Fact Sheet: Understanding Fire and Fire Behavior

Fire[1]

- Fire always obeys general principles of physics and chemistry; for fire to exist, oxygen, heat and fuel must present. Fire experts refer to this as the Fire Fundamental Triangle:

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- The principle sources of fire ignition in the West are lightning and people.

How does wildland fire behave?[2]

- How wildland fire behaves as it moves through the landscape is not precisely predictable. Because of the many variables influencing a wildland fire, no two fires are alike. Wildland fire exhibits a range of behavior—from smoldering in tightly packed pine needles under snow to surface fire through grasses under a pine stand (the type of fire typical of ponderosa pine forests prior to settlement) to blazing conflagrations of crown fire. Large fires moving through the canopies of forests are considered to be unnatural; "extreme" fire behavior for the ponderosa pine forest (as opposed to northern boreal forests that typically burn this way). This behavior is considered by experts to be an unusual phenomenon of the last 50 years resulting from man-induced changes on the landscape.[3]

Types of Fire
Surface fire (left)
Ground fire (burns below the surface)
Crown fire (right-burns tree canopies)

- Fire behavior is a product of the environment in which the fire is burning. Topography, weather, fuel, and the fire itself all influence fire behavior. As these variables interact the fire behavior will change.

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[1] Pyne, S.J., P. Andrews and R.D. Laven. 1996. "Introduction to Wildland Fire, 2nd Edition." John Wiley & Sons pp 3-44.
[2] Ibid, pp 46-87.
[3] Betancourt, J.L., T.W. Swetnam, C.D. Allen and M. Savage. 2003. "Fire in the West: It's No Simple Story." High Country News, July 7, 2003. www.hcn.org/servlets/hcn.Article?article_id=14110

- Fire spreads most rapidly in the direction of local wind and upslope in uneven terrain. The fastest-spreading part of the perimeter is called the ***front*** or ***head***; the slowest-spreading part is called the ***back***. The lateral portions, or ***flanks***, spread at intermediate rates. In Arizona, the spread and shape of fire is often in a Southwest to Northeast direction due to the prevailing winds during fire season in May and June.

- In some cases fire creates its own environment. Heating from the fire can produce local winds, create atmospheric instability, and cause cumulus clouds to develop. In an extreme state, a combustion cloud can develop and build to the point where it produces lightning, rain, and dangerous downbursts of winds up to 60 mph sending embers in all directions (the Rodeo-Chediski fire was a "plume dominated fire" characterized by this behavior).

- How a fire spreads varies depending on the fire. In general, it spreads by igniting new fuel along its outer perimeter. However, it may grow out of the immediate vicinity by producing embers or sparks that are carried by wind and the fire's convection column. Extreme fire behavior will generate embers that will travel ahead of the fire. For example, the Sundance Fire in 1967 traveled 16 miles in 9 hours, created spot fires 10 to 12 miles northeast of the place of origin, and overall traveled at an average rate of 1-6 miles per hour.

- The conditions described by fire experts as favorable for crown fire exist throughout the Mogollon Rim country in Arizona during fire season. These include: dry fuels, low humidity and high temperatures, heavy accumulations of dead and downed litter, conifer reproduction and other ladder fuels (midsize trees that permit fire to "climb" into the overstory canopy), steep slopes, strong winds, unstable atmosphere, and a continuous forest of conifer trees.

What we know about home protection[4] and the Wildland –Urban Interface (WUI)

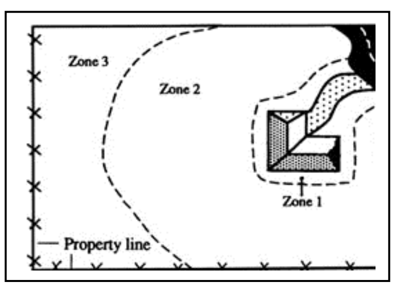
- Fire in the WUI and around homes depends on the same variables as wildland fire to ignite and spread.

- For a house to ignite from a surface fire, the flammable part of the fire must come within a few feet or come in contact with the structure. This includes grass, wood piles, wood chips, and any thing else that can serve as fuel. The other sources of ignition are wind borne embers.

- In the absence of fuel a fire cannot survive even if there is heat and a source of ignition (flame). Homeowners can minimize the risk of fire to property by reducing the hazardous fuel that exists around and adjacent to their homes. In addition, minimizing the amount of highly flammable material in building materials (such as cedar shake roofs and siding) can reduce the threat of wind-borne burning embers.

- A case study of the Black Tiger Fire in Colorado in 1989 states, "This fire, which soon outran the fire defenses in difficult terrain, demonstrated the predictable effects of a combination of factors: lack of rainfall, prolonged heat spell, wind, sloping topography, buildup of forest fuels, construction factors affecting the susceptibility of homes to fire, use of combustible construction materials, poor site access for emergency vehicles, and lack of home-site maintenance for fire protection."[5]

- "Another approach to managing fire on a landscape scale is the use of fuel breaks in strategic locations, such as along ridgelines or around communities. The concept behind fuel breaks is to provide a defensible location for use by firefighting crews, or to reduce fire intensity in the immediate WUI…Fuel breaks can be efficient and cost effective in protecting homes and other structures from catastrophic wildfire…Fuel breaks are not a replacement for a strategic fuels treatment program. They are most effective when incorporated into a strategic fuel treatment program or community protection and preparedness program."[6]



Creating defensible space involves developing
a series of management zones in which different treatments are used.[7]

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[4] Cohen, J. 2003. "An Examination of the Summerhaven, Arizona Home Destruction Related to the Local Wildland Fire Behavior during the June 2003 Aspen Fire." Unpublished Report/USDA Forest Service/Rocky Mountain Research Station/Missoula Fire Sciences Laboratory.
[5] Pyne, S.J., P. Andrews and R.D. Laven. 1996. "Introduction to Wildland Fire, 2nd Edition." John Wiley & Sons pp 3-44
[6] Graham, Russell T. 2003. "Influence of Forest Structure on Wildfire Behavior and the Severity of Its Effects: An Overview." U.S. Forest Service, North Central Experiment Station.
[7] Cooperative Extension, College of Agriculture and Life Sciences, University of Arizona. 2003. "Creating Wildfire-Defensible Space for your Home and Property". http://www.cals.arizona.edu/pubs/natresources/az1290/

Summary

- **Fire follows the laws of physics**. It is predictable that if there is fuel, oxygen, heat, and a source of ignition, something will burn. In wildlands, the amount of fuel is the only element we can control to reduce the risk of wildfire.

- **Homeowners are their own first line of defense**. Saving a home from wildfire depends primarily on two factors: roofing material and the quality of the "defensible space" surrounding it.[8] Research Physical Scientist Jack Cohen noted after visiting homes that survived the Rodeo-Chediski Fire and those that were consumed, that had homeowners followed guidelines for creating defensible space—described as creating an area around a structure where fuels and vegetation are treated, cleared, or reduced to slow the spread of fire—more homes would have survived.

- **Aggressive creation of defensible space around homes, combined with hazardous fuels reduction to explicitly protect communities, will go a long way to reduce the risk of wildfire to communities.** It is significant to note, however, that creating a band or a treated strip that is a fixed distance in width around a community (akin to a castle with a moat) will not necessarily provide effective protection. In reality the WUI protection zone should be designed strategically after consideration of topography, fuels, prevailing winds, and human dwellings and infrastructure. For example, treatments to protect Flagstaff should be prioritized for areas southwest of the city to account for prevailing winds. Given the ability of fire to spread rapidly through canyons, strategic placement would include canyons and other features that can act as chutes for fire.

- **There are two principal reasons for restoring greater forest ecosystems to improve forest ecosystem health and reduce hazardous fuels.**

    1. The first is that plume-dominated fire and extreme fire behavior can overtake wildland-urban interface treatments and ignite fire in a community. This may be in the form of surface fire, crown fire, or embers moving in front of a fire.
    2. The second relates to the unequivocal and critical relationship of forested communities to their greater ecosystems. "Removing biomass and fuels only in the wildland-urban interface can help protect homes and businesses. However, protecting resource values such as water quality, forest health and productivity, wildlife habitat, and recreation values requires vegetation and fuel management at a landscape scale. Fuel treatments carried out over large landscapes can reduce both the size and severity of wildfires and their effects on communities and the environment." [9]

    Fire behavior models developed by Mark Finney indicate that by locating fuel breaks in strategic locations it is possible to treat only 20% of the landscape and modify fire behavior. This approach is an effective first step to maximize protection and buy time while ecological restoration proceeds at the landscape level. Ecological restoration will be a necessary prerequisite for the reintroduction of natural fire on a large scale.

Fact sheet provided by the Ecological Restoration Institute, Northern Arizona University
For more information, visit our website at www.eri.nau.edu or call (928) 523-7182

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[8] University of Arizona Cooperative Extension. 2002. "Creating Wildfire-Defensible Spaces for Your Home and Property." Publication AZ1290. ag.Arizona.edu/pubs/natresources/az1290.pdf

[9] Graham, Russell T. 2003. "Influence of Forest Structure on Wildfire Behavior and the Severity of Its Effects: An Overview." U.S. Forest Service, North Central Experiment Station.