ARCHAEOLOGICAL SITES AND FIRE-INDUCED CHANGES

A verbal version of this manuscript was presented at the Sixth Biennial Rocky Mountain Anthropological Conference, Estes Park, Colorado, September 18-20, 2003. Subsequently, an edited version of the conference papers was electronically published on CD: In: *Ancient and Historic Lifeways in North America's Rocky Mountains: Proceedings of the Rocky Mountain Anthropological Conference, Estes Park, Colorado*. Edited by Robert H. Brunswig and William B. Butler, 2004.

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The 2003 Mustang Fire required Burned Area Emergency Response (BAER) treatment and monitoring of archaeological sites on Ashley National Forest in northeastern Utah. The fire burned over 20,000-acre area and nearly 300 known sites. Ashley Heritage staff performed archaeological reconnaissance, BAER site treatment, and monitoring of the treated sites. The fire and subsequent rainstorms transformed terrain, sites, and individual artifacts. This experience suggests that some changes provide valuable archaeological information. What archaeologists choose to document during survey and excavation, and how it is interpreted, can depend on identification of wildfire-induced patterns. Conversely, the observed presence (or absence) of fire-induced changes may reveal the past fire history of a site or an area.

Wildfire affects archaeological sites on nearly all landforms. Fire-related changes to the archaeological record can be obvious and immediate (a historic structure burns), or less obvious and more far-reaching. Less obvious changes range in scale from small and immediate (heat alteration of a single chert flake) to vast and enduring (artifact displacement and re-deposition, deposition of ash-stained strata along entire drainages).

Fire-induced changes obviously can affect the archaeological record, and thus affect survey, excavation and interpretation. Immediate and persistent changes in the vegetation density or composition affect visibility during survey. Fire can char and preserve organic materials that otherwise would rot and disappear within a few years. Increased erosion exposes or buries evidence. Palynological evidence of specific plants or plant communities in an archaeological sample, or rapid changes in plant communities in successive stratigraphic levels, may be due to past wildfires.

I doubt that most archaeologists routinely consider wildfire-induced changes to the archaeological record during survey, excavation, and interpretation activities. Texts (Binford 1981; Renfrew and Bahn 1991; Schiffer 1987; Stein and Farrand 2001) dealing with site formation processes often lack sections on wildfire. The Mustang Fire of 2002 made me very aware of fire-induced change as a factor in archaeological investigation.

The Mustang Fire occurred on the north slope of the eastern Uinta Mountains in northeastern Utah, in the fourth year of an ongoing, West-wide drought. The human-caused fire was truly accidental; a trailer tire went flat while a vehicle was in motion, and the tire rim struck sparks from a cattle guard. The Mustang Fire burned 20,000 acres of pinyon-juniper, Ponderosa pine, grassland and brush on Ashley National Forest, and threatened the town of Dutch John, Utah. Fire severity (heat intensity and duration) was patchy, ranging from high to low depending on terrain, ground cover and suppression efforts. The area experienced torrential rainstorms immediately after the fire.

There were 271 known archaeological sites within the burned area. We were charged with implementing Burned Area Emergency Response (BAER). We performed archaeological clearance of areas ahead of ground-disturbances such as construction of log erosion barriers (LEBs) and mechanized earth-moving activities. We identified National Register-eligible sites that were at risk from increased erosion due to the fire, and installed preventative treatments at those sites. We continue to monitor those treatments.

Working in the aftermath of fire had a salutary educational effect. A brief description of the local geology, terrain and archaeology will help define the nature and limits of the experience. The area is a marginal bench of the Uinta Mountains, cut by the canyon of the Green River. The burned area ranges from 1,700—2,600 m (meters) in elevation. The bedrock of the Uinta Mountains is largely Uinta quartzite, a relatively coarse-grained quartzite ranging from tool-quality to poorly metamorphosed. Bedrock is close to the surface, and exposed as ledges, outcrops, detached blocks, and clasts from boulder to cobble size. There are extensive areas where series of descending terraces are defined by successive bedrock outcrops. These terraces (and occasional large flats) support juniper and pinyon, sagebrush, and sparse grasses. Rocky ridges covered with pinyon-juniper, Ponderosa pine or brush are incised by ravines or draws covered with sagebrush, cacti and sparse grasses. Seeps, springs and small streams tributary to the Green River support narrow, lush riparian communities. The local archaeological record begins at least 8,000 years ago, but most of dated sites were utilized between 5,000 and 600 years ago. The most common site types are lithic scatters, rockshelter campsites and storage features. Open sites include short-term habitations and campsites with thermal features such as hearths, roasting pits and slab-lined basins. Tiger chert and Sheep Creek quartzite toolstone, and Uinta quartzite groundstone are the common lithic materials.

A useful understanding of fire-induced alteration to archaeological sites will require both experiments under controlled conditions and observations from actual wildfires in a variety of settings. The next section describes some notable fire-induced changes observed in the year since the Mustang Fire. I also made a post-fire visit to the Hammond Fire on the Manti-LaSal National Forest, which occurred at the same time as the Mustang Fire. The two fires created many similar effects, although the main post-fire threat at the Hammond Fire was wind erosion (Don C. Irwin, personal communication 2003), not water erosion. In a later section, I discuss the implications of these observations for fieldwork, documentation, description and interpretation.

THE MUSTANG FIRE: OBSERVED FIRE-INDUCED CHANGES

Fire Intensity, Direct Effects and Indirect Effects

The direct effects of fire on ground surfaces and archaeological sites include heat alteration of sediments and archaeological materials, and post-fire erosion. The effects tend to be greatest where fire is both intense and long-duration (high severity areas). Dense stands of trees or tall brush, or more open tree stands with ample dead wood and ladder materials, support intense, long-duration burns. Fire severity and related changes are less frequent or less severe in grasslands and in riparian or other areas with damp soils, although isolated hotspots occur even in these areas. The relationship between fire severity and direct effects varies with material. Intense heat of some duration is required to spall or shatter boulders and bedrock outcrops. Charring or carbonization of surface organics such as bone or wood occurs in a patchy manner that is less dependent on fire severity. Post-fire erosion can indirectly affect ground surfaces and sites down slope, including unburned areas. Post-fire runoff and sediments originating in burned areas result in channel cutting and filling and sheetwash deposition on distant, distant, unburnt ground surfaces and archaeological sites. While the magnitude and extent of these indirect effects depend on upslope fire intensity and topography, the most severely affected areas are ephemeral drainages and areas where slope and drainage channel gradients become less steep.

Effects of Fire on Natural Features

Vegetation. Tree loss was the most immediate and obvious direct effect of the Mustang Fire. Many areas looked like moonscapes, albeit moonscapes with lots of black things sticking up. Organic debris tends to accumulate under juniper and pinyon trees in a dense lens about the same diameter as the foliage. Growing trees can displace surface and subsurface rocks, resulting in rock rings, or even a circle of more or less vertical slabs, surrounding the base of the trunk. The burning of pinyon or juniper trees and the duff beneath them left circular, ash-filled depressions several meters in diameter, some with central "rock arrangements." Some depressions had central stumps remaining, but if the roots had burned only a central hole remained. These large, circular depressions contained ash 15 cm or more deep, with a layer of water-resistant, (hydrophobic) soil beneath the ash layer. Tree throws, a common fate for fire-killed trees, tend to leave depressions with a surrounding rock ring that may appear quite substantial in the direction of trunk fall. Tree throw depressions filled with ash-stained sediments. Charred limbs broke away from tree trunks, falling like spears to bury themselves in the ground below. Where fire intensity or duration was low, some grasses recovered within weeks, and trees and brush were only singed. Non-arboreal vegetation in riparian areas often did not burn at all, or recovered quickly. In areas of moderate to high fire severity, lichens on bedrock outcrops and boulders burned to a white ash or turned black. Clumps of cacti turned yellow; some clumps died and others recovered. The first native plants to appear after the fire were small-flowered mustards, *Chenopodium*, Thickstem wheatgrass and various bunchgrasses, and various "tuber" plants such as wild onions, Death camas, and Arrowleaf balsamroot.

Bedrock and Boulders. Bedrock exposures and boulders were directly altered in moderate and high fire severity areas. Uinta quartzite outcrops and boulders were blackened and spalled, creating a pattern of fresh, concave, spalled areas. The spalls were a characteristic "potlid" shape, ranging from about 1 to 30 cm in diameter. In the months after the fire, areas between the original spalls began to spall further and to exfoliate between spalls, softening and obliterating the distinctive pattern of spalled depressions. Within about a year, many of the affected bedrock exposures shed their pre-fire "skin" to relatively uniform depths. The resulting surface morphology is similar to before the fire, but virtually all the original, fire-blackened surface is gone, along with the lichens. The quartzite spalls themselves litter open ground, cracks and crevices, and rockshelter floors. Uinta quartzite boulders ranging from shoebox to Volkswagen size were sometimes fractured cleanly across. The fresh breaks were characteristically flat and smooth, so that from a distance the boulders appeared to have been sawn in half. The fragments typically lay only a few centimeters apart.

Ground Surface. Direct effects on the ground included patchy blackening of the entire surface, ash layers, and the appearance of fire-created surface features such as the circular ash depressions discussed above. Surface visibility increased. Bone was suddenly abundant. Complete skeletons (typically of large herbivores) were plentiful, as were isolated long bones and vertebrae. Regardless of fire severity in an area, the condition of individual bones ranged from unburnt to partially charred to entirely carbonized. Surface weathering of the charred bone was not always evident. Even where erosion channels were not obvious, exposure of non-lichenated and unstained areas on surface groundstone and rock-constructed features often indicated the loss of several centimeters of surface sediments within the year after the fire.

Drainages and Flats. Post-fire runoff filled the lower stretches of ephemeral drainage channels with thick layers of ash and fine-grained sediments. The sediment layers varied as to the proportion of included rocks, ash, charcoal chunks or flecks, and organic materials such as duff. Later channels cut through the newly deposited material and the original channel itself (Figure 1). Where drainages lost gradient and opened onto flats, outwash covered large areas of the flats with ash, charcoal-stained sediments and other materials transported from above.

Figure 1. Derek Stertz examines two meters of cut and fill in an ephemeral wash on Mustang Ridge (the dull green ground cover is spray mulch).

Slopes and Terraces. Much of the Mustang Fire area consists of low ridges separating small, ephemeral drainages. Series of low, stepped bedrock outcrops separated by small terraces flank the ridges. Before the fire, sediments were deepest on the terraces, but the rocky slopes also had thin sediments. After the fire, sediments were stripped from the ridge tops and the slopes, leaving only rocky rubble, even where slopes were short and not particularly steep. The sediments were deposited on the terraces immediately below each slope. Erosion of terrace sediments tended to begin at the downslope terrace lip and work back across a terrace.

Effects of Fire on Archaeological Sites and Materials

Site and Feature Visibility. Changes in the visibility of surface evidence were immediately noticeable at open lithic scatters and rockshelters. The burning of vegetation and organic surface debris can expose surface materials, or conceal them temporarily beneath ash layers. Exposed debitage and tools sometimes demonstrated that sites were more extensive than had been recorded. Rock alignments or constructions were more obvious after fire. Conversely, surface stains were no longer a useful criterion; the entire site surface was stained. A year after the fire, cultural stains are still obscured by overall surface staining and ash pockets. Fire may have little direct effect on rockshelter floors other than blackening the surface. However, burnt packrat nests may expose evidence of constructed rock, adobe or wood features.

Feature Physical Change. Wooden archaeological artifacts and construction materials typically are dry enough to burn easily even in low severity fire areas. Local surface features include brush structures and activity areas that are discrete, sometimes depressed areas of culturally stained sediments with thermal features that sometimes include fire-cracked rock, or are rock-outlined. As mentioned above, surface exposures of discrete culturally stained sediments were simply swamped in the overall surface staining. Depressions, regardless of their origin, tended to fill with a combination of ash and stained fine sediments. Some groundstone pieces heat-fractured, and some rock-constructed features cracked or spalled. The aboveground surfaces of groundstone and rock-constructed features such as slab-lined basins were at least temporarily blackened, regardless of fire intensity. While this surface staining survived, marking the ground level before the fire, it was apparent that some surface features experienced several centimeters of deflation.

Artifact Physical Change. For obvious reasons, lithics are the most prevalent surface archaeological materials. Fire-induced change in lithic materials is a complex issue. Direct effects on a tool or a piece of debitage depend on a combination of material type, shape, size, orientation, surface position, fire intensity, fire duration, and post-fire cooling rate. Quartzite (including Sheep Creek quartzite) in the form of relatively small tools and debitage showed no diagnostic effects regardless of area fire severity. Local prehistoric peoples intentionally heat-treated Tiger chert intermediate stage bifaces and projectile point performs before finishing them. Chert typically responds to heat-alteration with obvious changes in color, luster, and translucence; excessive heating (burning) additionally causes fine, vein-like crack networks, potlid fractures, and angular fractures. Burned Tiger chert tools and debitage were common in the fire area. These could be differentiated from intentionally heated materials due to their extent and distribution, the predominance of potlids (Whittaker 1994:72) and crack networks on small, finished tools, and the presence of potlids on the ventral debitage surfaces. Where fire severity was moderate or high, virtually all exposed Tiger chert debitage showed lost translucence, color change, crack networks, or potlids. Color change on only a portion of a chert flake or tool may be a clue to wildfire; three Tiger chert flake tools found laying flat in a moderate severity burn area one year after fire were intriguing because only a portion of each flake was burnt. The tools were apparently oriented vertically or at an angle and only partially exposed on the surface during the fire. After subsequent erosion of the fine sediments, the tools lay fully exposed and flat on the surface. Quartzite cores typically fractured into several fragments of distinctive, curvilinear, angular debris, often leaving a much reduced, poly-sided main fragment. Chert cores and larger tools, like quartzite cores, shattered in a diagnostic manner. The reported effects of fire on obsidian are extensive, and variable (Loyd et al. 2002). The possible effects on surface ceramics have implications for thermoluminescence and re-firing analyses and interpretation.

Rockshelters. Numerous rockshelters in the fire area attracted human use, and also provided conditions conducive to preservation of the evidence. Fire-induced changes to bedrock outcrops, surface features and surface artifacts discussed above are also relevant at rockshelters. Two additional considerations that can directly affect the nature and integrity of rockshelter deposits are spalling, and runoff patterns. During a fire spalls fall from rockshelter roofs and from the outcrop or cliff surrounding a rockshelter, tending to be most concentrated along the rockshelter dripline. Spalls continue to accumulate due to post-fire spalling and accelerated exfoliation. Accelerated post-fire runoff can cause severe erosion of rockshelters deposits that appear dry and safe under more normal conditions. The impact is not from direct precipitation or increased flows down the cliff face. The damage is due to inflows the sides, or less commonly, from the back of rockshelters. Virtually every rockshelter visited after the Mustang Fire experienced some degree of water inflow from the sides; the exit points were typically low points in the apron. In one case, runoff inflows through a previously unnoted crack in the back of a shelter combined with inflows from the sides to completely wash out the floor deposits to bedrock. Then as flows decreased, a low mound of fresh, fine, ash-stained sediments and debris was deposited on the shelter floor near the back wall. This caused a reappraisal of our original notion that the shelter likely had intact cultural deposits.

IMPLICATIONS FOR ARCHAEOLOGY

Useful Archaeological Indicators of Past Fire

The following examples are from the Mustang Fire. Different materials may be differently affected. It is essential to understand how fires affect on local materials; this can be achieved experimentally, or by local observations in previously burned areas.

Exploded Boulders. The characteristic planar fracture of Uinta quartzite boulders (Figure 2) leaves durable evidence of (typically severe) fires that remains on the surface. Since becoming aware of this indicator, we have noticed the diagnostic fractures in several areas that lack other obvious indicators of past wildfire. If natural factors (slope, position, shape) are considered, the distance between the fragments of an exploded boulder is an indication of time lapsed since the fire. The Mustang Fire fractured artifacts with a similar surface morphology (relatively thick metates, for instance) in a similar manner.

Figure 2. Exploded Uinta quartzite boulders.

Bedrock and Boulder Spalls. The Mustang Fire created abundant, enduring, characteristically potlid-shaped quartzite spalls. The spalls lay on extensive bedrock areas, surrounded boulders and low outcrops, and accumulated along rockshelter driplines and within rockshelters. Prior test excavations within several rockshelters in the burned area had yielded cultural materials and features as much as 3000 years old, but typically dating between 1400-800 Cal BP in the Fremont Period. Since no spalls had been observed in the excavated deposits, it is probable that the areas surrounding the excavated shelters had experienced moderate to high severity fires since the cultural occupations. There are implications for fire history, prehistoric land management, and climate change. The Hammond fire area is sandstone. Although sandstone spalls are less likely to endure than quartzite, they might preserve within dry rockshelters.

Faceted Chert and Quartzite Artifacts. Exposed debitage, tools and cores with angular, flaked facets tended to explode into multiple fragments of angular debris. I field-refitted several cores and a biface from angular debris. I later realized that a quartzite core with an unusual morphology I noted elsewhere on the forest shared the characteristic fracture pattern. That core was in a rockshelter affected by past wildfire, as evidenced by several remaining burned stumps. As is the case with exploded boulders, the dispersal over time of the angular debris from an artifact depends on site-local natural forces.

Small, Thin Chert Artifacts. Even low severity fires can affect small projectile points and thin debitage. These tools showed characteristic patterns of potlid fractures, crack networks, angular fractures, and changes in color, luster and translucency, even where exposed to short duration (but intense) fire. Some of these changes might be mistaken for intentional heat-treating. However, details such as potlid fractures across finished surfaces or on ventral debitage surfaces, or lithic scatters with high proportions of "heat-treated" tools or debitage not closely associated with thermal features, suggest past wildfire. Color, luster or translucence changes can occur on just the exposed portion of partially buried chert artifacts with thin cross sections. This pattern strongly suggests wildfire. Three modified flake tools with this partial burn pattern were recovered from a site ten months after the Mustang Fire. At that time all the flakes were completely exposed, laying flat on the surface, as a result of post-fire erosion.

Lichens. Moderate to severe fires can reset the "lichen clock," if not by burning the lichens, then by exfoliation of the growing surfaces. Given proper care to consider microhabitats and other factors (Benedict 1981:23-29), lichen age patterns can be clues to past site-local wildfires. Post-fire erosion rapidly deflates the sediments surrounding groundstone or constructed rock features protruding above the surface. Linear edges where lichens cease or where there is a dramatic reduction in lichen size suggest surfaces exposed by rapid, possibly post-fire erosion.

Wooden Artifacts. Since surviving exposed wooden archaeological materials are dry and char or burn very easily, the presence of these materials in an uncharred condition suggests that wildfire has not affected the site since it was abandoned.

Catastrophic Change Versus Gradual Change

Erosion and Deposition. Studies have shown that post-fire erosion can increase by three orders of magnitude, transporting as much as forty-nine tons of material per acre, and while the most severe effects are soon after the fire, increased erosion may persist for more than a decade (Robichaud et al. 2001). In the aftermath of the Mustang fire, rainfall on vast areas of modest slopes and small terraces stripped fine sediment (and low-density artifacts) from the slopes and deposited them on terraces or flats below. Natural depressions filled with stained sediments, charcoal flecks and ash. Ephemeral washes across the burned area collected and transported tons of sediment, organic detritus and rock debris in cycles of filling and cutting that sometimes left several meters of stratified deposits. New erosion channels cut into archaeological features and deposits. Freshly deposited materials ranging from fine sediment to small boulders covered large areas where ephemeral washes or more extensive slopes lost gradient, possibly creating a number of new "sparse lithic scatters." Areas of sheetwash "strata" comprised of stained sediments with charcoal flecks, ash, burnt bone and low-density artifacts formed, and were immediately buried. At the Hammond Fire, continued drought and windstorms rapidly deflated some areas.

Large-Scale Alteration of Materials, Surfaces and Features. Where fire severity was moderate or high, virtually all lichens disappeared, along with the original surfaces of most rock outcrops and boulders. At the Hammond Fire, at least one rock art panel spalled, and will probably be entirely lost to subsequent exfoliation (Figure 3).

Figure 3. Spalled rock art panel and outcrop exfoliation in the Hammond Fire area.

Surface artifacts and debitage were heat-altered or fractured over a vast area, although changes tended to be somewhat patchy. Large quantities of charred bone entered the record. Post-fire erosion visibly deflated and destabilized some features on the surface.

Abundant charcoal and ash were transported everywhere by wind and water. Thousands of juniper and pinyon trees burned, creating faux “structures” or “activity areas” two to four meters in diameter with rock “arrangements,” and central “thermal features” (Figures 4 and 5). I have belatedly become aware that Conner and Cannon (1991) and Conner et al. (1989) discuss the creation of faux features, but have not yet had the opportunity to read these sources.

Given the large quantities produced at a time, these “pyrofacts” have a high probability of preserving in the archaeological record. Ashley National Forest may have excavated and reported two such “cultural features,” Hearth 1 at 42DA599 (Pugh 2000: 69), described as having “vertical” charcoal, and 42DA669 Feature 3 (Johnson and Loosle 2002:140) in the early 1990s, at a cost conservatively estimated at several thousand dollars. Post-fire analysis indicated that a rockshelter (42DA874) originally recorded as NRHP-eligible due to a high probability of intact deposits likely has washed out and refilled repeatedly over time. Constructed features and artifacts on the surface are likely to be deflated or exposed very quickly after a fire. If the situation then stabilizes as slowly erosional or steady state, features are likely to collapse. If situation becomes depositional, then a fresh layer of ash-stained materials from the fire may become incorporated in feature fill. Where wildfire is a factor, a majority of both obvious and subtle N-transforms (Schiffer 1991) to the archaeological record, including added strata or materials, alteration of materials and feature degradation, may not occur gradually. They may occur catastrophically within a few years after moderate to severe wildfires.

Figure 4. Burnt juniper: (a) thick, roughly circular ash layer, (b) burnt limb, (c) outer rock "ring at approximate extent of roots, (d) central area, burnt trunk charcoal and rock "ring."

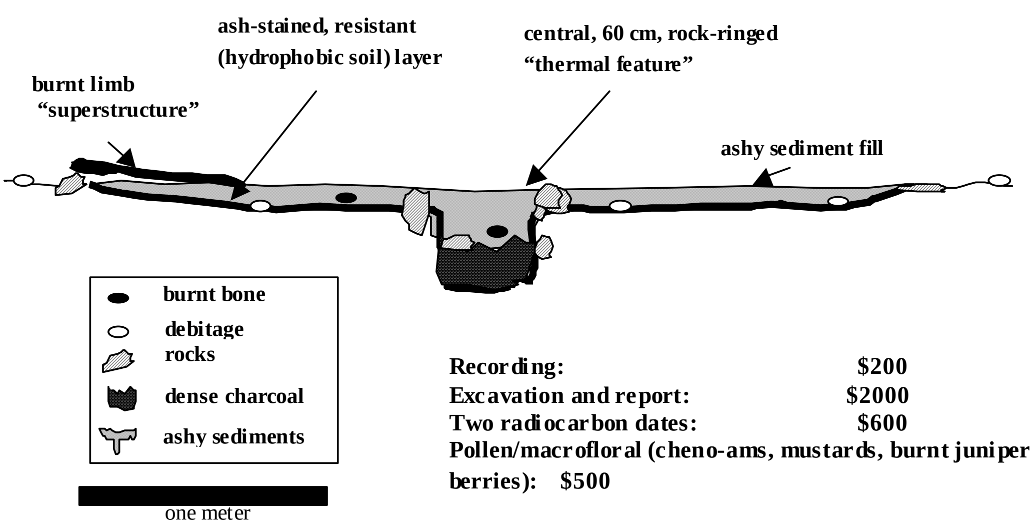

Figure 5. Hypothetical excavation profile of Figure 4 faux "feature" after decades to centuries of elapsed time.

Survey, Site Recording, and Interpretation

Archaeologists will see (or already are aware of) several implications for survey, recording, and cultural resource management. The Mustang Fire experience suggests several important points. Proactive treatment in the form of hand-removal of fuels immediately adjacent to rock art, rockshelters, or other surface features can alleviate at least the direct effects when wildfire strikes. Proactive collection of surface obsidian and ceramics may best preserve the possibility of future analysis. Good accurate GIS site and feature locations will beat site photos and landmarks such as “the big dead tree” when relocating sites after wildfire.

There are numerous implications for analysis. Large quantities of charred and burnt bone can enter the post-fire physical record. The pollen produced by post-fire survival and rapid recovery of adventitious, succulent, and bulb or tuber producing plants, most of which are considered “economic” species, may swamp the fire area pollen record for a time. Both bone and pollen may be transported by wind and water, becoming added to or mixed with archaeological deposits, and a potential sources of bias. The cultural or non-cultural nature of some stained sediments and rock arrangements may not be accurately determined without testing. The proportion and distribution of burnt chert or angular debris in a lithic scatter, or the presence of potlids on debitage ventral surfaces, can be useful data.

Consideration of topography, geology, hydrology and biology during site recording improves interpretation, and may better prepare archaeologists to manage sites in the aftermath of the next fire. An awareness of how local materials and terrain respond to wildfire and the aftermath will usefully inform interpretation of fire history, prehistoric occupation, artifact distribution and excavated features.

CONCLUSIONS

In the Uinta Mountains, fire-related events created patterned soil stains, rock alignments, charred bone concentrations, and ash-charcoal stained strata. Artifacts were both exposed and buried, were concentrated vertically where fine sediments washed away on slopes and flats, and were re-deposited into fine-grained sediments on terraces. Fire charred wood and bone materials on open surfaces and inside rockshelters. Ceramics on the surface (or buried in combustible materials such as pine duff) were burnt, and temperatures may have exceeded the original firing temperatures. Toolstone and groundstone responded differently, and diagnostically, based on material and surface morphology. Observation of fire-induced changes in both natural and cultural materials suggested that: a) fire and the aftermath can substantially alter natural and cultural features, b) fire can create faux “features” that mimic cultural features, c) there are some enduring indicators of past wildfire, and d) some of these some indicators are a guide to the antiquity of past fires.

Archaeologists need to discover and consider the ways that wildfire can affect terrain, archaeological sites and materials. The best way to understand the nature and range of fire-induced change for an area is to observe the aftermath of fire with the implications for local archaeology in mind. Awareness of the potential effects, and knowledge of how to identify those effects, will improve archaeologists' understanding of local formation processes. The exercise may save money and effort through more effective decisions and documentation during survey and excavation, and improved interpretation of the data.

Acknowledgments. My thanks to Ashley National Forest and Forest Archaeologist Byron Loosle, to Derek Stertz, to Don Irwin on the Manti-LaSal National Forest, and to Sheila Goff for steering me to a couple of references I hadn't seen. Thanks also Bob Brunswig, Bill Butler and the other RMAC 2003 organizers for providing a fine forum.

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