Abstract

This study was an investigation of the effects of timber harvest activities on subsurface archaeological deposits. Research efforts involved construction of artificial archaeological deposits in timber stands scheduled for harvest, using materials that closely replicate those typical of authentic archaeological sites in Northern Minnesota. After harvest, data recovery was conducted to retrieve replica artifacts and document the extent to which they had been displaced or damaged by harvest activities. Results suggest that horizontal displacement of shallow materials and breakage of fragile materials are the most likely effects of harvest activities, although they tend occur only in areas directly trafficked by heavy equipment.

EFFECTS OF TIMBER HARVEST ON ARCHAEOLOGICAL SITES

Understanding the precise manner in which archaeological deposits are affected by contemporary human activities is a vital part of efforts to devise strategies for mitigation of those effects. Although harvest impacts to archaeological deposits have been documented anecdotally, there has previously been no formal research on such effects in Minnesota. The present study was a first step in the process of collecting information relevant to the formulation of effective and practical recommendations for reducing the effects of forest management activities on cultural resources.

The research as proposed was based on a set of generally held assumptions about the nature of archaeological data -- particularly the concept of “site integrity”, which for our purposes is defined as the extent to which artifacts and features or the stratigraphic relationships among them accurately reflect the human cultural behavior that created an observable archaeological deposit. A related concept is the theoretical definition of artifacts as conveyors of cultural information. In this view, objects are of value not *qua* objects but as carriers of meaning. The physical integrity of objects is important to the extent that it reflects the manufacture or use of the object in a cultural setting. Depending on the nature of the artifact, changes to its physical properties may lessen its potential to transmit information about past cultural behavior, thereby reducing the research value of the object.

The scientific value of archaeological evidence is thus diminished when stratigraphic relationships are disrupted or the physical properties of artifacts are changed. These effects can occur when activities such as heavy equipment traffic result in soil compaction, rutting, mixing of surface soils or removal of ground cover. Indirect effects such as increased potential for wind or water erosion may also result in loss of archaeological data.

While effects such as these can often be observed after the fact, quantifying the extent of data loss from specific management activities is challenging because of the nature of archaeological phenomena. Every site is a unique combination of cultural and natural characteristics that occurs nowhere else. "Before and after" studies of authentic archaeological sites cannot be conducted using convention research techniques such as formal excavation, because preharvest data collection would destroy stratigraphic relationships and remove physical evidence from its original context.

Researchers in other states have addressed this difficulty by conducting studies of "replica" archaeological sites created specifically to document disturbance from management activities, including timber harvest and other forest management practices. While some understanding of processes that affect site integrity has been gained, it is difficult to draw general conclusions from these studies due to variations in regional conditions of topography, soils, archaeological stratigraphy and harvest techniques.

In the present study, an effort was made to ensure that experimental results parallel “real-world” situations to the extent possible. Three aspects of experimental design were particularly critical: the use of authentic materials for creation of replica archaeological deposits; preharvest field methods that resulted in minimal alteration of the physical properties of the soil column, and characterization of site disturbance in absolute measures of displacement and mechanical modification of replica materials.

Procedures

Artifact preparation

A set of replica artifacts was prepared for use in this study. (Here, "artifacts" refers to discrete, portable material objects made or used by humans, or generated as byproducts of human activities.) A range of materials was selected to represent items typically found at archaeological sites in Northern Minnesota. It should be noted, however, that the assemblage included only a subset of the full range of functional classes, technologies and raw materials commonly observed in the archaeological record.

One focus of this study was mechanically induced change to the physical properties of archaeological materials. It was therefore important to represent properties of hardness and friability accurately, so replica lithic and ceramic artifacts were prepared using authentic raw materials and techniques. Because faunal remains are an important component of PreContact sites, a selection of animal bone was also included in the set of replica materials.

Lithic artifacts were prepared from typical primary or secondary source materials: quartz, jasper taconite, Swan River Chert, Red River Chert, Knife River Flint, Cedar Valley Jasper and till cherts. Nodules or core fragments of each material were hand-knapped to produce debitage specimens in a range of sizes. No effort was made to replicate particular functional artifact classes. Replica ceramic vessels were produced from local clays and tempering materials, fired in an outdoor hearth. The fired vessels were broken, and an assemblage of sherds in various sizes and from various parts of each vessel was collected. Faunal material samples were extracted from specimens obtained opportunistically. Portions of crania, vertebrae, long bones and teeth from two mammalian genera (*Alces* and *Procyon*) were used; a subset of the raw bone specimens was thoroughly burned before use.

After the full set of replica artifacts was assembled, each item was assigned a catalog number and recorded on an index list. The items were then painted with fluorescent paint to aid in recovery, and catalog numbers were applied. To document original size and shape, sets of artifacts were placed on a photocopier and a series of copy sheets was produced. Images on the copy sheets were labeled with the appropriate catalog numbers.

<u>Study Plot Preparation</u>

All the experimental work discussed in this paper was conducted at the Little Pokegama Creek property near Grand Rapids. Time limitations did not allow for preparation and analysis of replica deposits in all the stands that would be harvested, so a subset of stands was selected at which all of the relevant variables of harvest technique could be accessed.

Six locations were selected for creation of replica artifact deposits. Four study plots were established in locations designated for harvest with a feller-buncher and tree-length skidding using a grapple skidder, and one plot was established in a location designated for harvest with a cut-to-length/forwarder system. A single control plot was established in a stand that would remain unharvested. In selecting exact locations for the test plots, skid trail location and slash treatment prescriptions were also taken into account. Other aspects of harvest strategies such as clumped versus dispersed residuals were deemed negligible in terms of variation in effects to archaeological materials, so no effort was made to sample these attributes.

Provenience control at each study plot was established with the use of a grid template: an 8-by-12 foot tarp with forty-eight 3” (7.5 cm) diameter holes cut in it. The holes were spaced 40 cm apart and arranged in a 6-by-8 grid. At each study plot, the template was stretched out on the ground surface and pinned down. The tarp location was recorded relative to benchmarks that included two local datum points (nails pounded into exposed tree roots) near each study plot. To further aid in documenting the grid position, template corners were marked on the forest floor with fluorescent paint, and large washers were placed within the top 5 cm of soil at two grid openings. A soil probe was used to remove columns of soil at the midpoints of the template's long edges, and the holes were filled with white aquarium gravel. Thus, several means by which the plot could be relocated were available, even if topsoil was severely disturbed by harvest activities.

Soil was removed from each of the openings in the template, artifacts were placed in the holes, and the soil was replaced and tamped down. It was often possible to retain the removed soil plug and place it back in the hole with little effect on the integrity of the soil matrix. Artifacts were buried at depths between 3 and 20 cm below the ground surface. The placement depth of each item was recorded as depth below ground surface as well as depth below one of the local datum points.

Data Recovery

The study plots were revisited after harvest and each template location was re-established relative to local datum points. At most plots, before the template could be repositioned, it was necessary to remove logging slash and other debris from the ground surface. Large logs were cut with a chainsaw or handsaw and moved; limbs that had become pressed into the ground surface were pried out and removed. Small branches and sticks, bark and leaf litter were removed with a garden rake.

One unanticipated effect of the harvest activities was discovered as data recovery progressed. At 4 of the 5 harvested plots, local datum points had been damaged by heavy equipment traffic. However, the other markers retained enough integrity to provide guidance in relocating the study plots. After the grid template was repositioned at each study plot, elevations were taken at each grid opening relative to the artifact placement datum. Although this vertical datum was often bent from its original position, it was hoped that relative changes in the micro-topography of the plot area (the difference, for example, between elevation of the gravel columns) could be measured even if absolute changes could not.

After the template had been repositioned, the grid openings were marked and excavated, limiting the horizontal extent of excavation to a circle 10 cm in diameter larger than the area excavated for artifact placement. Where the local datum used for artifact placement was unaffected by the logging (plot 1 and plot 3), the exact depth of artifact recovery was measured from this datum. Where the datum had been compromised (plots 2, 4, 5, and 6), the vertical position of the artifact was measured in 5 cm arbitrary levels below ground surface. Thus, an artifact should have been found if it moved fewer than 5 cm horizontally from its original position. Similarly, vertical displacement by more than one level should be identifiable. Recovered artifacts were examined for evidence of damage, comparing them with their pre-placement photocopied images when necessary. The physical condition of each study plot (i.e. rutting, apparent compaction, extent and type of ground cover) was also noted and compared to pre-harvest conditions.

Results

Inasmuch as the local datum points were almost universally compromised (typically bent), direct comparisons of depth below datum at placement to depth below datum at recovery were only possible at two of the study plots. For the other four plots, comparisons of depth below ground surface were made, using the original ground surface elevations as a measure of accuracy. Postharvest surface conditions were also recorded at each plot and compared to preharvest conditions.

Plot 1

This was a control plot, located on an upland terrace in Stand 1, which was unharvested. The ground surface at data recovery was essentially unchanged from the surface at plot creation. All replica items were recovered, although proveniences for about one-third of them varied from placement depths by one to two centimeters. This degree of variation, however, is not significant for the purposes of this study, and indicates that recovery techniques had a reasonable degree of reliability.

Plot 2

This plot was located in Stand 6, near the edge of the riparian zone, in uplands clearcut with a feller-buncher. The logger had been instructed to create slash piles in this stand. Post-harvest conditions found the plot under a significant tangle of large limbs. Large sticks and branches were embedded (often frozen) in the slightly wet soil. In this plot, 4 of the original 48 replica items were not recovered, and 3 were found to be broken. About one-third of the items that were recovered were found at proveniences deeper than those of placement, but most of the changes were only in the range of 2 to 4 cm.

Plot 3

This plot was located far from the riparian zone in Stand 4, in uplands that were clearcut with a feller-buncher. Slash was not deliberately piled by the logger in this stand. Post-harvest, the area was almost totally clear of vegetation and debris; only a few limbs had to be moved to expose the ground surface. A large rut ran along the edge of the plot, and in one place the sod had been dislodged and redeposited. Comparisons of relative surface elevations before and after harvest suggested that much of the study plot had been compressed by equipment traffic, although the damaged datum made an exact determination impossible. The observed surface compression resulted in many artifacts being recovered from proveniences that appear shallower than those of placement. No recovered items were broken, but 17% of the original assemblage was missing; all of these items had initially been at depths less than 10 cm below ground surface.

Plot 4

This plot was located in Stand 2, on an upland slope that drops off to the east. This stand was clearcut with a cut-to-length system. The logger did not complete harvest of this stand until late in 1997, so data recovery was not done until 1998. Post-harvest conditions found the area relatively clear of debris but growing over with weeds. Logging equipment tracks were apparent, but the surface appeared to be compressed rather than rutted. Overall, the cut-to-length system appeared to have had minimal effect on the study plot. The entire artifact assemblage was recovered and only one very fragile piece of burned moose vertebra had been broken. Eight items were recovered from proveniences shallower than placement, but the differences were all in the range of 1 to 5 cm and therefore not considered significant.

Plot 5

This plot was located within the riparian zone in Stand 6, on a terrace with a slope of approximately 10%. Here, uplands were clearcut with a feller-buncher and slash was piled; selective harvest was conducted in the riparian zone. The artifact grid was placed on a natural ramp down from the upland that was used as a skid trail. Post-harvest conditions found the plot totally denuded with what appeared to be substantial surface disturbance. Six of the original 48 replica artifacts were not recovered and 4 (2 ceramic sherds and 2 pieces of burned bone) were broken. All of the missing or damaged items had originally been in shallow (< 10 cm) proveniences.

Plot 6

This plot was positioned on a slope of approximately 15%, in an upland portion of Stand 4 that was clearcut with a grapple skidder. No slash piling was done in this stand. Like plot 5, this study plot was situated on a natural ramp that served as a skid trail. Post-harvest conditions found the plot totally denuded, but with minimal apparent surface disturbance. Plot 6 had 5 missing items and 2 broken pieces of burned bone. Most of the lost or damaged items were originally at proveniences between 4 and 12 cm below the ground surface, slightly deeper than those of the items lost or broken at other study plots.

General effects

Nine of the 219 recovered artifacts (4%) were moved a significant distance vertically, and much of the noted vertical displacement appears to have been due to changes in the elevation of the ground surface (compression, rebound, or addition or removal of soil) rather than actual migration of artifacts. In contrast, 21 items (9.6%) were not recovered and are assumed to have been significantly displaced horizontally. Losses were almost universally from shallow contexts; that is, from depths less than 10 cm below ground surface at the time of placement. In both horizontal and vertical dimensions, artifact displacement did not occur in isolation. Typically, groups of adjacent artifacts were displaced, suggesting that significant disturbance was limited to discrete areas that were most heavily trafficked by harvest equipment.

Approximately one in twenty-two recovered artifacts (4.6% of total) exhibited some type of physical damage than can be attributed to logging activities. No lithic items or raw bone fragments were damaged; the broken pieces were all either ceramic sherds or burned bone. All damaged pieces were recovered within 5 cm of surface except for two items that were more than 10 cm below ground surface.

Discussion

Overall, the extent of effect to the replica archaeological deposits seen in this study was variable within study plots as well as across them. The harvest strategy employed does not appear to have been the sole determinant of effect, although the plot harvested with a cut-to-length system did suffer less disruption than the other study plots.

Although the disturbance pattern was not consistent, there was some commonality in the localized nature of observed effects. That is, within each affected plot, some areas were essentially intact while other areas suffered moderate to significant disruption. Assessment of surface conditions suggested that equipment traffic patterns are the most important factor in explaining the observed variations in artifact displacement and alteration. Areas directly trafficked by equipment – particularly by multiple passes -- were likely to sustain damage, while adjacent areas remained unaffected.

This suggests that it would be difficult to predict the extent of data loss for a given archaeological site in a harvest area, because the exact location of the disturbance will be largely determined by equipment operators as they move through the stand. Even if one can predict an average affected area of, for example, 10% of a total site area, this does not necessarily translate to loss of 10% of the data contained within the site. An archaeological site is a highly patterned assemblage of cultural and natural features in which there may be some areas that are almost devoid of data and other areas that contain dense deposits of artifacts or other materials that are critical to site interpretation. Therefore, disturbance of a small portion of a site, if it occurs in an area of high artifact concentration, may result in loss of a significant proportion of the total information contained within the site.

Of note in this regard is the fact that the faunal materials used in this study sustained more physical damage than ceramic or lithic materials. Faunal remains tend to be poorly preserved in archaeological contexts in Northern Minnesota, while being of particular value for such analyses as radiometric assay, dietary studies, seasonality determinations and paleoenvironmental reconstructions. Their apparent susceptibility to damage from equipment traffic must therefore be a significant consideration when assessing the potential for harvest activities to affect archaeological sites.

Although limited in scope, this study yielded results that begin to suggest which aspects of the harvest process are of most concern to protection of subsurface archaeological deposits. It also resulted in definition of an efficient and reliable protocol for the creation of replica archaeological deposits, although a minor revision is needed to better protect local datum points from damage by logging equipment. Application of the experimental design described here at additional harvest sites will expand sample size and allow for more detailed investigation of specific aspects of the effects observed in the present study. The DNR-Forestry Heritage Resources Program intends to conduct further research as opportunities arise on State Forest lands. In time, the body of accumulated data should provide a better understanding of how to accommodate cultural resource considerations within the framework of forest management in Minnesota.