Learning from the Texas Wildfires:
Bastrop State Park and Beyond | 2013-06
Texas Parks and Wildlife
“Learning from the Texas Wildfires: Bastrop State Park and Beyond”

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Texas Parks and Wildlife

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The Report Team and Staff of Texas Parks and Wildlife would like to acknowledge and commend the extraordinary efforts of the Bastrop firefighting team in saving the important historic structures in the park. In addition, the park staff at Bastrop State Park, who were able to efficiently evacuate the entire park on a busy holiday weekend, thus assisting firefighters and law enforcement and possibly saving lives, deserve high praise as well.
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Executive Summary

In early 2012, associates of The University of Texas School of Architecture’s Materials Conservation Laboratory first approached staff of the Historic Sites and Structures Program in the State Parks Division at Texas Parks and Wildlife Department to sponsor an investigation on the impacts of fire and fire retardants on masonry construction. Only a few months earlier, a wildland fire had devastated one of the state’s premier parks, Bastrop State Park, a CCC-constructed park designated as a National Historic Landmark. Ironically, the tragedy provided the opportunity for an excellent case study.

After thoughtful discussion, it was deemed a valuable project for both institutions.

For UT it would mean:
- working with state agency with responsibility for lion’s share of Texas’s historic properties;
- providing research opportunities for talented graduate students;
- becoming more familiar with statewide disaster planning agencies;
- engaging in focused scientific research;
- working with staff in several areas, such as park units, resources programs, and the Wildland Fire Team at TPWD.

For TPWD it would mean:
- having access to a state-of-the-art building conservation lab, its staff and equipment;
- continuing its architectural conservation partnership with the flagship university in state system;
- investing in future opportunities to provide a “learning laboratory” for conservation practices;
- promoting the conservation efforts of TPWD;
- and practicing, encouraging and enabling science-based stewardship of natural and cultural resources, as identified in the 2013 Land and Water Resources Conservation and Recreation Plan.

It was with these goals in mind that TPWD sponsored a primarily UT-staffed grant proposal to NCPTT, which was successful. This report is the result of that grant-funded study.
# Acronym Glossary

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<th>Acronym</th>
<th>Description</th>
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<td>BCW</td>
<td>Bastrop Complex Wildfire</td>
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<td>BSP</td>
<td>Bastrop State Park</td>
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<tr>
<td>DHS</td>
<td>Department of Homeland Security</td>
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<tr>
<td>DOA</td>
<td>Department of Agriculture</td>
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<td>DOI</td>
<td>Department of the Interior</td>
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<tr>
<td>FEMA</td>
<td>Federal Emergency Management Association</td>
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<td>IWUI</td>
<td>International Wildland-Urban Interface Code</td>
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<tr>
<td>NCPTT</td>
<td>National Center for Preservation Technology and Training</td>
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<td>NPS</td>
<td>National Park Service</td>
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<td>SOI</td>
<td>Secretary of the Interior</td>
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<td>TPWD</td>
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<td>USFS</td>
<td>United States Forest Service</td>
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<td>WUI</td>
<td>Wildland-Urban Interface</td>
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1. Introduction

In May 2012, Texas Parks and Wildlife was awarded a 2012 National Center for Preservation Technology and Training grant to investigate the effects of the 2011 Bastrop Complex Wildfire on cultural resources in Bastrop State Park (BSP). The grant project – *Texas Wildfires: Bastrop State Park and Beyond* – began on May 1, 2012, and continued through June 30, 2013. The team approached this subject from the perspective of historic preservation specialists trained in materials conservation, with a desire to better understand the impact a wildfire of this size has on historic materials and structures. The team also wanted to learn more about ways to minimize damage in future fires, while maintaining the historical integrity of the sites.

1.1 Project Team

Dennis Gerow, historical architect for the Historic Sites and Structures Program in the State Parks Division of Texas Parks and Wildlife Department (TPWD), was the Principal Investigator for this grant project. TPWD staff members working with Dennis included Dr. Cynthia Brandimarte, Historic Sites and Structures Program Director, and Jeff Sparks, a Wildlife Biologist who manages the State Parks Wildland Fire Program. TPWD staff provided documents relating to the fire and park, as well as input on aspects of the response to, and impact of the fire. Gerow accompanied the UT team on three site visits.

The grant project team also included Frances Gale, a Senior Lecturer and Research Scientist at the University of Texas. Gale is Director of the Architectural Conservation Laboratory at the UT School of Architecture. Also representing UT was Miriam Tworek-Hofstetter, a 2013 graduate of the Historic Preservation program. Her Master’s thesis focused on the effects of the Bastrop Complex Wildfire on cultural resources at BSP. Tworek-Hofstetter’s research contributed greatly to this report.

Team member Casey Gallagher is a historic preservation and materials conservation consultant in private practice. She is a graduate of the UT School of Architecture Historic Preservation program, and has provided consulting services on previous TPWD projects.

In this report, Gale, Tworek-Hofstetter, and Gallagher are referred to as the “UT Team” (or we unless otherwise noted)
1.2 Scope of Work

The scope of work for the grant project included developing tools to assist in assessing fire damage to historic structures, stabilizing conditions resulting from exposure to fire and providing guidelines for protecting cultural resources from future damage associated with wildfire. Grant objectives were:

<table>
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<tr>
<th>Grant Objective</th>
<th>Report Section</th>
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<tr>
<td>Develop an understanding of cultural resources of BSP</td>
<td>(2) Background Information</td>
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<tr>
<td>Assess the current conditions of the cultural resources at BSP</td>
<td>(2) Background Information</td>
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<tr>
<td>Sample historic building materials exposed to the fire and evaluate effects</td>
<td>(3) Aftermath</td>
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<tr>
<td>Evaluate remedial treatments such as cleaning on historic materials affected by wildfires</td>
<td>(3) Aftermath</td>
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<tr>
<td>Consult with TPWD experts regarding their recent response to wildfires</td>
<td>(4) Recovery</td>
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<tr>
<td>Gather, compile and review existing information on disaster preparedness and recovery relevant to wildfires</td>
<td>(5) Preparing for Future Wildfires</td>
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<tr>
<td>Develop guidelines for protecting cultural resources from future damage associated with wildfire</td>
<td>Appendix 1</td>
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<td>Develop a Rapid Assessment form for use immediately after a wildfire</td>
<td>Appendix 2</td>
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<td>Create a training module that incorporates the findings of this report for dissemination to staff at vulnerable state parks</td>
<td>Appendix 3</td>
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1.3 Methodology

Grant project work began with archival research at TPWD Headquarters in Austin where we reviewed historical information, including BSP project files, oral histories, drawings, photographs and maps. The UT Team conducted a literature review of wildfire disaster recovery and preparedness and researched topics including appropriate fire-resistant materials for replacing fire-damaged elements of historic structures in BSP and the use of defensible space zones around historic structures. Were Archeology Lab materials consulted?

Oral history interviews, conducted by Cynthia Brandimarte, included Wildlife Fire Program Manager Jeff Sparks and Facility Management Information System Director Robert Crossman who discussed their involvement in efforts to contain the wildfire at Bastrop State Park.

The UT team made six site visits to BSP during the grant period. Our initial visit included an inspection of cultural resources, including the Civilian Conservation Corps (CCC) cabins, refectory, entry wall, culverts and the two overlook structures that were damaged by the wildfires. During subsequent site visits, we assessed existing conditions of the overlook structures and the culverts and obtained small samples of sandstone and mortar.

To evaluate the effects of fire retardants on historic masonry, which were not used on the Bastrop wildfire, the team visited Sanders Cemetery in Magnolia, Texas, where retardant was dropped to control a wildfire threatening the site. During our visit, we inspected conditions of historic gravestones that had been covered with the fire retardant and met with Magnolia resident Sharon Russell, who directed clean-up efforts.

Examination and testing of these samples was carried out in the Architectural Conservation Laboratory and in at the UT Jackson School of Geosciences Electron Microbeam Laboratories. Laboratory testing also included evaluating cleaning methods to remove fire retardants commonly used to control future wildfires. We obtained samples of the fire retardant that was used to control last year’s wildfire in Magnolia, Texas, and carried out cleaning tests to determine materials and procedures for safely removing it from masonry and mortar samples.

Although fire retardants were not used in Bastrop State Park during the 2011 wildfire, our investigation of possible adverse effects to historic materials will help determine whether their use on historic materials is advisable. Our laboratory testing was also important in developing recommendations for removing fire retardant residues.
2. Background information

Bastrop State Park (BSP) is located in Bastrop County near the town of Bastrop at the intersection of State Highway 21 and Loop 150 to Park Road 1. The park was established in 1933 when the City of Bastrop and private donors gave 2100 acres to the Texas State Parks Board. The park gained 1450 acres in 1979 and another 100 in 2000. With purchases made in 2001, BSP consists of 5926 acres.

2.1 Civilian Conservation Corps

Construction of buildings in BSP began shortly after 1933 as part of U.S. President Franklin Roosevelt’s New Deal, and was primarily carried out by the Civilian Conservation Corps (CCC). The CCC employed men between the ages of 18 and 25 who worked on state parks across the nation from 1933-1942. Supervisory positions were created for unemployed architects and skilled craftsmen. Roosevelt’s intention for the CCC was to “strengthen and discipline boys below draft age,” to conserve natural resources, and implement planned land use.

BSP is a flagship of the Texas state parks and remains one of the best examples of the National Park Service (NPS) Rustic style. Pivotal in the creation of this style was Herbert Maier, the Region III (including Texas, Oklahoma, and the Southwest) director. Maier designed National Park structures in Yosemite, Yellowstone, and the Grand Canyon before working with the CCC and, although he did not design the buildings at Bastrop, he supervised planning and design efforts. More direct control was given to Arthur Fehr who came to Bastrop in 1934 with the title of park architect and construction supervisor. Fehr designed all 1930s buildings except for the entrance portals and refectory exterior which came from the State Parks Board. He often worked at the site on drawings and developed relationships with CCC workers. Landscape architects Norfleet Bone, H.L. Scogland, and Rufus Hirsch, further contributed to the Rustic and naturalistic architectural style. CCC companies 1805 and 1811 arrived on site late in 1933 and early 1934.

Between 1933 and 1937, the CCC completed entry structures, refectory, cabins, overlook shelters, some erosion-control and landscape beautification work for the park, including park roads and associated culverts. Since there was no funding to buy building materials and transport them from other locations, CCC enrollees quarried local stone and cut nearby trees for park structures. Although the locations of the Bastrop quarries are uncertain, interviews with former CCC members place them a few miles outside the park. Stone was blasted with dynamite, loaded into trucks, and hauled to the park.
Local sandstones include Carrizo sandstone and members of the Reklaw formation. Carrizo is the majority of the stone underlying the park; it consists mainly of rounded quartz grains cemented with iron oxide which gives the stone a reddish color. However, Carrizo generally is poorly cemented and unfit for use as building material. Much of the stone used for CCC buildings is Newby, which constitutes the basal beds of the Reklaw formation. CCC members also recall quarrying shale. Other likely sources include consolidated gravel deposits along the Colorado River and the Sabinetown Formation found east of Bastrop. These sources provided material for the visitor center and flagstones. Original woodwork was also created from locally sourced trees including oak and pine.

2.2 Significant Features
The majority of historic structures in BSP are intact, and subsequent building in the park is in keeping with the master plan developed between 1933 and 1942. The principal idea behind the spatial organization of BSP was to make all developed features of the park consistent with the historical period. The variety of structures and the preservation of the CCC buildings highlight their significance in understanding the practices of the time. The visitor center, with its CCC-era design, not only serves as a functional facility but also as a reminder of the era's approach to public service and environmental conservation.
accessible by vehicle via the main park loop (Park Road A), while limiting vehicle intrusion in less developed areas. The developed areas are well defined and discrete. The roadways and structures are also sensitive to the park’s topography: the CCC enhanced the artificial lake on Copperas Creek, constructed overlooks in natural high places, and used the western level space for golf course and day use buildings. Landscape and forestry work was also conducted by the CCC alongside building structures roadways and trails: construction was generally followed by “landscape naturalization” to eliminate signs of construction and enhance the buildings. Circulation through the park also was part of the master plan, focusing on control of vehicle access through a single park entrance and the separation of vehicle and foot traffic.

Characterizing the National Park Service Rustic style are low buildings constructed of wood and roughly cut stone, with wide, deeply struck mortar joints. Lower courses of walls have larger blocks of stone than the upper courses, and unbroken horizontal joints are avoided. CCC recruit Otto Pruetz recalls cutting his first stone: “The first time I made one, I think I spent all day on it. They had a foreman and he came along and he measured them and put them down in the book. [H]e told me, go ahead and chip on that and make it look a little rougher. It was too smooth.”

The degree of this Rustic style varies from the more developed area of the park, where buildings and walls were constructed with regular stone blocks, to the cabins and overlooks which are nestled more deeply in the forest, where their random coursed stonework blends in with the landscape. Masonry walls are load-bearing, and the heavy timbered roofs are covered with heavy shingles.

Because a survey of extant historic buildings and structures in BSP completed in 1993 and published in 1997 as part of its National Historic District nomination is easily accessed, a detailed description is not included in this report. However, a brief description of park zones and significant characteristics of buildings affected by the 2011 wildfire follows. The nomination divides BSP into the following groups: park entrance and day use (e.g. refectory, gate house, swimming pool), park loop road 1A (e.g. Lost Pines Overlook, culverts), cabin area (e.g. cabins of “Pioneer Village,” cabin spur road 1B, foot bridge) maintenance area (maintenance spur road, pump house), and park lake and other resources (e.g. lake and dam, Lost Pines Overlook, trail, fire rings, buildings associated with golf course). The overlook on the park loop road (i.e. Lost Pines Overlook) is constructed with “six heavily battered round columns built of irregularly coursed sandstone.” The hexagonal floor is also of sandstone, and was originally covered with a hipped, wooden roof with heavy timber frame and shakes. Photos taken of the Lost Pines Overlook before the 2011 fire show what is likely to be a replacement of this original roof, and it is apparent that the masonry was repointed at some time. The second overlook, also known as Fehr’s Overlook, is rectangular in shape with sandstone walls, steps and floors. This overlook was burned in an earlier fire, and its roof had not yet been replaced by 1997.
2.3 Bastrop Complex Wildfire

Beginning on September 4, 2011, the Bastrop Complex Wildfire (BCW) was the largest Wildland-Urban Interface (WUI) fire in Texas history, and the third largest nationally. It impacted 32,400 acres, 1,696 structures and 96% of BSP’s pine forest. While most of the forested area of the park was lost to the massive and fast-moving fire, firefighters were able to save all of the park’s cabins and larger structures, losing only the roofs of the two overlook structures. After the fire, a thorough case study was completed by local wildfire experts. Our summary of the BCW is below.

![Figure 2. Bastrop entrance during fire (courtesy of TPWD)](image)

**Contributing Factors**

On the Labor Day weekend of 2011, Tropical storm Lee brought high winds to Bastrop County, but no precipitation. The sustained high temperatures of the preceding few months had heated the ground, and the ambient heat, combined with the already dry surface pushed the relative humidity down, creating ideal fire conditions. There were sustained wind speeds of 10 – 15 miles per hour. The high winds of the tropical storm collided with a cold front from the north, reducing the moisture in the air, and as the winds moved west, the relative humidity dropped further.
The historic drought had been building since 2010, with some areas in central Texas at 25 – 40 inches below normal levels of rainfall. This severe drought created massive amounts of dry fuel (pine needles, foliage, vegetation, trees, etc.), which was readily combustible. Extreme dryness also contributed to the speed at which the fire spread, the height of the flames, the extent of the spotting and length of the smoldering time.

The Wildland Fire Program had undertaken an aggressive burn program at Bastrop and numerous other parks, but with the excessive fuel loads, volatile vegetation, persistent long-term drought, and natural resource habitat concerns for the Houston Toad and other endangered species, the program was severely limited in the number of days, areas and sites that could be burned in a given year or treatment period. Proximity to urban areas and other smoke sensitive areas further affected the reach of the program. In the previous year, BSP had completed a series of prescribed burns as part of its long-term burn program, but some sections of the park were still vulnerable. The CCC cabins were in part saved due to recently conducted prescribed burns in that area, but given the severity and magnitude of the fire, luck played a large part as well.

Firefighting Efforts
Before the fire, Bastrop and all of Central Texas was under a red flag warning, with conditions ripe for fire activity. Red flag warnings are issued when relative humidity is at 25 percent or less, with wind speeds of 15 mph or more and a temperature 10 percent above average. The conditions at Bastrop averaged to 8 degrees above normal, 14 mph winds, and a relative humidity of 20%. The fire spread at a rate of 5 mph for the first few hours. Wind speeds encouraged heavy spotting: it is estimated the spotting distance in the Bastrop fire was almost 3 miles. The extreme heat and wind also created vertical and horizontal vortices, which propelled the fire forward, increasing its speed, and crown spread.

Sparked by a downed power line, and fed by the weather and drought factors, the BCW fire spread at a rate of 5 mph for the first few hours. Wind speeds encouraged heavy spotting: it is estimated the spotting distance in the Bastrop fire was almost 3 miles. The extreme heat and wind also created vertical and horizontal vortices, which propelled the fire forward, increasing its speed, and crown spread.

Battling a blaze of this size required a coordinated effort among several fire departments at the local and state levels. BSP had its own fire department working to save the structures, but the larger area of the fire was battled by local fire departments and the Texas Forest Service. In addition, hundreds of firefighters from across the state and as far away as California assisted in the effort once the severity of the wildfire was understood.

The response was swift and organized, in part because many of the fire departments had received specialized wildland firefighting training. Containment lines were built using shovels, axes and bulldozers, which aided in containing the spread of the fire to other populated areas of Bastrop County. Air support with helicopters and planes dropping water and fire retardant began on the first day, with the total from September 4 – September 9 at 1,880 air drops of 2,059,323 gallons. No fire retardant drops were made over Bastrop State Park. The decision to divert fire retardant was a combination of resource availability (when the fire began resources were spread throughout the state), and a prioritization of threats to more populated areas. Visitors to Bastrop State Park,
through the quick and effective efforts of park staff, had been completely evacuated when the fire began to threaten the park, and while the cultural resources were still a priority, the large scope of the fire, and others across the state, diverted some resources (such as fixed wing aircraft retardant drops) to other locations.\(^{30}\)

While the fire spread rapidly, its arrival at the historic structures of the Park was not immediate, giving the fire fighters time to protect the cabins as best they could. The overlook roofs were lost because of their remote locations and hilly terrain, the latter causing updrafts which intensified the fire. The firefighting focused on the areas with a more dense collection of historically significant buildings that were also more easily accessible.

Figure 3. Firefighters dousing cabins (Courtesy of TPWD)
Cultural Resources
During the 2011 Bastrop Complex wildfire, firefighters remotely communicated with historic preservation specialists who, because of safety concerns, were not allowed in BSP during the fire or immediately afterwards, when the roads and park itself were deemed unsafe for entry. Information about the condition of CCC buildings was relayed to Preservation staff at TPWD headquarters in Austin immediately after the fire had been suppressed. They did not learn that overlooks were badly damaged and the main buildings were saved until after the event.\textsuperscript{31} When BSP was declared safe for access by assessment teams, archeologists were among the first to begin an assessment of cultural damage.

In describing the efforts made by wildland firefighters to save the cabins and day use buildings, Wildland Fire Program Manager Jeff Sparks sheds light on how historic preservation staff participated in the process. According to Sparks, there were a number of certified firefighters from Bastrop State Park and the Regional Office who were on the fireline, providing critical information regarding structures and assisting other firefighters and the Incident Management team with prioritization for response and protection. Firefighters were in constant contact with park and regional personnel including Cultural Resource Specialist Rich Mahoney, and with their help, firefighters were able to identify and prioritize efforts to protect historic resources.\textsuperscript{32}
3. Aftermath: Effects of the Fire

The USDA Forest Service classifies the impacts of wildfire on cultural resources as direct, operational and indirect. Direct impacts are those caused by the fire itself or byproducts such as smoke. Operational impacts are caused by fire management actions to extinguish fires. Examples are fire line construction and fire retardant drops. Indirect impacts occur as a result of fire-induced changes to the sites in which cultural resources are located. Erosion due to loss of vegetation cover is an example of an indirect impact. Because damage to the scenic overlooks in Bastrop State Park was due to their exposure to the wildfire, the resulting conditions are classified as direct impacts. Descriptions of direct impacts to wood, mortar and sandstone are below.

3.1 Direct Impacts: Wood

When wood is burned, it eventually breaks down into flammable gases and charcoal. The burning process begins at 248-302 ºF (120-150 ºC) and involves several steps. During the initial stage, interior moisture is released and, as the chemical composition of wood changes, it begins to lose structural integrity. In the next stage, moisture is driven off and volatile gases escape. During the final stage, at 752-842 ºF (400-450 ºC), the remaining charcoal is burned.

Regarding wildfires, the Texas Forest Service “Bastrop Complex Wildfire Case Study” report states that "Even before the flames of a wildfire arrive at a particular location, heat transfer from the wildfire front warms the air to 1,470 ºF (800 ºC), which pre-heats and dries woody material. It will start to smolder at 720 ºF (380 ºC) and ignites at 1,000 ºF (590 ºC)." The 2011 wildfire that traveled through BSP is said to have burned 95% of the park's 6,500 acres see page 9 as this number is not same. Although most historic structures in the Park were spared, wood roofs of the two Overlooks that were located in the path of the wildfire were affected.

Wood - Bastrop State Park
During our May 2012, site visit, we briefly inspected conditions of the Overlooks in BSP. Although the shingles and rafters of the Lost Pines Overlook roof had been destroyed by the wildfire, a charred horizontal beam survived the blaze. Also, some of the lower beam pockets contained charred remains. At Fehr’s Overlook, the roof was entirely gone. All that remained were some charred wood pieces on the floor of the Overlook and on the ground surrounding it.

3.2 Direct Impacts: Mortar

Previous researchers have described some of the problems that occur following the exposure of masonry mortars to wildfires. Discoloration particularly affects mortars that
contain iron minerals. This effect occurs after exposure to temperatures of 482-572 °F (250 to 300 °C).34

Other problems are caused by dehydration of the cements present in mortar. At temperatures above 572-752°F (300-400°C), mortars begin to lose strength. However, the damage generally is shallow, extending ½ to ¾ inch below the surface.35 After exposure to extremely high temperatures, mortars begin to powder, eventually disintegrating. If severe, this damage can result in structural failure.36

**Mortar - Bastrop State Park**
The effects of the wildfire on masonry mortar of the overlook structures were not obvious during the inspections that we carried out during our July 2012, visit to BSP. The mortar joints of Lost Pines and Fehr’s Overlooks appeared to be in generally good condition, with little discoloration or damage. Regarding the Lost Pines Overlook, some of the mortar is tan-colored and, in other locations, it has a pinkish color. Both mortars appear to be repointing mortars, and not original to the structure. The beam pockets, located in the columns several feet above the shelter floor, are now empty. Dark-colored soiling (presumably from soot) was noted on mortar on interior surfaces of the beam pockets.

At Fehr’s Overlook, some of the existing mortar is white and, in other locations, the mortar has a darker, grey color. The latter appears to contain Portland cement, which was used by the CCC in some construction, but it is possible some of it is not original. There are numerous open joints, but this condition may be unrelated to the wildfire.

When reconstruction of the roofs was begun by TPWD staff during the summer of 2012, some of the existing mortar was removed by the workmen prior to repointing. During our July visit, small samples of the discarded mortar were collected from the area immediately surrounding the overlooks. Although these samples appear to be intact, we did not have reference samples to evaluate the effects of their exposure to the wildfire. Although masonry mortar of the overlook structures was exposed to the 2011 wildfire in BSP, we did not detect discoloration, powdering or other damage that might be attributable to direct impact. However, exposure to the wildfire may have affected porosity and other physical and chemical properties that determine its long-term performance. **For this reason, it is important to conduct periodic inspections of both overlook structures, and replace any deteriorated or missing mortar.**

### 3.3 Direct Impacts: Sandstone
Fire decay studies have shifted from macro-scale observations—which include phenomena like spalling and color change—to micro-scale issues of texture and mineralogical change. Similarly, conservation scientists are re-evaluating the temporal aspect of how we assess fire decay, including immediate decay symptoms, effects that appear following several years, and those that develop over a long period of time. Our literature review focused on these topics, especially on manifestations of fire decay on sandstones.
At the macro-level, fire decay is more severe and its products more visible in dense stones such as granite. Because of its low porosity and interlocking of minerals, differential thermal expansion often leads to cracks and fissures. These effects are less significant for most sandstone as space between skeletal grains allows for expansion without cracking. Color change occurs with oxidation of iron compounds; for example, in sandstones with iron compound matrices, the formation of hematite (the most stable of iron compounds) produces a red to purple color.\(^{37}\) While this chemical change does not affect its structural integrity, the resulting color change is not always desirable.

Although sandstone does not always exhibit dramatic damage on a macro-scale, both skeletal grains and matrices of different minerals are affected by fire. Quartz minerals sometimes increase in volume (with the transformation from alpha quartz to beta quartz) at 986°F (530 °C), rupture at 1063.4°F (573 °C), and develop micro-cracks at 1382-1652°F (750-900 °C).\(^{38}\) While scientists note these alterations, the changes in quartz grains appear not to affect structural integrity of the sandstone or future weathering patterns. However, examination of quartz may be used to determine the severity of heat that radiated from the fire.\(^{39}\)

The most severe effects of fire on sandstone involve micro-changes to its matrix. It has been well-documented\(^{40}\) that sandstones with clay-rich matrices begin to deteriorate at relatively low temperatures: as the matrix is exposed to heat from 842-1382°F (450-750 °C), clay minerals begin to dehydrate, changing the matrix structure.\(^{41}\) Calcareous matrices are also affected by heat albeit at higher temperatures due to the calcination of calcite.\(^{42}\)

Both alteration of grain structure and decay of the matrix can alter the stone’s porosity. For example, in their 2004 report on fire decay, Gomez et al. document that two different Spanish sandstones show alterations in their calcareous and siliceous matrices. In the case of the calcareous sandstone, the total porosity of the stone increased as did the average mean size of pores.\(^{43}\) These alterations affect moisture migration within the stone, often contributing to deterioration processes, especially when soluble salt are present.\(^{44}\)

Wildfires also contribute directly to salt weathering as the byproducts of ash include carbon, sulfur, nitrogen, phosphorus and organic compounds. When these contaminants fill surface pores, they combine with other substances to form salts. Soot accumulation from fire can also form an uneven crust with reduced permeability and increased hydrophobicity. The crust dehydrates the surface of the stone, trapping salts that were deposited within the stone. Gradually salt decay may cause the soot layer and surface stone to exfoliate, leaving an exposed new surface with higher permeability due to the salt and fire decay.\(^{45}\)

In a paper published in 2009, Gomez-Heras calls for more studies on interactions between fire decay and other forms of weathering as “little is known of how fire exploits weaknesses and by-products generated by other decay mechanisms, and how the sensitivity of a given stone to fire evolves with time.”\(^{46}\) This remark brings up two
problems in fire studies: first, the issue of time and its relation to fire decay (commonly thought of in terms of shock versus fatigue), and second, the reality that stones constituting historic structures (and more recent buildings for that matter) accumulate weaknesses from various cycles of weathering (e.g. insolation weathering, salt weathering, mechanical damage etc.) that may exacerbate deterioration—especially spalling or granular disaggregation—in the event of fire damage.

Figure 4. Exterior Wall of Fehr's Overlook. Colorado River Terrace Sandstone is visible above Newby Sandstone. (Photo by authors)

Sandstone – Bastrop State Park
Most of the sandstone used to construct the CCC structures was quarried from the nearby Reklaw Formation. The two layers of this formation used in BSP were the Colorado River Terrace (CRT) deposits and Newby (Figure 1). CRT sandstone is characterized by a larger aggregate, and some examples are more like a conglomerate. The Newby has smaller aggregate consisting mostly of quartz. Both are ferricretes, and hematite is the primary cement in the dark purple sandstone. Upon first examination, the UT team was
concerned about the dark color of the stones of the overlooks, which in some cases appeared charred and ashy with granular disaggregation. The team suspected that these characteristics indicated the stone had suffered thermal shock and was altered on a micro level. Samples were collected between May and December of 2012. Samples exposed to the fire were taken from the rubble left around the overlooks after the roofs collapsed, and also from sandstone outcrops in the path of the wildfire. Unburned samples were taken from the cabins and sandstone outcrops outside the path of the wildfire.

A group of burned samples from the overlooks and an unburned sample from the cabin area were tested for water absorption and observed with a scanning electron microscope (SEM). Differences in absorption between the unburned and burned samples might provide information about the degree to which the sandstone’s pores were altered by fire decay. Water absorption for the unburned sample, a Newby sandstone sample from one of the cabins, was measured at 10%. With the Newby samples from the outlooks that were exposed to wildfire, water absorption ranged from 6-12%. Water absorption on five CRT samples from the overlooks ranged from 6-9%. Considering the range of water absorption results for the exposed Newby samples and the lack of pre-fire data, the UT team throughout? was not able to draw conclusions about the effect of the BWC’s on water absorption.

![SEM Image of Newby sandstone from Fehr's Overlook](image)

**Figure 5.** Scanning Electron Microscope Image of Newby sandstone from Fehr's Overlook. Cracking from unknown cause is visible in crust.

A total of 12 samples were examined with an SEM, and we compared exterior surfaces and interior surfaces to determine if exposure to the fire had produced visual damage. The samples showed no definitive fire decay. Based on the scholarship reviewed above,
we expected fire damage to manifest itself mainly in the matrix. With our samples, however, the matrix appears to be intact, except for a few instances of cracking. We observed gaps between the quartz grains and the crust, which may be signs of matrix shrinkage and separation due to the thermal differences between grain and crust. However, we do not believe this has major implications for the integrity of the stone.

3.4 Conclusion
The BSP materials—except for wood—do not exhibit signs of immediate decay: variations in color across both mortar and sandstone reflect their composition. The sandstone’s cement is an iron oxide, already reddish, and not likely to show color change; variation in mortar color is caused by the mix and mortar on sides of the overlooks exposed to fire are not exclusively pink. Nor is there any clear evidence of spall from stones on the overlooks.

Based on the findings of other conservation scientists, exposure to the 2011 wildfire may have long-term effects on weathering of the BSP sandstone, especially in combination with deterioration processes such as salt crystallization. The UT Team did note more severe granular disaggregation on fired sandstone in comparison with the sandstone taken from the cabin, but beyond this qualitative observation, no quantitative or conclusive evidence of stone decay was discovered with water absorption testing or during SEM examination.

The UT Team recommends close attention should be paid to the condition of the overlooks in regular and cyclical inspections. Specifically, signs of cracking or other damage that could be a result of exposure to such extreme heat should be ruled out.

3.5 Operational impacts: Fire Retardants
As stated above, operational impacts are caused by fire management actions to extinguish fires. Fortunately, we did not find examples of operational impacts on cultural resources at BSP. However, during the 2011 BCW, retardants were used in nearby locations, including an historic cemetery in Magnolia, Texas. This section discusses potential damage to cultural resources from exposure to fire retardants.

Classifications
The USDA Forest Service has used chemicals to reduce the spread and intensity of wildfires in National Forests for over 50 years. Solutions of fire-fighting chemicals are spread over at-risk areas by low-flying airplanes. The Forest Service describes three different types of wildland fire chemicals: long-term retardants, foam fire suppressants and water enhancers.

Long-term retardants “contain retardant salts (typically fertilizers) that alter the way the fire burns, decreasing the fire intensity and slowing the advance of the fire, even after the water they originally contained has evaporated.” Long-term retardants are mixed with water to “aid in uniform dispersal over the target area.”
Foam fire suppressants, the second category, contain foaming and wetting agent. The composition of these suppressants determines the “accuracy of an aerial drop, how fast the water drains from the foam and how well the product clings to the fuel surfaces. Wetting agents increase the ability of the drained water to penetrate fuels.”

Water enhancers are the third category of fire-fighting chemicals. They contain “ingredients designed to alter the physical characteristics of water to increase effectiveness, accuracy of the drop, or adhesion to fuels. They also improve the ability of water to cling to vertical and smooth surfaces.”

Long-term fire retardants are the most widely used of the fire-fighting chemicals, and statistics provided by the Texas Forest Service state that over 5 million gallons were aerially applied in 54,192 drops during 2012.49

**Long-term Retardants**

According to a USDA Forest Service publication, long-term retardants are “typically 85% water, 10% fertilizer and 10% minor ingredients (thickeners, corrosion inhibitors, stabilizers and bactericides) color from iron oxide or fugitive color.”50 Fertilizer refers to the ammonium phosphate compounds in long-term retardants. ICL Performance Products, LLC is a major manufacturer, supplying Phos-Chek ® P100-F and Phos-Chek ® LC-95A. The colorant in P100-F is fugitive, designed to fade to an earth tone color after exposure to sunlight. LC-95 A contains iron oxide.

During 2011, a DC-10 jet carrying large containers of Phos-Chek ® fire retardant was deployed from California to combat the Central Texas wildfires. Originally, the fire retardant carried by the aircraft was intended for the Bastrop Complex.51 However, the Texas Forest Service directed the aircraft to an endangered area north of Houston where thousands of gallons of fire retardant were deposited. The area targeted included historic Sanders Cemetery in Magnolia, Texas, where grave stones were covered with fire retardant. This historic cemetery provided an opportunity to investigate possible adverse effects of a fire retardant on cultural resources.

In recent years, the use of fire retardants has been a subject of debate. Proponents of their use claim that fire retardants slow down the spread of wildfire, allowing fire fighters to develop effective strategies for combating wildfires, greatly reducing property losses. Those against the extensive use of fire retardants argue that the chemicals kill fish and encourage the growth of invasive plants. The Forest Service Employees for Environmental Ethics (FSEE), an organization whose membership includes present, former, and retired Forest Service employees, has been an outspoken critic of fire retardants. In 2003, the FSEE challenged the widespread use of fire retardants by the USDA Forest Service, claiming that these chemicals were responsible for killing steelhead trout, an endangered species, and threatening fragile ecosystems. Lawsuits asserted that the Forest Service violated the National Environmental Policy Act and the Endangered Species Act by failing to prepare an Environmental Impact Statement on fire retardant use.52
Cultural Resources
Our literature review indicates that there also is evidence that fire retardants have damaged cultural resources. A Bureau of Land Management report lists several possible adverse effects to cultural resources, including salt damage to masonry materials, wood desiccation, metal corrosion and discoloration and staining of a variety of materials. A National Park Service report, cited in a FSEEE lawsuit, provides information about fire retardant damage to archeological resources at Mesa Verde National Park, stating that the discoloration from exposure to fire retardants has persisted for years, requiring substantial effort to partially mitigate the effects. A 2008 Department of Defense Legacy Management Resource Program report describes staining and damage to masonry surfaces from following exposure to fire retardants. The report concludes that these chemicals may not be suitable for use on cultural resources.

Given the reports of their adverse effects on natural and cultural resources, restricting the use of fire retardants in National and State forests seems judicious. In March 2012, a report from the USDA Forest Service announced a “new direction” in the use of fire retardants. The Implementation Guide for Aerial Application of Fire Retardant report establishes “avoidance areas” and sets up a system for incident reporting. The report defines avoidance areas as “threatened, endangered, proposed, candidate or sensitive (TEPCS) species or in waterways. Although not included in the definition, the report provides for greater protection of cultural resources, stating that “historic properties, traditional cultural resources, and sacred sites will be given case-by-case consideration when ordering the aerial application of fire retardant.” The report further dictates that “incident commanders will consider the effects of aerial applications on known or suspected historic properties, any identified traditional cultural resources, and sacred sites” and states that the Forest Service intends to use cultural resources specialists, archeologists, and tribal liaisons to assist in considering their effects as well as alternatives for protection. The 2012 report sets a new standard for protecting cultural resources in our National Forests during fire-fighting efforts.

3.6 Indirect Impacts: Erosion
As stated above, indirect impacts occur as a result of fire-induced changes to the sites in which cultural resources are located. An example is the damage to cultural resources caused by soil erosion and related flooding. In most cases, the potential for damage from wind and water erosion is greatly increased following a wildfire. Soil erosion occurs because exposure to wildfires reduces soil stability; when the organic component of soil is lost, the slow rate of re-vegetation exacerbates the problem.

Erosion - Bastrop State Park
The park was at increased risk for soil erosion following the 2011 wildfire. According to the TFS Bastrop Complex Wildfire Case Study report, soils in Bastrop County consist of “fine sand to gravelly fine sandy loam,” with most soil in the area affected by the 2011 wildfire classified as “moderately well to well drained.” Slopes range from “gentle (0-5 percent) to very steep (greater than 20 percent). In discussing soil and erosion potential, the report indicates “moderate to very high wind erosion vulnerability” and “increased risk for water erosion issues to occur” in nearly 30 percent of the affected area.
Problems did occur following a severe storm in January 2012 that resulted in flooding along the creeks and rivers of Bastrop County; these added to the damage already caused after the 2011 fire by lighter rains. In discussing the aftermath of that January 2012 storm, Texas Parks and Wildlife staff referred to resulting conditions as an “emergency situation.” Not surprisingly, the most severely affected areas in the Park were those with significant slopes that had been heavily burned in the wildfire.

In addition to the impacts to wildlife and natural resources, soil erosion and flooding also damaged cultural resources of Bastrop State Park. The scenic overlooks are located in steeply sloped areas that were heavily burned during the 2011 wildfire. However, because both overlooks were built on high ground, erosion does not appear to have affected their condition. Likewise, because of their locations (higher ground), soil erosion has not damaged the cabins. In contrast, deterioration of many of the sandstone culverts appears to be the result of soil erosion and associated flooding.

The culverts were constructed by CCC workers along the road between Bastrop State Park and Buescher State Park (Park Road 1-C). Many of the culvert headwalls are concrete, and some have been lined with steel pipe to conduct water. However, local sandstone was used to face the culverts and to construct retaining walls, guard walls and abutments. To Park visitors, the appearance of the culverts is similar to the cabins and other historic buildings and, according to the National Historic Landmark nomination, the “rustic construction and stylistic uniformity” of these structures are important to the significance of Bastrop State Park.

In March 2012, Dennis Gerow carried out a visual assessment of fifteen culverts along Park Road 1-C. His inspection was conducted to assess damage caused by the rains and subsequent flooding that occurred following the January storm, and to identify deterioration related to the 2011 wildfire. In addition to assessing the condition of sandstone of each culvert, Gerow documented the material and size of culvert liners and provided observations about drainage.

Several of the conditions that Gerow observed during his inspection appear to be related to soil erosion and flooding. Sandstone conditions included displacement, surface erosion and losses, missing stones, and silt- and debris-covered stone work. In some cases, the condition of sandstone walls was judged to be unstable and Gerow recommended immediate repair work. Gerow’s report, which includes a photograph of each of the fifteen culverts and a summary of its condition, is included as an appendix to this report.
4. Recovery

4.1 Introduction

Following a wildfire, recovery begins with an assessment of damage related to exposure to the fire and its byproducts. In addition, the assessment should include adverse effects that are related to fire management actions and fire-induced changes to the sites. With historic structures, managers must consider how recovery efforts will impact the integrity and significance of the cultural resource before beginning the work. Although much initial work can be accomplished in a relatively short period of time, the recovery process generally is slow, with challenges along the way.

This section describes the recovery process at Bastrop State Park, including TPWD’s efforts to replace materials that were consumed by the wildfire and to control the erosion related to loss of vegetation. Contract work to remove soot and smoke from CCC cabins is described, and appropriate cleaning materials and methods are briefly discussed. Regarding cleaning, removing fire retardants from cultural resource materials is sometimes problematic. Although fire retardants were not used at BSP, our research also included an evaluation of their removal from samples of sandstone and mortar from Bastrop State Park.

4.2 Cleaning: General Overview

Direct damage from wildfires includes soiling from smoke and other products of incomplete combustion. If severe, cleaning masonry, wood, metals and other historic building materials may be desirable. In addition to improving the appearance of these materials, cleaning may help to remove surface contaminants that cause deterioration. Smoke contains gases and small particles of carbon, soot, and ash that leave a film on the surface of affected materials. The film is acidic, and sometimes causes discoloration, corrosion, and overall damage.

Commercial cleaning companies are sometimes contacted to clean commercial and residential properties with smoke and soot damage. Most companies have technicians with training in inspecting, cleaning and deodorizing following a fire. Cleaning is accomplished using dry cleaning sponges and chemical cleaning solutions. The Institute of Inspection, Cleaning and Restoration Certification (IICRC) sets standards for the fire restoration industry and certifies technicians. Their website provides guidance about fire and smoke restoration, suggesting that most exterior walls can be cleaned by “spraying with a detergent, agitating soot with a soft-bristled brush, pressure washing from bottom to top, then rinsing from top to bottom.” Homeowners are cautioned to hire a professional cleaner if the damage and residue are heavy.

Cleaning - Bastrop State Park

ServPro of North Central Austin is a local company specializing in “cleanup and restoration of residential and commercial property after a fire, smoke or water damage.”
The UT Team learned that TPWD had hired ServPro to carry out soot removal and deodorization of two buildings in Bastrop State Park. In addition to dry sponge cleaning, ServPro Green and ServPro Orange were also used. Although we did not review Material Safety Data Sheets, both products are reported to be alkaline cleaners. Carpets were cleaned with chemical cleaning and hot water extraction. ServPro deodorized the structures using an ozone generating machine for 24 hours. Ducts were cleaned with a Rotobrush air duct cleaning equipment.

Cleaning recommendations for cultural resources are generally less aggressive than the approach described above. Conservators recommend removing soot and other residue using a dry, soft natural bristle brush or sponge. If additional cleaning is required, a mild pH-neutral detergent is recommended for wet cleaning operations. Pressure water rinsing and the use of acidic or strongly alkaline cleaning are NOT recommended for cultural resources.

Soiling is sometimes related to the use of fire retardants. Similar methods are recommended for cleaning historic materials that have been contaminated with fire retardant chemicals. Dry brushing (using natural bristle brushes) should be carried out first. If dry brushing is not effective in removing the fire retardant residue, hand brushing with water or with a mild detergent solution can be evaluated. With some materials, presoaking with water may be required.

4.3 Immediate Erosion Stabilization: Bastrop State Park

In the immediate aftermath of the fire, virtually all ground cover had been consumed and there was up to a foot of ash throughout the park. Logs continued to burn for weeks, and there were hidden sinkholes created from the burnt stumps that pocketed the landscape. This made for treacherous conditions for the assessment teams working in the park. Of immediate concern was the weather. Weeks after the fire, heavy rains fell in the vicinity, and without the vegetative cover, erosion became a chief cause for concern. Sections of the park road collapsed, placing the CCC culverts in jeopardy. The rolling terrain, devoid of groundcover, was in danger of eroding at an alarming rate, placing numerous cultural resources and artifacts in jeopardy, so crews moved quickly, using felled trees and biodegradable wattle diversion systems to control run-off, then stepped-up reseeding efforts to repair the landscape.

4.4 Overlook Roof Reconstruction – Bastrop

In the fall of 2012, Texas Parks and Wildlife preservation craftsmen reconstructed the roofs at both the Lost Pines overlook and Fehr’s overlook. Neither of the roofs lost in the fire were original. The Lost Pines roof design had been changed significantly from the original at some earlier, unknown date and bore little resemblance to the original CCC design. Because of the total loss of the roof framing, an opportunity presented itself to return the Lost Pine overlook roof to the way it looked originally, as depicted in the CCC design drawings.
Fehr's overlook had been missing its roof for years, but in 2006 the Historic Sites and Structures Program of the State Parks Division of Texas Parks and Wildlife received an award of $5,000 from the National Park Service Heritage Partnerships Program towards its reconstruction. The work was completed, but sadly, this roof was completely destroyed in the wildfire. Again, the original CCC drawings were used as a guide, and the roof structure once again reflects the original design intent.

4.5 Fire Retardant Removal: Laboratory Testing

Although fire retardants were not used in BSP, we investigated their removal from gravestones in an historic cemetery in Magnolia, Texas. During July, 2012, we visited Sanders Cemetery to inspect conditions of gravestones that were covered with fire retardant during the 2011 wildfire. We met with Magnolia resident Sharon Russell, who directed volunteer workers in clean-up efforts following the wildfire. According to Russell, the volunteers used water and Orvus WA Paste, a detergent cleaner manufactured by Proctor & Gamble, to remove fire retardant from the gravestones. Orvus has a near neutral pH and is recommended for gravestone cleaning by the Texas Historical Commission. The Sanders Cemetery gravestones were cleaned in March and April, several months prior to our July visit.

During our brief inspection during the July visit, we noticed traces of retardant residues on some gravestones, particularly on marble and other light colored masonry. However, on most of the gravestones there was little evidence of retardant use. Russell provided digital photographs of the affected gravestones before and after cleaning.

Our research also included a laboratory evaluation of fire retardant removal. For this research, we obtained samples of ready-to-use solutions of Phos-Chek P100-F and Phos-Chek LC-95A from ICL Performance Products, LLC. During January 2013, the fire retardants were applied to sandstone and mortar samples collected from the Bastrop State Park Overlook structures during a December, 2012 site visit. Sample size was approximately 3”x 2”x 2-4.” One half of each sample was immersed in the fire retardant solutions and allowed to dry at room temperature. Following drying, the samples were placed in a drying oven at 100 degrees Fahrenheit for several days to simulate outdoor temperatures in Texas during wildfire season.

Following cooling, water and light scrubbing were used to remove the fire retardants. The cleaned surfaces were evaluated following drying. Although water washing removed most of the fire retardant, there were residues of LC-95A on some of the samples. These residues were most noticeable on the lighter colored mortar samples. Given the iron oxide colorant in LC-95A, these results were not surprising. We expect that detergent cleaning might improve effectiveness. Also, the reddish color of the fire retardant should be less noticeable following exposure to the weather.
During August, 2012, the UT Team learned that Travis County Emergency Services was evaluating TetraKO, a fire chemical classified as a water enhancer. Manufactured by EarthClean Corporation, TetraKO is a stable white powder containing more than 50% corn starch. TetraKO is diluted with water, and can be sprayed applied or used in aerial application. During a wildfire, the TetraKO forms a gel, improving the ability of water to cling to vertical and smooth surfaces.\textsuperscript{65}

Because of Texas Parks and Wildlife’s interest, the UT Team included TetraKO in our laboratory evaluations. Application of TetraKO temporarily darkened the surface of treated sandstone and mortar samples. However, this effect dissipated following drying. Cleaning with water and light scrubbing completely removed TetraKO from the samples. Although reports of its effectiveness are promising, TetraKO is not currently on the USFS list of approved products.\textsuperscript{66}

Considering the potential for damage to cultural resources, the USDA Forest Service 2012 report establishing new guidelines for the use of fire retardants is an important first step. The report recommends consultations with historic preservation specialists prior to widespread aerial application of fire retardants. The guidelines were developed for federal lands, and were not intended for management of property under the jurisdiction of States. However, the collaboration between fire fighters and specialists described in the report may serve as a model for stewardship of cultural resources.
5. Preparing for Future Wildfires: Recommendations

5.1 Introduction
In the wake of natural disasters, historic preservation specialists face difficult decisions if treatments for damaged historic properties are poorly understood prior to recovery efforts. The best way to avoid this situation is to participate into the disaster-planning process to ensure that a treatment plan for cultural resources is developed. While the most important concern in disaster planning is protecting human life, saving historic buildings and important local landmarks can help survivors retain a sense of place and security amid an otherwise devastated landscape.

This section begins with a brief review of treatments to reduce the risk of fire damage to cultural materials, focusing on fire-resistant substitute materials. Next, creating defensible space for cultural resources located within wooded areas is considered, including potential impacts on significance. Finally, our discussion of disaster preparedness reviews the governmental agencies and preservation organizations that manage disaster planning and recovery at international, national and local levels, and explores the roles that the historic preservation specialist can play.

5.2 Substitute Materials
In 2007, the Department of Agriculture published a document entitled “Alternative Roofing Materials: A Guide for Historic Structures.” Information about categories for all roofing material into fire classes is below.

*Class A* uses a class B fire retardant product plus an Underwriters Laboratories (UL)-rated fire retardant fiberglass cap sheet underlay. It is not readily flammable, has a high degree of protection, does not slip, and does not have a flying-brand hazard.

*Class B* provides a moderate degree of protection, is not readily flammable, has a high degree of protection, does not slip, and poses no flying-brand hazard.

*Class C* provides light fire exposure protection, is not readily flammable, and there is a measurable degree of fire protection.

Substitute materials for historic wood shingle and shake roofs must be considered appropriate replacements. The substitute materials listed in the USDA study that comply with the SOI Preservation Standards are cedar treated shakes and cedar treated shingles, both are Class A fire resistant. Except for impact resistance and durability, cedar is comparable to the two materials that are non-combustible—clay tiles by Gladding, McBean and Stone TruSlate (natural) tiles. Regarding durability, cedar has a service life of 25-30 years in temperate climates, compared to the 75-lifetime service life of clay and TruSlate. However, that lifespan is reduced significantly in Texas because of the extreme heat it is exposed to over the course of its service life.
5.3 Defensible Space

At Bastrop State Park and elsewhere, the buildings constructed by the Civilian Conservation Corps were intended to nestle into the woods, subordinate to their natural surroundings and unobtrusive to the eye. That being said, it’s important to understand that at that time, the forest structure was much different than it is today. Tree densities would have been a fraction of what they are today, and understory and mid-story shrubs would have been much less dominant. Over the past 80 years, with little forest management, densities have increased dramatically and species such as yaupon, an extremely volatile fuel, have taken over the understory and mid-story, allowing fire to move easily from the ground to the crown, and making fire suppression more difficult.

During the time before the wildfire reached the CCC cabins, firefighters prepared the area by: wetting the cabins with water from nearby sources, clearing leaves and pine needles, and building fire breaks. All these activities contributed to making defensible space: a clear area where firefighters can work and that keeps fire away from the building. Codes from international to local levels suggest clearance of fire-prone trees and vegetation from at least a 30 foot radius to allow for a minimum amount of defensible space and early protection from fire spreading to a structure. These codes, however, were written for homes in the WUI (Wildland Urban Interface) — not for historic buildings in a state park. Is it possible to apply standards in WUI codes to CCC buildings in BSP without damaging their historical integrity? This section will discuss fire policy created for private buildings and then consider how they can be adapted to the situation in BSP.

International Wildland-Urban Interface Code

Wildland-Urban Interface (WUI) refers to the area where a developing community meets undeveloped land, and the IWUIC applies to “the construction, alteration, movement, repair, maintaining and use of any building, structure or premises within the wildland-urban interface areas.”69 The code’s regulations are intended to “mitigate risk of life and structures from intrusion of fire from wildland fire exposures and fire exposures from adjacent structures and to mitigate structure fires from spreading to wildland fuels.”70 CCC buildings in parks such as BSP can benefit from the consideration of this code because their position within a forest puts them at imminent risk for wildfire exposure.

In section 603, the IWUIC calls for fuel modification up to 30 feet from the house measured on a horizontal plane from its perimeter. Section 603 of the code also allows trees to be in the defensible space as long as the “horizontal distance between crowns of adjacent trees and crowns of trees and structures, overhead electrical facilities, or unmodified fuel is not less than 10 feet.” Ornamental vegetation is also allowed in the defensible space as long as it does not provide a way for fire to spread from it to the building. Maintenance of defensible space is crucial: plants that are not fire resistant should be kept clear of buildings; dead growth (e.g. leaves, needles, bark, branches) also must be regularly removed. There must be ten feet of clearance between the roof of the house and overhanging trees, which will require pruning of trees if they extend below ten feet. Trees within the defensible space must also be pruned so that no limbs exist less than six feet above the ground.72
Firewise Communities

Firewise is a program run by the National Fire Protection Association: an international non-profit advocacy group for fire safety (among other issues), which works to educate communities and prepare them for wildfire events. Firewise is co-sponsored by the USDA Forest Service, US Department of the Interior, and the National Association of State Foresters. A number of Texas communities participate in the Firewise program, and although Bastrop is not one of these, Firewise principles are incorporated into Texas A&M Forest Service guidelines for wildfire safety.  

Principles of the Firewise program focus on the creation and maintenance of defensible space around buildings, as “it is not a geographical location, but a set of conditions that determine the home’s ignition potential in any community.” A home’s “ignition risk” is determined by its materials and its immediate surroundings which may consist to up to 200 feet surrounding the home. They require that construction materials be non-flammable or of low flammability (especially for roofs, siding and windows) and for flammables, plantings, and mulch to be at least five feet from the building. Firewise promotes the creation of a defensible space divided into four zones:

Zone 1 extends 30 feet from the building to provide space for firefighters and equipment. Zone one should be well-irrigated with maintained lawns; planted with limited and carefully spaced low-flammability vegetation; and use non-flammable mulch.

Zone 2 extends from 30-100 feet from the home and has the same criteria as Zone 1 except that it allows for shrubs and trees so long as they are “limbed up” and spaced to prevent the tree crowns from touching.

Zone 3 extends from 100-200 feet and may have low-growing plants and well-spaced trees and requires that the volume of vegetation stay low.

Zone 4 is the natural area beyond zone tree, where homeowners should selectively thin and prune all plants and remove highly flammable vegetation.

Firewise also provides guidelines for preparing the house itself. In addition to keeping the area within five feet of the house (including roofs and gutters) clear of dead vegetation, Firewise recommends that areas below patios, decks, and attic, under-eave, and soffit vents be screened with metal mesh no more than 1/8th of an inch to prevent embers from blowing under them.
Figure 8. Firewise defensible space illustration. www.firewisekp.org
While these actions are still featured on the Texas Fire Service website, shortly after the Bastrop fire there was a push in Texas to change the suggested 30 feet of defensible space to 100 feet from homes in the WUI. As precedent for this change in practice Texas looks to state code in California—home to the only two wildfires larger than BWC: the Oakland Fire and Cedar Fire. One hundred feet is the extent of defensible spaced required by California law PRC 4291, and is similar to the four zone system set by Firewise. In PRC 4291, the first thirty feet surrounding a house—termed the “Lean, Clean, and Green Zone”—all flammable, dead, and dying plants must be removed. Single trees and vegetation over two feet are allowed but only if they are well pruned. The remaining seventy feet is called the “Reduced Fuel Zone.” Here, stumps must be removed that are not embedded in the ground, and dead trees (which may be kept for the sake of wildlife habitat) must be limited to one per acre and to locations where they will not fall on houses, power lines or across roadways. Grass is not to exceed four inches generally but can grow to eighteen inches when it is separated from other fuels and preventing soil erosion. PRC 4291 stipulates to what distance trees and bushes must be separated horizontally and vertically. This distance ranges between 4 feet for shrubs and 30 feet for trees depending on the ground slope between the two. PRC also allows for “defensible space with continuous Tree Canopy” so long as the lower tree branches are pruned 6-15 feet above the vegetation below them. All ground fuels above four inches must be removed and single trees are allowed if well-pruned and creating “an overall condition that avoids the spread of fire to other vegetation or to structures.”

<table>
<thead>
<tr>
<th>WUI Code</th>
<th>&quot;Defensible space radius*&quot;</th>
<th>Trees within Radius</th>
<th>Shrubs Within Radius</th>
<th>Maintenance</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>30 Feet</td>
<td>Yes - horizontal distance of 10 feet from structure and other tree crowns. Lowest limb must be 6 feet from ground or higher.</td>
<td>Yes - as long as it does not encourage fire spreading. Non-fire resistant plants not allowed.</td>
<td>Remove dead growth, trees pruned</td>
</tr>
<tr>
<td>Firewise</td>
<td>30 feet (Zone 1)</td>
<td>None</td>
<td>Must be 5 feet from building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 - 100 feet (Zone2)</td>
<td>No crown touching, trimmed</td>
<td>Well spaced</td>
<td>Remove dead growth. Metal Mesh protecting under decks/attic/soffit vents.</td>
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<tr>
<td></td>
<td>100 - 200 feet (Zone 3)</td>
<td>Well spaced</td>
<td>Low volume, well spaced</td>
<td></td>
</tr>
<tr>
<td>California Code</td>
<td>30 feet</td>
<td>Single trees only, lowest branch 6 - 15 feet above vegetation, depending on slope.</td>
<td>Well pruned</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 - 100 feet (zone 2)</td>
<td>Stumps removed, dead trees limited to one per acre</td>
<td>Remove dead growth, grass kept to 4 inches and shorter, although if well separated from other fuel, can be 18 inches.</td>
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</table>
Defensible Space in Parks
Wildfires threaten most state and national parks requiring park staff to prepare for them as well as possible—including the creation of defensible space. Recently, the National Park Service and local conservation and historic preservation groups joined to reduce build-up surrounding historic buildings on Baker Island, Maine. Baker Island was settled beginning in 1806 and still has a number of historic buildings from its early occupation including a lighthouse, barn and oil house, and residential buildings. By the late 1930s all the trees on the island were cut for housing and fuel. The last occupants of the island left shortly after World War II, and the island’s forest grew unchecked. By the 2000s, coastal spruce re-colonized the island covering 96% of its area. This combination of fuel and strong winds caused the historic buildings to be at high risk for damage by wildfire. Recognizing this danger, NPS and local groups interested in the island joined to plan for a fire resistant landscape. The basics of the plan were to trim or remove all coniferous trees and leave deciduous trees intact. All removed biomass was cut and burned by the NPS. Though a dramatic example of the creation of defensible space and certainly not appropriate in every application, this project is considered a success because it achieved its goal of providing that space while at the same time restoring the historic landscape to the time of its primary significance.

Figure 9. Baker Island Maine Lighthouse before and after selective landscape trimming to provide defensible space.
In another example from Arizona, NPS was involved in implementing Firewise principles in Montezuma Castle and Tuzigoot National Monuments. The Zion Wildland Fire Module (WFM) began in 2011 by working on the first 30 feet surrounding the buildings: they removed dead and flammable vegetation, and cut grass to 4 inches. In 2012, the Saguaro WFM extended the fuel reduction zone to 100 feet beyond the buildings; here they cleared brush and mesquite trees as well as smaller and dead vegetation.

While both of the above examples demonstrate methods for making defensible space around park structures, they do not quite address the unique challenges facing CCC structures in Bastrop. In the case of Baker Island, removal of trees restored the historical landscape: during the building’s period of significance trees were being removed, and during most of the human occupation of the island trees were nonexistent. In Arizona, the park structures that were being protected were not historical nor were they intended to blend with the environment.

Nevertheless, these two examples teach us that defensible space is an important consideration for parks with important historic structures. Enhancing the protection of historic structures and viewsheds within natural resource settings warrants substantial planning and consideration, especially with regard to decisions affecting vegetation removal. The UT Team recommends that cyclical maintenance programs for each site/facility should include a defensible space component, which can be adapted for each unique site to best protect their important resources.
Defensible Space - Bastrop State Park

The Overlooks  The overviews were the two structures most damaged by the fire. With the altered landscape stripped of surplus fuel, the Lost Pines Overlook today has adequate horizontal and vertical separation from the forest. In Figure 3, no shrubbery grows nearby, nor is there tall grass or dead vegetation. Since the fire removed all local fuel from the area, this overlook is now in compliance with both the WUI and Firewise Defensible space recommendations.

Fehr’s Overlook  accessed by a trail and an unpaved park road. Due to its remote woodland location, Fehr’s Overlook is at greater risk than the Lost Pines Overlook and is less compliant with Firewise guidelines. In Figure 11, an overhanging branch is within the 10 foot space. We can also see grasses over 4 inches, and potentially over 18 inches, close to the structure and close to a tree within what would be Zone 1. In Figure 12, a small tree grows close to the front of the overlook with limbs within the recommended 10-foot space of vertical clearance. Because of its remote location, the UT Team recommends removing the close growing small tree, and trimming back the overhanging branch. This nearby tree should also be monitored periodically, especially in the aftermath of this fire. If it shows signs of weakness, the UT Team recommends removing it. It is not feasible to suggest the grasses around the overlook be trimmed regularly, but the UT Team would encourage the creation of a non-combustible perimeter around the structure, with gravel that could protect the structure but still blend into the natural environment.

Figure 10. Lost Pines overlook has a good amount of defensible space around it, with few trees and low grass. (Photo by authors)
Figure 11. Fehr's Overlook showing overhanging limb and vegetation within defensible space

Figure 12. Fehr's Overlook showing close growing tree (Photos by authors)
The cabins—saved with great effort by firefighters—have close growing trees, and some close growing, smaller vegetation such as yaupon, which creates the understory that allows a fire to burn hotter and travel into the pine canopy (Figure 13). The cabin area provides the greatest challenge for creating a defensible space and maintaining a balance with historical landscape. Adding to the charm of the NPS style rustic architecture, the cabins are nestled in amongst the landscape. However, opportunities exist to decrease their vulnerability with simple landscape maintenance, saving valuable time for the first responders. Trees growing right against the structures could be removed or trimmed back, and flammable vegetation trimmed or removed within five feet of the structure. Overhanging branches can be removed without significantly impacting the overall look of the cabin area, while providing additional protection to the wood shingle roofs. In addition to the upkeep of defensible space and mitigation of fuel load, consideration should be made to install a nearby dependable, high volume water source (such as a hydrant) in areas with a density of historic structures, such as the cabin area.
Culverts

CCC Culverts in BSP are generally covered with vegetation. Because vegetation is necessary to prevent soil erosion in this area, it may be important to continue to allow it to grow up to 18 inches. Close growing trees could be thinned out and trimmed to help slow fires.

![CCC Culvert with surrounding vegetation](Photo by authors)

Protecting CCC structures from wildfires with defensible space creates a dilemma: how will the removal of vegetation around buildings and structures that were historically intended to blend with their forest environment affect their significance? Can we find a balance between preserving the historical context and reducing fire risk with defensible space? This balance seems possible for most of the historic structures in BSP with the exception of the culverts where drainage systems may depend on roots for erosion control—vegetation can easily be carefully trimmed back – and the UT Team recommends removing close growing trees which, as they get larger, could cause significant damage to the culvert masonry and impede the flow of water through the drainage conduit.
Conclusion:

Although Lost Pines Overlook is currently in compliance with recommendations for defensible space, regular, cyclical maintenance will be required to prevent future encroachment as the surrounding forest matures. Because Fehr’s Overlook is both difficult to access by vehicle and perched atop a steeply sloped gradient, it would be beneficial to clear defensible space around it. The topography helped increase the intensity of the wildfire at that site, which emphasizes the importance of creating and maintaining defensible space around it if possible.

The cabins would also benefit from such an approach as a first line of defense. In addition, though the cabins are more accessible to first responders and equipment, their historic significance warrants an additional level of protection—that being the installation of a system of high volume hydrants that can provide a more comprehensive defense. The narrowness of the roads is a challenge for firefighting purposes, and a difficult one to address since the park roads are significant CCC features to this National Register District, greatly contributing to the aesthetic of the park. Several of the FireWise suggestions could be employed near the cabins without significantly impacting or altering their historic appearance and significance. Performance-based compliance (focused on the overall goal of lowering a structure’s vulnerability in whatever feasible way is possible) instead of prescriptive compliance (a rigid set of guidelines with little flexibility for differing situations) is a viable option for historic buildings like the cabins, where different but equally effective fireproofing strategies are used for the sake of retaining significant historic features that would be destroyed if code was followed prescriptively.81 The UT Team recommends thoughtful, scheduled maintenance for the cabins to reduce build-up of dead branches and pine needles on roofs, as this would save valuable time and effort when the next wildfire occurs. Cyclical maintenance for the park buildings should include a component focused on defensible space creation and maintenance, as well as fuel load mitigation.
6. Coordinating Efforts

6.1 Introduction
In the wake of natural disasters, historic preservation specialists may face difficulties if treatments for damaged historic properties are poorly understood prior to recovery efforts. The best way to avoid this situation is for preservationists to participate in the disaster-planning process to make sure cultural resources issues are incorporated into the overall agenda. While the most important concern in disaster planning should always be protection of human life, saving historic buildings and important local landmarks can help survivors retain a sense of place and security amid an otherwise devastated landscape. The role of the preservationist must begin early in the planning stages and preparation of a disaster response, helping insure that historic structures are prepared: protected and maintained, with as much defensible space as possible. Nothing less will provide a greater chance of survival, and help provide the safest situation possible for firefighters to use their expertise and judgment during an actual fire event.

Starting at the international level, this section reviews the governmental and non-governmental organizations and groups that manage disaster planning and recovery, and explores the ways in which the historic preservation specialist can participate. Unfortunately, there often is a gap in communication between First Responders and historic preservation specialists during and after a wildfire. Because of this, it is imperative for historic preservation specialists and First Responders to communicate prior to a fire.

6.2 International Level
It is helpful for us to look at coordinating efforts at the international level because many of these have been in place for some time, and offer good examples on which Texas can base future efforts. They also illustrate that it is a challenge for every level of agencies to work together in effective ways.

At the international level, there are several organizations focused on cultural heritage preservation, and many examples of their desire to better coordinate various agencies during disasters. The best known organization advocating for the preservation of cultural heritage is the United Nations Educational, Scientific and Cultural Organization (UNESCO). Founded in 1945, UNESCO work includes protecting tangible and intangible heritage, and promoting “diversity of cultural expressions and the dialogue of cultures with a view to fostering a culture of peace.” UNESCO’s disaster management arm, founded by the International Council on Archives (ICA), International Council of Museums (ICOM), International Council on Monuments and Sites (ICOMOS) and International Federation of Library Associations and Institutions (IFLA), is the International Committee of the Blue Shield (ICBS). Originally created in reaction to widespread destruction caused by World War II, ICBS’s work now includes preparing for...
natural disasters. The 2011 Seoul Declaration on the Protection of Cultural Heritage in Emergency Situations calls for increased training and education in emergency preparedness, and increased use of technology during all parts of emergency events to record the extent of damage and to better prepare for the next emergency. ICBS has pledged to explore the feasibility of establishing a fund for relief efforts, procedures to plan and prepare a response to emergencies around the world, and the viability of partnering with other cultural and relief organizations to improve on-the-ground response.\textsuperscript{84}

The mission of the European Union’s Cooperation in Science and Technology (COST) is to provide an intergovernmental framework for cooperative and coordinated European research in science and technology. One research network created by COST is Action C17, Built Heritage: Fire Loss to Historic Buildings. Action C17 convened several meetings where countries shared statistics and methods for historic building managers to work with fire control personnel. These meetings provided a venue for discussing the development of cultural resource training for fire engineers and fire officers.\textsuperscript{85}

6.3 Federal Level

It is also instructive to consider how disaster planning and recovery are managed at the Federal level, especially with regard to regulatory requirements that impact cultural resources. Standard practices for wildfire issues are created and disseminated by coordinating groups like the National Interagency Fire Center (NIFC) and the National Wildfire Coordinating Group (NWCG). Regarding protection of cultural resources, the Federal statutes requiring their consideration are the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA). Both provide avenues for collaboration between fire-regulating groups and historic preservation specialists. The following section discusses the ways in which historic preservation specialists are involved in planning and mitigation of wildfires at the Federal level.

**NEPA and NHPA**

When a federal agency considers a major undertaking that may have significant impact on the environment (including cultural resources) or buildings on or eligible for the National Register, they must first comply with relevant sections of NEPA and/or Section 106 of NHPA.\textsuperscript{86} Every national park with burnable vegetation must have an approved Fire Management plan, and creating the FMP constitutes a major federal undertaking triggering NEPA and, if cultural resources are present, Section 106.\textsuperscript{87} Section 106 requires the consultation of different parties interested in the cultural resources including State or Tribal Historic Preservation Officer, tribes and local governments, and the public and the consideration of all possible ill effects. Compliance with NEPA may culminate in an Environmental Impact Study (EIS), which would require documentation that the Federal agency—often the NPS—consulted with specialists on beneficial or detrimental effects of wildfire planning on historical and archaeological sites.\textsuperscript{88}

**Cross-training**

NPS also provides opportunities for historic preservation specialists to be trained in wildfire science so they can be directly involved with planning and even be on site during
wildfire events. Even without wildfire training, historic preservation specialists who meet the Secretary of the Interior’s Standards for Archaeology and Historic Preservation can qualify as Cultural Resources Technical Specialists (CRTS) and participate in planning, cultural resource data collection, and mechanical fuel reduction (e.g. removing dead vegetation within defensible space.) If a CRTS completes tests for a “red card” or Incident Qualification, she or he may assist with prescribed burns, be present on fire lines, and research within fire perimeter. Historic preservation specialists who complete Wildfire Resource Advisor training can work within Incident Command to make recommendations. The NPS also encourages training in recognizing the special needs of historic properties for Wildland firefighters.

The National Wildfire Coordinating Group (NWCG) coordinates programs of the participating wildfire management agencies, and training to be a Resource Advisor is available to historic preservation specialists working in other participating agencies from the Department of the Interior (DOI), Department of Agriculture (USDA), and the Department of Homeland Security (DHS).

6.4 State and Local Levels
There are several ways in which historic preservation specialists and emergency managers can collaborate at state and local levels. Texas is divided regionally into Disaster Districts for preparedness and response activities. Committees created for each district are composed of local representatives of the state agencies, boards, and commissions and organized volunteer groups. The Emergency Management Council, an advisory council to the governor, coordinates emergency response efforts. The Council is composed of 32 state agencies and the American Red Cross and the Salvation Army. TPWD and the General Land Office (GLO) are the agencies entrusted with stewardship of cultural resources on the Emergency Management Council.

In Texas, some local historic preservation ordinances include specific regulations about protecting historic building and assisting with disaster preparation and recovery. For example, if the San Antonio fire chief and director of development services determine that an historic building damaged in an emergency “poses a clear and imminent danger to the life, safety or property of any person unless it is demolished,” the Office of Historic Preservation has 72 hours to create a stabilization plan for the building. Municipal ordinances such as these are supported by Texas Local Government Code 214.00111, which stipulates that a municipality has the authority to retain a substandard building for the sake of historic preservation.

Most Texas municipalities, inter-jurisdictional districts and counties are required to create and maintain an Emergency Management Plan and information in the plan must be provided to the Texas Department of Emergency Management. County disaster management programs have liaison officers who coordinate with State and Federal level programs. The designated Emergency Management Director for local programs is “the presiding officer of the governing body of an incorporated city or county or the chief administrative officer of a joint board,” and is given the governor’s power at the local level, and may appoint a person to act as an emergency management coordinator.
Local governments can make allowances in their codes for special treatment of historic structures in the event of an emergency. This basic provision would be enhanced if historic preservation specialists—including city and state historic preservation officers, specialists at the Texas Historical Commission or Texas Parks and Wildlife—participated in creating EMPs. Preservationists should consider this part of their responsibility, as stewards of historic structures, and should actively seek out positions on these types of programs. Emergency Management Programs at local and regional levels in Texas are based on the Incident Management Team platform that can expand to meet the varying size of any particular threat, with a place for historic preservation specialists to contribute, however there is often a lack of awareness that such a possibility of participation exists. This situation underscores the importance of educating public officials about historic preservation and the threat posed by natural and man-made disasters, and offers an avenue to create that dialogue. At the regional level, representatives from TPWD and GLO are explicitly included in the Emergency Management Council, and provide voice for the inclusion of historic preservation concerns.

**Coordinating Efforts - Bastrop State Park**

Fortunately, the BSP fire-fighters were instructed to focus suppression efforts on protecting the cultural resources in the park, and the CCC cabins and other historic buildings were saved. Direct impact damage occurred to the two overlook structures, and several culverts were later affected by indirect damage from erosion.

Our review indicates that there often exists a gap in communication between first responders and preservation professionals at the international, federal and local levels. Creating a dedicated group of fire fighters and historic preservation specialists who are trained in both realms is an important first step addressing this problem. In addition, considering the state and local agencies involved with disaster planning and recovery efforts, there certainly are opportunities for historic preservation specialists to participate in planning efforts to help mitigate the impact of a wildfire. Their work with disaster management agencies and organizations includes educating members about historic preservation issues, and creating plans for preparedness and recovery that include provisions for protecting and treating cultural resources. In addition, preservationists need to become educated on effective fire protection methods, such as those covered briefly in this report. While most preservationists obviously cannot assist with the immediate emergency response in the event of a fire, through responsible planning and monitoring of fuels and defensible space surrounding historic structures, they can assist firefighters by insuring their historic site is as prepared as possible for a fire.

**6.5 Conclusion**

Certainly, the 2011 wildfire that consumed much of Bastrop State Park was a large-scale disaster. Although the losses suffered by the people of Bastrop County were tragic, the wildfire provides a valuable teaching tool for Texas Parks and Wildlife. Bastrop State
Park serves as a case study illustrating the success of the park firefighters. The actions taken by the BSP Firefighters saved some of the most significant examples of Civilian Conservation Corps park architecture in Texas.

The Texas Parks and Wildlife Department staff members are stewards for significant CCC structures that are treasures enjoyed by the people of Texas. These structures are also unique in their vulnerability to the ravages of major wildfires because of their locations nestled in their natural surroundings. Protecting them requires a combination of proactive training, responsible maintenance focused on defensible space and fuel mitigation, quick and focused fire suppression, and rapid response once a fire has passed. The example of Bastrop State Park has shown that parks can survive and come back from the devastation of a wildfire, and provide lessons from which others may learn.

From Bastrop we have learned of the importance and value of a highly trained and organized firefighting team, who were proactively instructed on the importance of the historic structures. From our investigation of conditions of the overlooks following the fire, we have learned that Bastrop sandstone was able to withstand the high temperatures with relatively little damage. The long term effects of erosion have also shown us the importance of a quick response to attempt to lessen the dramatic effects of that, especially when historic culverts are present.

With proactive training and team building among historic preservation specialists within TPWD and Incident Management staff, each side could inform the other of considerations to prepare historic park sites for catastrophic wildfires, and put them in the best possible position to minimize fire damage. Historic preservation specialists need to educate park staff about ways to balance defensible space principles with appropriate historic landscape appearances, as well as create a proactive disaster plan with each historic structure recorded, prioritized, and located to provide a quick resource for incident management personnel, should a wildfire threaten a park. In addition, preservationists should be educated in incident management, to better understand what firefighters face, and what steps preservationists could take to help protect historic buildings.

With the guidelines provided in this report, it is hoped that state parks will have the tools needed to begin the process of considering changes that might be necessary for individual parks and developing appropriate training. In addition, the assessment form serves as an organizing tool for use in the immediate aftermath of a wildfire, collecting information for TPWD historic preservation specialists to assist their efforts in stabilizing historic architecture, preserving it for future generations.
7. Appendices

- Appendix 1 - Guidelines for protecting cultural resources from future damage
- Appendix 2 - Form for assessing building and site conditions following wildfire
- Appendix 3 - TPWD Culvert Conditions report
- Separate PowerPoint - Training Module for TPWD (PowerPoint Presentation)

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1. Steely, Parks for Texas, 199.
3. Steely, Parks for Texas, 199.
5. ibid 24.
6. Steely, Parks for Texas, 199; Interview with Sam Jones, 13.
7. While the majority of the park was built by CCC, additions were made by other groups both under the New Deal and afterwards. The original nine-hole golf course and swimming pool were in part WPA projects. In the 1950s, TPWD built another group of cabins (separate from CCC cabins), and by 1997 they also added nine holes to the golf course. Steely, Parks for Texas, 200.
9. Interview with Otto Pruetz, 3.
12. ibid; Maxwell, Geologic and Historic Guide to the State Parks of Texas, 47.
13. Interview with Sam Jones, 6.
16. ibid 6.
17. ibid 7.
18. Interview with Otto Pruetz, 3.
21. ibid, 17.
27. ibid, 34.
30. Email from Jeff Sparks, June 11, 2013. To whom throughout
31. Email from Dennis Gerow, 17 September 2012
Email communication with Jeff Sparks

http://www.nps.gov/lavo/parkmgmt/upload/Reading-Fire-BAER-Plan-Website.pdf

http://www.ashireporter.org/HomeInspection/Articles/The-Effects-of-Fire-on-Structural-Systems/1154


Hajpal and Torok, “Mineralogical and colour changes of quartz sandstones by heat,” 313.

Hajpal, “Changes in Sandstones of Historical Monuments Exposed to Fire or High Temperature,” 381.


Conversation with Professor Earle McBride, October 18, 2012. See also pg. 5 herein.


http://texasforestservice.tamu.edu/main/article.aspx?id=12888

http://www.fs.fed.us/fire/retardant/eis_info.html

http://www.texasforestservice.tamu.edu/main/article.aspx?id=1013


http://www.blm.gov/wo/st/en/prog/more/CRM/fire_and_heritage/fire_effects_on_cultural.print.html


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http://austin.ynn.com/content/top_stories/286319/travis-county-firefighters-test-out-new--gooey--tool

http://www.fs.fed.us/rm/fire/wfcs/documents/qpl_we.pdf

For example see Craigo, “A Helping Hand,”18, on the situation after the Loma Prieta Earthquake.


International Code Council, “IWUIC,” 101.2


For example see: http://texasforestservice.tamu.edu/main/article.aspx?id=1602

Firewise, “A guide to Firewise principles.”
Firewise, “Firewise tips checklist for homeowners.”


California Department of forestry and fire protection, “Why 100 Feet?...”


For example see Bukowski, “Performance-based Fire Protection of Historical Structures,” 23-42.

For example see Craig, “A Helping Hand,” 18, on the situation after the Loma Prieta Earthquake.


NPS Directors Orders 18


NCPTT, “Preparing for Fire,” 2.

NCPTT, “Preparing for Fire,” 2.


While the GLO does not specifically focus on historic buildings, it has a definite cultural materials imperative. The GLO’s Mission Statement reads, “The Texas General Land Office serves the schoolchildren, veterans, and all people of Texas by preserving their history, protecting their environment, expanding economic opportunity, helping communities rebuild after disasters, and maximizing state revenue through innovative administration and prudent stewardship of state lands and resources.” http://www.glo.texas.gov/GLO/index.html

ibid

Stabilization plan must still be approved by the director of development services; San Antonio Unified Development Code 6-175 (a), (b) (3), (e). A similar provision does not exist for Bastrop.

Does not apply to owner-occupied, single-family dwelling (214.00111 (b)).

An interjurisdictional district is formed if “the governor finds that the establishment and maintenance of a joint program or participation in it is made necessary by circumstances or conditions that make it unusually difficult to provide disaster mitigation, preparedness, response, or recovery services under other provisions of this chapter.” Texas Government Code, 418.104.

Texas Government Code 418.102-104

Texas Government Code 418.105 (b)

Texas Government Code 418.1015 (a)

Texas Government Code 418.1015 (b)