Saguaro (Carnegiea gigantea) cacti attract millions of visitors to the Tonto National Forest (TNF), Arizona each year. Unfortunately fires occurring during the last few decades burned large portions of mature saguaro habitat--landscapes now devoid of centuries old behemoth cacti. Based on a developing understanding of disturbance effects on saguaro, TNF is modifying grazing and fire policy on its desert rangeland. They have placed a greater emphasis on the protection, maintenance and recovery of this valuable resource, yet little is known about long-term consequences of historical range practices. The arson-set ignitions known as the Vista View Fire burned saguaro habitat near Four Peaks, Mesa District, TNF during mild fire-weather conditions in May 1993. A 1994 post-fire study evaluating fire effects on saguaro and associated vegetation compared unburned and burned habitat. Survival and mortality of saguaro and associated vegetation was measured using point quarter techniques along four 350 m transects. Initial saguaro mortality was recorded at 19 percent in the burned areas yet long-term mortality was expected to increase based on the 90 percent injury recorded. Delayed saguaro mortality from other fires had been documented for up to 5 years after injury. Preliminary analysis now shows that after 10 years saguaro mortality attributable to the Vista View fire has increased to almost 30 percent. Similarly, some of the associated vegetation that had sprouted after the fire eventually died. Although many obviously fire injured saguaro continued to grow in height and produce additional arms evident deterioration and partial decay suggest more will eventually die from injury suffered during the 1993 fire. Higher numbers of juvenile saguaro were observed in unburned when compared to burned areas. Further comparisons between burned and unburned vegetation will elucidate how the extended drought during the last decade influenced mortality of saguaro and associated vegetation. Another decade or two may be necessary to determine the full impact of the Vista View fire on this saguaro population.

P2.10

SURFACE FIRES AND STEM MORTALITY: PHYSICAL CONNECTIONS

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Flames in surface fires cause tissue necrosis to some depth within tree stems through heat transfer and tissue response mechanisms. Tissue necrosis kills stems and trees when it extends below the bark. No studies exist that provide data and physically-based equations linking flames, stem heating and tissue necrosis although parts of the problem have been investigated intensively. The rate of flame spread over a surface fuel and its fuel consumption may be used to calculate a fire intensity that in turn may be used to estimate flame velocity, height, and depth and, therefore, convective and radiative heat flux into a tree stem. Given certain boundary conditions—the convective coefficient, flame and surface temperatures, and bark moisture—temperature rise within the stem may then be modeled by computationally intensive numerical methods or by dimensional analysis of variables involved in heat and mass transfer. In this paper, heat flux and thermocouple data from surface fires, and measurements of bark moisture and tissue response, are combined with physical and dimensionless equations to elucidate the strong correlation between fire intensity and the depth of tissue necrosis in tree stems. Using known allometric relationships between tree diameter and bark thickness along with forest structural data (i.e., species composition and size distributions) our equations can be used to predict tree mortality in surface fires.

P2.11

LONG-TERM RESPONSE OF TWO EXOTIC PLANT SPECIES FOLLOWING A WILDFIRE IN THE BLACK HILLS, SOUTH DAKOTA

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Exotic species potentially play an important role following wildfires. Their establishment has been documented widely in the past, though few research studies have data that span more than two or three years. This study was established following the Shirttail wildfire, which burned approximately 445 ha in Wind Cave National Park, SD in April 1991. In response to park managers' concerns about the persistence of exotic species in the area burned by the wildfire, this project was designed to quantify the long-term population trend of two exotic plant species. In 1992, research plots were established in dense patches of common mullein *(Verbascum thapsis)* and Canada thistle *(Cirsium arvense)*. Common mullein was by far the dominant species, in terms of cover, frequency, and density, in the mullein plots in both 1992 and 1993. However, by 1995, common mullein had nearly disappeared from the plots and Canada thistle had become the major species on these sites. By 2002, mullein cover and frequency averaged <1%, and thistle cover averaged 4%, but occurred in 33% of the sampling frames. On the thistle plots, density of both Canada thistle and common mullein increased from 1992 to 1993. In 1993, thistle densities averaged more than 12 plants/m^2 and mullein densities averaged >44 plants/m^2. By 1995, density of common mullein had declined to an average of about 8 plants/m^2, but Canada thistle densities remained in the 10 to 12 plants/m^2 range. In 2002, Canada thistle persisted at relatively low cover levels (<10%), but was present in around half of the quadrats and had densities averaging between 5 and 8 plants/m^2 on both seeded and unseeded plots. The persistence of these two species following wildfires is partly related to their differing life history strategies. Canada thistle spreads via extensive lateral root systems as well as by seeds, and its success is likely dependent on adequate soil moisture. Common mullein is an ephemeral species following wildfire, as it reproduces only by seeds. Long-term data such as these are crucial in developing management strategies following wildfires.

P2.12

FIRE SEVERITY CLASSIFICATION: USES AND ABUSES

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Burn severity (also referred to as fire severity) is not a single definition, but rather a concept and its classification is a function of the measured units unique to the system of interest. The systems include: flora and fauna, soil microbiology and hydrologic processes, atmospheric inputs, fire management, and society. Depending on the particular system of interest, the unit of measure changes. For example, in fire management the units of measure include consumption of organic material, flame length, torching index and other indicators of risk and fire behavior. For the atmosphere the units of burn severity include particulates and toxic gasses as a result of smoke and other inputs from fires. For society the number of homes damaged, injuries, and net value changes would be the units of measure. Flora and fauna and soil microbiology and hydrologic processes units of measure would quantify residual ecosystem structure after the fire and then subsequent responses in nutrient cycling, erosion, and species diversity and recovery rates to name a few.

The challenge to burn severity classification is to develop consistent ecological meaningful information that can be readily related to secondary fire effects. Currently, burn severity classification is based on qualitative estimates or include detailed information on individual forest components that are difficult to summarize into one classification system. In addition, forest structure that is measured may have no

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Cover image: Prescribed burn in cutthroat grass (Panicum abscissum) and south Florida slash pine (Pinus elliottii var. densa) at Archbold Biological Biological Station, Florida.

Photo by R. Myers, The Nature Conservancy

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