cause cracking or breakage (Mathewson, Gonzalez and Eblen 1992:17).

Bone is best preserved in slightly moist, alkaline and cool conditions. Hot and cyclically wet and dry environments are detrimental to the preservation of bone. Deterioration of bone is also a problem in surface contexts. Bone buried within a zone of fluctuations in the ground water table will suffer leaching of its collagen. Shallowly buried bone will be exposed to contamination from vegetation and its decay (Mathewson 1989:130-32).

Specimens suitable for thermoluminescence dating, fission track or alpha-recoil track dating, and uranium-thorium dating are all detrimentally affected by submergence or ground water. The disturbance of radioactive elements through leaching or heating of samples in direct sunlight will weaken the atomic properties which allow thermoluminescence dating. Mica is well suited to fission track dating techniques but is unstable in saturated ground water zones which also affects the uranium content through leaching. Uranium-thorium dating is also affected by ground water for the same reason (Mathewson 1989:130-32).

The magnetic properties of mineral samples with potential for archaeomagnetic dating can be adversely affected by weathering or the introduction of oxidizing conditions (Mathewson 1989:130-32).

With respect to preservation, different materials react differently to changes in pH. Wood and some charcoals will be adversely affected by a change toward an alkaline pH and by the humic acid content of soils, but these same conditions may benefit the preservation of bone. A more acidic pH will degrade shell and bone, but will better preserve wood (Mathewson 1989:130-32).

Buried soils

Burial changes the soil environment and knowledge of those changes is an important requirement prior to undertaking site burial as a conservation measure. The effect and degree of change is dependent on both the depth of burial and movement of water through the overburden and soil. The composition of the soil matrix and overburden will determine the nature of the chemical reactions, weathering and mineral formation that will take place. The chemical properties of the overlying layer can change those of the buried layer, and in general, the greater the difference between the buried and overlying soils, the greater the degree of change (Hallmark and Wilding 1989:168-80).

Changes in pH, base saturation, exchangeable cations and other properties can occur rapidly soon after burial and appear to be determined primarily by the cover material. Buried soils will lose their original properties and acquire new ones as a result of pressure from overburden, infiltration and ground water, mass movement, biological activity and other processes. The changes that occur in buried soils are dependent on the type of soil buried and the duration and conditions of the burial. Within the first ten to 40 years of burial there will be a decrease in the organic matter content in the upper horizons with a consequent loss of colour and structure (Mathewson, Gonzalez and Eblen 1992:22-24).

A number of chemical properties undergo change immediately upon the burial of a soil including pH, organic matter, redox potential of iron, total nitrogen and salt concentrations, including calcium carbonate. Of the morphological and physical properties of soil, those most affected include soil fabric, structure and bulk density, all of which are altered due to compaction. To a large extent the physical and chemical properties of the original soil will determine its properties after burial. The particle size, distribution and chemical composition of the overburden or fill will control the amount of infiltration to the buried soil and the chemical imprint upon it that will develop with time. Deeply buried soils will undergo processes similar to those responsible for converting sediment to rock, while pedogenesis will continue to act on shallowly buried soils. Ground water is a determining factor in whether the character of a buried soil will change physically or chemically, and whether burrowing organisms will be present (Mathewson, Gonzalez and Eblen 1992:24-25).

Differences in the texture and flow rate of soils can result in changes in the flow of water through them and may cause water to perch at the interface between the two layers. The burying material must be carefully matched to the soils being buried to avoid creating such problems (Hallmark and Wilding 1989:168-80).

The following points outline some of the other relationships that exist between the various properties and conditions of a buried site (Mathewson, Gonzalez and Eblen 1992:26-33):

- moisture content and pH of buried soil will control the amount of organic matter
- burrowing invertebrates can be found to depths of over two metres
- burrowing vertebrates generally dig less than 1.5 metres in sandy, silty and loamy soils with a moderate moisture content
- effects of gravitational or solar energy fluxes change or cease altogether in deeply buried soils
- daily soil temperature fluctuations are negligible below 30 centimetres and annual variations are insignificant at depths greater than six metres
- there is a decrease in pore space in deeply buried soils due to compaction destroying soil

structure

- the addition of soil to a surface area can raise the ground water table
- soils above the ground water table will change due to pedogenic and geologic processes
- pedogenic processes will dominate if the soil is found above the maximum wetting front (from surface infiltration)
- soils below the ground water table will be modified by geologic processes because water available for leaching and other pedogenic processes will reach only as far as the ground water table
- buried soils that are in the influence of a fluctuating local ground water table will develop a distinct set of properties as a result of the wet/dry cycles.

Preliminary work
In light of the above the following preliminary work should be completed:

- identify site contents, through test excavations if necessary, to ensure that potential negative effects can be predicted
- particular attention needs to be given to mitigating impacts to organic remains and architectural features
- determine the chemical background of the site and the pH of the soil
- identify the chemical and material differences between features and their surrounding matrix
- fill material should be chemically compatible with the site matrix as well as the artifacts for both analysis and preservation
- in some cases a chemical distinction can be made between post holes and rodent burrows
- fill material should be culturally sterile
- fill should contrast with original matrix
- fill material must not interfere with the chemical composition or water regime of buried layers
- properly record the location of the site so it can be relocated in the future.

Cautions
Destructive site conditions may be controlled by site burial but it is necessary to consider the potential impacts from such actions (White 1989:159-67):

- raising the water table with its inherent problems to the site, such as increased or fluctuating moisture levels
- creating an environment attractive to destructive organisms
- increasing erosion due to increased slope or prominence; blowouts may be the result in dry environments
- if the site is buried too deeply it may be affected by compaction
- in periglacial environments, burial of a site may remove it from the freeze/thaw zone and place it in the permafrost layer, enhancing preservation but making access more difficult.

Moisture

Field investigations show that burial tends to increase the moisture content of the buried soils, though the amount of increase depends on topographic and climatic factors. In areas with very high or very low moisture levels the increase may not be significant. A moderate increase in moisture that results in a wet aerobic condition could have the most deleterious effect. Such conditions may also lead to an increase in burrowing activity by both micro- and macro organisms. If moisture increase results in permanent or seasonally wet conditions, an anaerobic environment may be created which may be damaging to some types of materials but aid in the preservation of organic matter (Mathewson, Gonzalez and Eblen 1992:98).

Compaction
The potential of artifacts to break under pressure is related to certain characteristics of the objects, including thickness, orientation and proximity to other artifacts, burial depth, compressibility of the matrix, and the characteristics of the protective cover. Differential strain rather than total stress is the primary mechanism causing fragile artifacts to break. The protective cover should allow for the compressibility of the burial matrix and minimize differential settlement. The following points outline some of the specific properties to be considered (Mathewson, Gonzalez and Eblen 1992:87-96, 99):

- thin-walled pottery will fracture more readily than thick-walled pottery
- pottery oriented horizontally will break more frequently than pots standing vertically
- rapid loading tends to cause more damage than slow loading
- pottery in contact with dense materials or in contact with other pottery is more susceptible to failure than isolated pottery
- the controlling factor is related to total stain rather than total stress
- weaker but more brittle charcoal sticks tend to fracture more readily than stronger more ductile pottery
- amount of damage drops off rapidly with increasing depth
- breakage is a function of both size and orientation
- on average pots buried in the more compressible silty loam matrix are damaged more than pots buried in the fine sand matrix, indicating greater differential movement in the silty loam material
- unprotected sites will suffer the most damage
- spreading the load provides the best protection against damage
- amount of breakage decreases with increasing depth
- artifacts oriented in such a manner that they can transfer the compressive load onto the underlying matrix are less susceptible to breakage
- artifacts in contact with other artifacts so the stress is transferred from one artifact to the other are more susceptible to damage
- artifact damage is greater in compressible matrix material
- protective covers that minimize the amount of differential strain on buried artifacts provide better protection than those that allow the transfer of strain downward
- artifacts that become ductile when wet, such as charcoal, tend to deform or bend without breaking.

Monitoring
Monitoring is an important part of any site stabilization measure, and at its most basic level should include an inspection of the cover material at the surface of the site with some measurements taken regarding the stability of the cover. Monitoring of the buried layer will require a more elaborate procedure. Any decision regarding whether or not to monitor the buried site should be made prior to the site being buried and locations chosen so they will not impact any known cultural features. The same areas should be examined each time monitoring is performed and therefore need to be accurately located. Some forms of monitoring, such as moisture, pressure and movement, can also be done through electronic instruments.

Summary
As a method of site protection, burial has the advantage over excavation of maintaining the contextual integrity of a site. In implementing burial as a protection measure, however, the potential detrimental effects need to be taken into consideration. Burial can change the environment surrounding the site and in turn affect the preservation of archaeological remains. These changes can enhance preservation, enhance destruction or have a neutral effect (Mathewson, Gonzalez and Eblen 1992:97).

Burial has the potential to limit erosion and weathering as well as impact from micro- and macro organisms, though it will increase the vertical load on sites and, if the matrix is compressible, may displace or damage artifacts such as ceramic and bone. The extent of damage can be predicted and mitigated. Site burial may result in an increase in moisture level and in most cases will have a deleterious effect on archaeological remains. Exceptions include the creation of a permanently wet anaerobic environment or a reduction in the seasonal variations in wet/dry or freeze/thaw cycles. The most beneficial change that can occur is one which reduces the variation in freeze/thaw and wet/dry cycles but retains the original chemical characteristics of the soil (Mathewson, Gonzalez and Eblen 1992:104-05).

The design of a protective cover needs to consider the compressibility of the burial matrix. Rigid covers such as board road, landing mats or concrete slabs should be used on compressible matrices. The cover should minimize differential strains within the site and dissipate stress over the site (Mathewson, Gonzalez and Eblen 1992:105).

The following is a list of environmental factors associated with buried sites, ranked from least damaging to most damaging to archaeological sites (Mathewson, Gonzalez and Eblen 1992:97):

- dry
- thaw
- basic condition
- movement
- micro-organisms
- acidic conditions
- wet anaerobic

- freeze
- macro-organisms
- compression
- wet aerobic
- wet/dry and freeze/thaw.

Site burial implementation
Through careful consideration of the variables affecting the buried environment of an archaeological site, a preservation strategy to protect a select group of artifacts can be planned and implemented. The environment chosen must complement the specific needs of the site and its resources. An initial survey is required to determine the types of materials present and their condition, as well as to assess the research value of the site to ensure that the costs of the preservation effort are warranted. A soil scientist would analyze the physical chemical and biological properties of the soil matrix, noting in particular the texture, pH, moisture conditions, geomorphology and topographic position. An engineer would then design a cover that would induce the desired environmental changes to minimize differential strain on the buried resources (Mathewson, Gonzalez and Eblen 1992:100-01).

Arid and frozen environments provide the best conditions for site preservation. In such sites the buried environment can retain as much as possible the same physical and chemical characteristics that occur in the archaeological soils. If a site is in an acid or alkaline soil matrix and subject to wet/dry or freeze/thaw conditions, it is likely that only a distinct set of artifacts would have been preserved over time. In this case the best solution would be to reduce the variation in freeze/thaw or wet/dry conditions and preserve the chemical characteristics of the site (Mathewson, Gonzalez and Eblen 1992:100-01).

What follows are comments on some of the alternatives to or elaborations on soil burial. These approaches have much in common with soil burial in terms of suitability and effects on resources. Rather than repeat those comments here, just a brief outline of their own distinct benefits and shortcomings are presented.

Stone and gravel burial or riprap

Advantages

- can provide greater protection from natural forces or vandalism than earth burial
- flexibility, individual pieces can move independently and conform to surface features
- gravel can be layered so smaller sized gravel is placed close to the resources being protected with the larger sizes being laid on top.

Disadvantages

- can be greater risks of damage to resources from increased pressure on fragile artifacts or features or from the equipment required to place the covering (Thorne, Fay and Hester 1987:26-30).

Sodding
Sodding consists of earth burial and revegetation. Grass is one of the most effective means of controlling streambank erosion (Thorne, Fay and Hester 1987:50).

Advantages
- allows natural revegetation to occur
- can blend into a natural environment.

Cautions
- grass needs to be carefully selected to ensure compatibility as the roots can be damaging to cultural resources
- ensure environmental appropriateness to the proposed location.

Disadvantages
- grass with deep root systems should be avoided due to possibility of damage to cultural resources.

Revegetation
Revegetation has been among the most useful actions to control various forms of erosion. The root systems of the plants hold the soil together to resist erosion forces. The upper portions of the plants act as buffers against the actions of wind and water. Plants also have the capacity to respond to external forces and can develop greater resistence to applied forces when required. This ability to respond to changes in site condition cannot be achieved through other mechanical means. Simply encouraging the natural revegetation of an area is often all that is required. This is one of the cheapest, easiest and most effective methods of site preservation to initiate and maintain (Thorne 1990; Thorne, Fay and Hester 1987:33-34).

Advantages
- highly effective
- cost efficient
- aesthetically pleasing
- beneficial to the environment
- no special tools or knowledge required.

Cautions
- shrubs and trees may be appropriate for some applications but care must be taken to ensure that roots of those plants introduced or allowed to grow not cause additional damage
- if selection of trees does not adequately take into account the depth of penetration of the root system, severe damage may result from wind-fallen trees.

Disadvantages
- roots can damage fragile artifacts and disturb site integrity
- may cause changes in the soil chemistry and moisture levels

- small roots can contaminate specimens that would otherwise be suitable for radiocarbon dating.

Concrete slabs
(Thorne, Fay and Hester 1987:34-39)

Advantages
- lattice pattern blocks allow for vegetation to grow in their cavities, are lighter than solid blocks and provide good erosion control
- can offer good protection from vandalism.

Disadvantages
- often requires relatively more expense and surface preparation than other methods
- greater risks of damage associated with installation
- frequently does not conform easily to irregular surfaces
- can concentrate runoff along the edges of the surface causing increased erosion and undercutting of protective layer
- prevents observation of resources by archaeologists
- weight can be an issue
- often do not allow for revegetation
- some types of blocks may be easily removed and fail to offer sufficient protection from vandalism.

Filter fabric
Filter fabrics can be used to add strength and stability to soils and are frequently used under roadbeds and other types of construction projects. They can be formed from either woven or unwoven fabrics and are available in different weights and porosities. They are relatively inert and resistant to ultraviolet degeneration. Filter fabrics are not in themselves permanent but can be used in conjunction with other more permanent stabilization methods, or can provide an easily installed temporary protection measure until a more permanent solution can be found (Thorne 1988).

Advantages
- fairly elastic and can be shaped to the contours of an archaeological site
- lightweight and easy to handle and install on horizontal, vertical or sloping surfaces
- resistant to wave, rain and surface water erosion
- permeability can be controlled through a selection from a range of fabric with different porosity
- growth of surface vegetation can be encouraged or discouraged through the selection of the proper fabric
- can be used in combination with other materials such as riprap.

Disadvantages
- can be fairly expensive

- needs periodic inspection, maintenance and replacement
- can be easily cut, vandalized or stolen
- protective properties can be reduced if improperly installed.

Gunite

Gunite is a mixture of sand cement and water (Thorne, Fay and Hester 1987:42-44).

Advantages

- can be mixed in the field and pressure sprayed onto surface
- easier to apply than other hard surfaces in remote situations where water and sand are available.

Disadvantages

- surface not as hard as concrete

Geoweb

Geoweb is a trade name for an expanding system of honeycomb cells (Thorne, Fay and Hester 1987:49-50).

Advantages

- compact, lightweight and easily applied
- can be used in areas of wind blow erosion to trap silts and sands and stabilize an area.

Stream training

Stream training refers to mechanisms employed to direct the force of a current away from a bank in order to minimize erosion and increase stability. These measures may also allow for sediments to be trapped, soils to build and revegetation to occur. The barriers used can be either permeable or impermeable, with permeable barriers having the advantage of allowing sedimentation and encouraging bank building. Impermeable barriers are oriented perpendicular to the bank edge and in effect move the stream's channel away from the eroding bank (Thorne, Fay and Hester 1987:56-58).

One of the risks associated with an impermeable barrier is the possibility of debris being trapped in the barrier, turning the current toward the bank and increasing erosion. There may also be impacts associated with the installation of the barrier depending on the type of barrier created (Thorne, Fay and Hester 1987:56-58).

Summary

Some key points to remember in the implementation of any site preservation or stabilization effort are (Thorne, Fay and Hester 1987:66):

- the measures taken must be in keeping with the site's values and purpose
- few if any in situ preservation methods have received sufficient long-term testing for determining their effectiveness or potential adverse effects, so it is necessary to exercise

caution in the implementation of any protective measure and to closely consider the resource protection needs and likely effects of any action taken
- avoid making the assumption that once a protective measure has been taken there will be no need for further concern; monitoring of the effectiveness of the preservation or stabilization effort and determining whether there are any adverse effects is an essential component of any such program.

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