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Burn Severity Maps for the 2017 Panhandle Fires

M.L. Russell, D. Doan-Crider, and T. Steffens*

In March of 2017, wildfires erupted throughout multiple counties in the Texas Panhandle, causing evacuations, destroying homes, and closing highways. The Dumas Complex, Lefors East, and Perryton wildfires started as numerous small fires resulting from severe thunderstorms beginning early Monday, March 6, 2017 (Figure 1). Ochiltree, Roberts, Hemphill, Lipscomb, Randall, Potter, Hutchinson, Gray, Wheeler, Carson, and Childress counties all reported grass fires that spread quickly. Strong winds accompanied by near-record high temperatures, and large quantities of fine-fuel due to the previous year's high rainfall, all contributed to the perfect storm of fire events. For 90 days before the wildfires, less than one inch of rainfall had been reported at Rick Husband Amarillo International Airport, and relative humidity in some areas was a low as 8 percent. During the fires, the National Weather Service reported southwest winds in the region of 35 to 45 mph with gusts of 60 to 65 miles per hour.

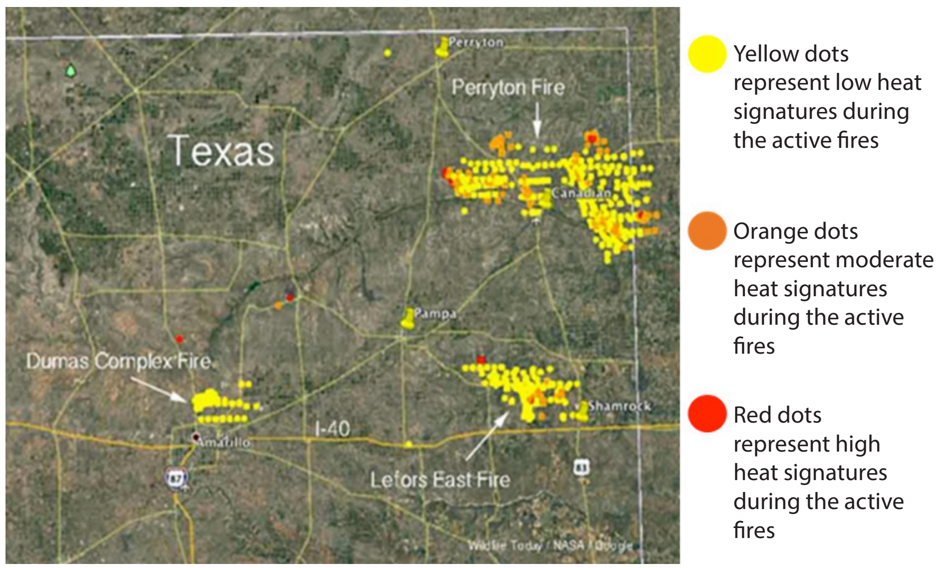


Figure 1. Perryton, Dumas Complex, and Lefors East wildfires started on March 6, 2017 and burned approximately 437,000 acres across Ochiltree, Roberts, Hemphill, Lipscomb, Randall, Potter, Hutchinson, Gray, Wheeler, Carson, and Childress counties (map courtesy of USDA-RSAC, 2017).

The Dumas Complex, Lefors East, and Perryton wildfires burned about 500 square miles of land (roughly 437,000 acres) in the Texas panhandle. Five people were killed, and five firefighters were severely injured. Despite the number of acres burned, damage to structures and animal mortalities were minimal: two confirmed houses lost, several outbuildings, three to five commercial hog barns, and approximately 500 animals killed.

The initial effects of the wildfires devastated many landowners. Grazing livestock, wildlife, and

*Assistant Professor and AgriLife Extension Range Specialist; Adjunct Faculty, Ecosystem Science and Management, Texas A&M University; Assistant Professor and AgriLife Extension Specialist; The Texas A&M University System

firefighters were caught off guard by the speed of the fire which burned close to 30,000 acres in 24 hours. Dense accumulations of dormant, cured, fine fuel, paired with high winds and temperatures made these Texas wildfires some of largest and most traumatizing in recent history. Many landowners suffered immediate loss of grazing livestock, wildlife, structures, and aboveground biomass.

Burn severity maps

Recent advancements in satellite and computing technology enable us to assess both the short and long-term impacts of the fire on vegetation. Burn Severity Maps, or differenced Normalized Burn Ratio (dNBR) maps, categorize burned areas (soils and vegetation) into 4 levels of severity: high, moderate, low, and unburned. These maps can be used to assess fire impacts across large, inaccessible landscapes, and to support assessment of impacts to soils and short- to long-term impacts on vegetation. Their application as a public outreach tool remains largely unexplored. However, as opposed to visual impressions produced by blackened landscapes, burn severity maps can help landowners and managers quickly, and more thoroughly, grasp the ecological impacts of wildfire.

The information these maps provide regarding the effect of wildfire on the landscape can be interpreted and applied. The initial aftermath of wildfire is always devastating, but these maps reveal that from a natural resource perspective, the burn severity of these fires was only mild to moderate. The March 2017 Wildfires were a devastating natural disaster for Panhandle ranchers and landowners, but maps like these can provide objective insight into how fires burn and their potential effect on plant communities in the future.

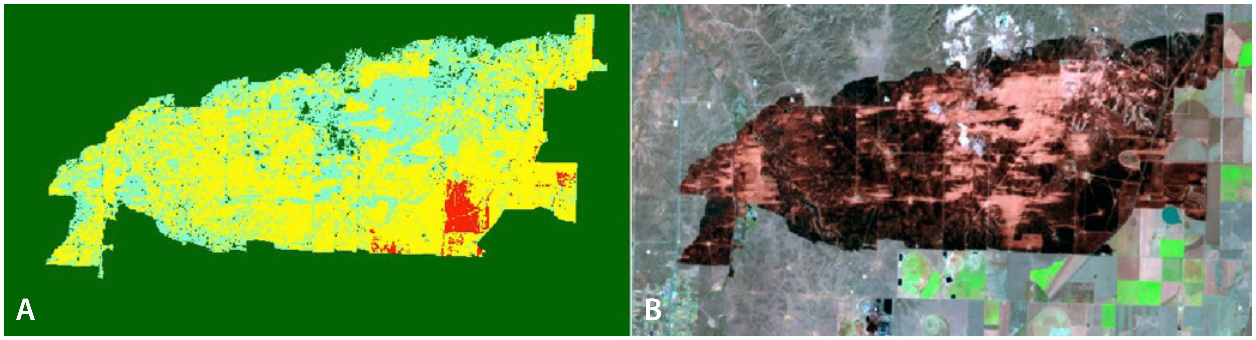
Satellite based burn severity maps for large wildfires are common in the western U.S. and on public lands because they can be used to rapidly assess fire impacts on large and sometimes hard-to-reach areas. This information can then be used to target areas that need erosion control or restoration. Burn severity information is produced by the USDA Forest Service's Remote Sensing Applications Center in Salt Lake City, Utah. Federal, state, and international fire-management agencies commonly use their information. However, land conservation agencies such as the NRCS and Texas A&M AgriLife Extension Service have recently used their products for fire assessment and recovery efforts. Burn severity maps of the Dumas Complex (Figure 2), Lefors East (Figure 3), and Perryton (Figure 4) wildfires can be used to assess actual impacts of the wildfires on natural resources and provide baseline information for long-term land management. The detail provided by burn severity maps can also be useful to agencies for allocating disaster funding or planning fence reconstruction.

How do the maps work?

The normalized burn ratio (NBR) is commonly used to measure and monitor wildfire impacts on large landscapes—this ratio is a comparison of satellite images before and after a fire. NBR maps that are validated with field assessments after at least one post-fire growing season provide the best information; however, "raw" maps such as Figures 2, 3, and 4 are useful for initial assessments. In the case of grasslands, grasses, forbs, or invasive species will green up much more quickly than the woody overstory. High levels of change for grasslands, as indicated by the satellite imagery, may not necessarily reflect burn severity; it can simply reflect the fact that grasslands are either green or black and this can change quickly because of vegetation regrowth.

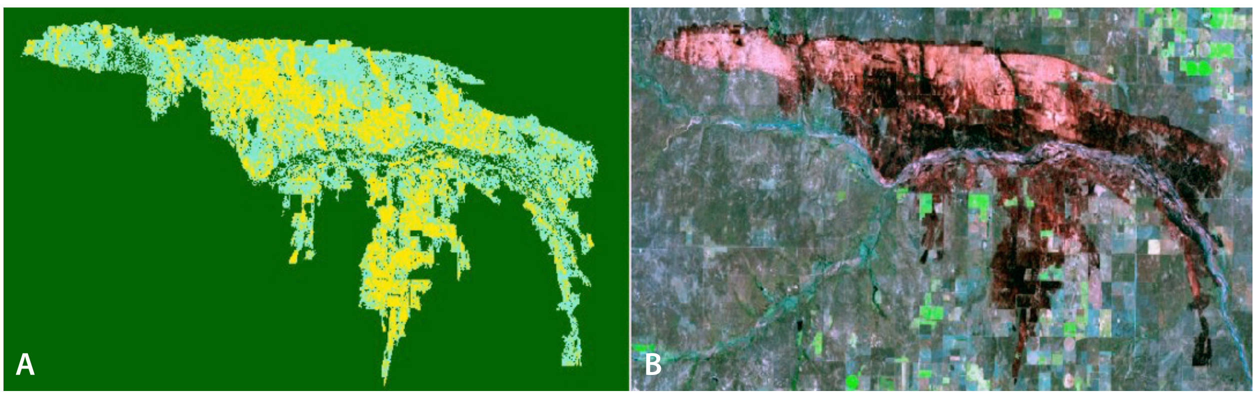
How should the maps be used?

Rehabilitation and restoration planning begin immediately after a wildfire. Burn severity maps help because they provide an initial assessment of the degree of damage to soils and vegetation. Agencies, managers, and ranchers can use these maps to estimate negative impacts due to soil erosion. They can also be used to identify areas that might be susceptible to encroachment by invasive species. The initial (raw) maps can be used for basic assessments, but for further analysis on habitat recovery, they should be field-tested (validated) to ensure that given classifications are what the maps are actually indicating.



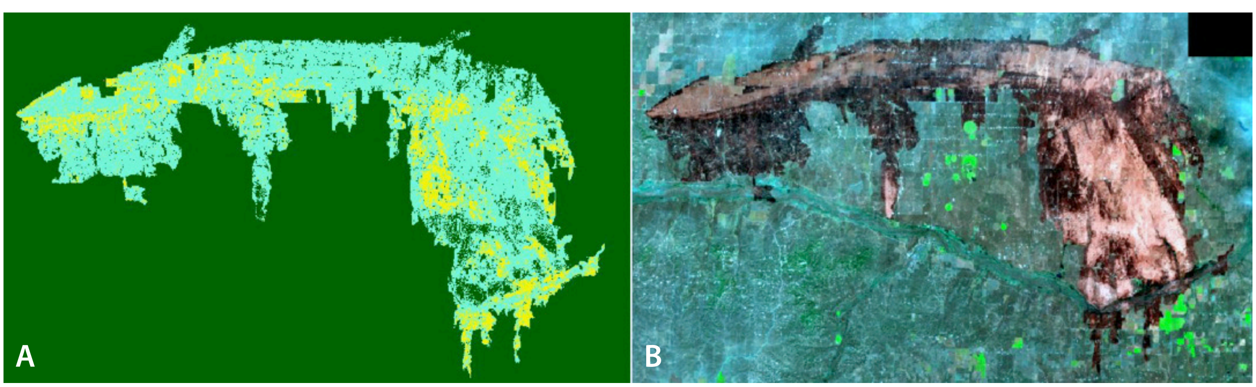
Burn Severity
Unburned to Low
Low
Moderate
High
Increased Greenness
Non-Processing Area Mask*

Figure 2. (A)Thresholded burn severity maps for Dumas Complex wildfire in Potter County, Texas that burned approximately 29,197 acres. Burn severity levels are: 1) dark green for unburned/very low (800 acres), 2) aquamarine for low (8,000 acres), 3) yellow for moderate (19,000 acres), and 4) red for high (1,400 acres). (B) Aerial imagery of the Dumas Complex area post-fire (Imagery was taken March 17, 2017 courtesy of USDA-RSAC, 2017).
** Areas in either the pre-fire or post-fire reflectance imagery containing clouds, snow, shadows, smoke, significantly sized water bodies, missing lines of image data, etc.*



Burn Severity
Unburned to Low
Low
Moderate
High
Increased Greenness
Non-Processing Area Mask*

Figure 3. (A) Thresholded burn severity maps for Lefors East wildfire in Gray and Wheeler counties Texas that burned approximately 92,571 acres. Burn severity levels are: 1) dark green for unburned/very low (2,000 acres), 2) aquamarine for low (70,000 acres), 3) yellow for moderate (20,500 acres), and 4) red for high (0 acres). (B) Aerial imagery of the Lefors East post-fire (Imagery was taken March 17, 2017 courtesy of USDA-RSAC, 2017).
** Areas in either the pre-fire or post-fire reflectance imagery containing clouds, snow, shadows, smoke, significantly sized water bodies, missing lines of image data, etc.*



Burn Severity
Unburned to Low
Low
Moderate
High
Increased Greenness
Non-Processing Area Mask*

Figure 4. (A) Thresholded burn severity maps for Perryton wildfire in Ochiltree, Roberts, Hemphill and Lipscomb counties, Texas that burned approximately 315,135 acres. Burn severity levels are: 1) dark green for unburned/very low (4,000 acres), 2) aquamarine for low (250,000 acres), 3) yellow for moderate (61,000 acres), and 4) red for high. (B) Aerial imagery of the Perryton area post-fire (Imagery was taken March 17, 2017 courtesy of USDA-RSAC, 2017).
** Areas in either the pre-fire or post-fire reflectance imagery containing clouds, snow, shadows, smoke, significantly sized water bodies, missing lines of image data, etc.*

A burn severity map is useful in that it provides comprehensive mapping of the fire regardless of land ownership—images of the fire area are obtained via satellite. Identifying areas of specific fire severity may improve overall strategies and opportunities to assess primary and secondary fire effects not evident to the human eye.

Burn severity maps can provide imagery to gauge potential fuel loads and consequently be used to plan prescribed burns for improving rangeland productivity. Understanding the distribution of fire severity—low, moderate, and high—from past fires can help predict the effects of prescribed burns or even future wildfires for specified plant communities (validated through in-field assessments).

Burn severity maps can also be used to identify the specific implications of suppression tactics and placement of range management treatments. For example, high severity fires may be recurring in certain plant communities and conditions (e.g., grazed/nongrazed). Furthermore, burn severity maps in addition to field data may be used to analyze how the spatial complexity of fire affects wildlife habitat utilization and even predict the eventual recovery of certain wildlife foods

Map interpretations

A majority of the acreage burned in the Dumas Complex, Lefors East, and Perryton wildfires consisted of low to moderate burn severity (Table 1 outlines severity classes). Late dormant season fires tend to burn over more area and are less patchy than growing-season fires. Grasses, as a combustible fuel, cure progressively and collapse with the onset of the dormant season. Moisture content has a major effect on fire spread. Fires typically will not spread when grasslands are 50 percent cured or less and only reach their full fire spread potential when they are more than 95 percent cured.[1] Decreasing relative humidity and soil moisture combined with increasing temperature and wind speed create ideal conditions for fire spread. Therefore, their low to moderate fire severity classifications indicate that these wildfires moved very fast, consumed mostly fine fuel, and were predominantly wind driven. The duration of extreme temperatures was most likely short; however, the fire temperature was possibly very high assuming accumulated fine-fuel loads were abundant due to above-average precipitation the previous growing season.

Areas classified as high-severity (as seen in parts of the Dumas Complex wildfire) typically contain white ash—an important indicator of fire severity.[2] White ash has been positively correlated with fire intensity and represents near complete combustion of the available fuel. This condition offers the soil little protection from rainfall and, therefore, increases erosion potential.

Ecological implications

Burn severity, as used in the maps depicted here, can be defined as the "degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and fire residence time."[3] Burn severity is a composite of direct and indirect fire effects within one growing season. It relates principally to visible changes in living and nonliving plant material, fire byproducts (scorch, char, ash), and soil exposure. These maps show that burn severity occurs on a gradient or ordinal scale and is mosaic within a fire perimeter. Mapped burn severity can provide a framework to guide future grazing and range improvement decisions. Learning how a fire behaved and where it burned is key to a broader understanding of rangeland management in the Texas Panhandle.

Plants respond to fire according to variables such as post-fire climate conditions, species characteristics, and site productivity. This makes it challenging to predict how an environment or plant community will respond after a fire. However, Table 1 provides some general management recommendations that correlate with burn severity classification. Some species survive fire and then resprout. However, some may not when fires are too severe—particularly if soils and the supporting microbial communities are damaged and need time to recover. Other species are killed by fire, but reestablish through germination of fire-resistant seeds. If fire severity is high or fire patchiness is low, or both, the seed and bud bank could be at risk.

Table 1. Below is a short list of the burn severity classes and respective potential environmental impacts and potential management strategies and actions for plant communities in the Perryton, Dumas Complex, and Lefors East wildfires in March 2017.[4] The amount of pasture rest necessary after a fire varies according to vegetal composition, site conditions, and objectives of the fire. These guidelines are general and should be validated in the field before implementation.

Burn severity class	Potential impacts on plant communities	Potential management strategies and actions post-fire
Unburned – Low	No evidence of char on standing or downed vegetation or within or under litter layer.	Carefully monitor post-fire growing conditions. If livestock have premature access to the burned area, the full benefits of the fire may not be realized, and negative impacts may occur unless livestock management is included in the overall plan. Grazing management following burning can significantly affect the degree of change in forage species productivity and the composition of postburn vegetation. Livestock management on a burned area is most critical during the first growing season after fire, particularly in plant communities of arid and semiarid regions.
Low	Some low char on standing vegetation, very little char in litter layer; no mineral soil patches; litter layer intact. Surface organic layers are not completely consumed and are still recognizable. Roots are generally unchanged because the heat pulse below the soil surface was not great enough to consume or char any underlying organics. The ground surface, including any exposed mineral soil, may appear brown or black (lightly charred), and the canopy and understory vegetation will likely appear "green."	Start with a decision to stock the pasture at a rate to permit improvement. Various combinations of rotation land deferment have proven successful where such factors as range condition, kind of livestock, stocking rate, season, and intensity were given proper consideration. Rate of Stocking—balancing numbers and grazing time of animals with forage resources—is the most important part of good grazing management.
Moderate	Litter layer consumed in places; patches of mineral soil present, some charred; char on most mid-story vegetation, mostly standing, with moderate mortality; some mid-story stump sprouts; char on most overstory vegetation with low to moderate mortality. Up to 80 percent of the pre-fire ground cover (litter and ground fuels) may be consumed but generally not all of it. Fine roots (~0.1 inch or 0.25 cm diameter) may be scorched but are rarely completely consumed over much of the area. The color of the ash on the surface is generally blackened with possible gray patches. There may be potential for recruitment of effective ground cover from scorched needles or leaves remaining in the canopy that will soon fall to the ground. The prevailing color of the site is often "brown" due to canopy needle and other vegetation scorch. Soil structure is generally unchanged.	Aftermath of fire changes animal behavior including grazing pattern, preferences, utilization rates, forage consumption, and frequency of grazing. Wildlife and domestic animals are attracted to recently burned areas and use the burned area more than surrounding vegetation. Cattle, horses, and sheep usually have the greatest impact. Grazing animals frequently concentrate on a burn because the herbage or browse is more accessible, palatable, and nutritious. Plant growing points may also be exposed, increasing the likelihood of damage from a foraging animal. Carbohydrate reserves of sprouting plants are usually depleted because of energy required to regenerate after a fire. Repeated use of these plants can reduce vigor considerably, and sometimes kill key forage or browse species.
High	Majority of litter layer consumed and charred mineral soil common; mid-story vegetation consumed and mostly absent; lots of mid-story stump sprouts; standing overstory trees have heavy char, and in some cases, are mostly consumed; overstory trees experience moderate to heavy mortality. All or nearly all the pre-fire ground cover and surface organic matter (litter, duff, and fine roots) is generally consumed, and charring may be visible on larger roots. The prevailing color of the site is often "black" due to extensive charring. Bare soil or ash is exposed and susceptible to erosion, and aggregate structure may be less stable. White or gray ash (up to several centimeters deep) indicates that considerable ground cover or fuels were consumed. Sometimes very large tree roots (> 3 inches or 8 cm diameter) are entirely burned extending from a charred stump hole. Soil is often gray, orange, or reddish at the surface where large fuels were concentrated and consumed.	The initial concern following burning is the restoration of plant vigor and bud bank production. At least two growing seasons rest are generally recommended to allow reestablishment of preferred species and to deter reinvasion of shrubs. Recommended rest for one year and deferment of grazing until after seeds have ripened the second year, if the range is otherwise in adequate condition. Some species of sprouting shrubs take much longer than two years to recover, and longer is necessary if reestablishment of browse species is an objective.

The native perennial grasses found in all burn severity classes of the 2017 fires are exceptionally resistant and resilient due to belowground accumulation of dormant and active vegetative buds. Belowground bud banks respond positively to moderate fire intensities due to increases in bud activity and minimal bud mortality following fire. Native grasses such as blue grama (*Bouteloua gracilis*) and western wheatgrass (*Pascopyrum smithii*) have responded to fire with increased bud activity throughout winter dormancy to replenish bud bank reserves and capitalize on early spring precipitation. This plant strategy is effective in the Southern Great Plains due to variation in precipitation patterns.

Whether to graze livestock following fire is based on land manager's objectives—for moderate to high burn severity, grazing deferment should be assessed. However, for low burn severity, there may be opportunities to maximize ranch goals. For example, following fire, there may be flash grazing opportunities that take advantage of new grass growth or specifically target invasive and previously unpalatable plants. If flash grazing, livestock should stay in the burned pasture (depending on grazeable acres) for only a short time. If you are concerned with native perennial grass response following a fire, defer grazing for at least one growing season. In the case of the 2017 Panhandle fires, an August or September turnout date with low stocking rates may have been appropriate given the native grass bud bank response to fire. However, overall fire effects are unique to each situation—when in doubt, deferred grazing may be most beneficial.

The impact of fire on animals is harder to assess than its impact on plants. Some animals prefer little or no burning of their habitat. Others prefer more frequent burning, while still others have complex responses based on fire patchiness and landscape context. Most native wildlife throughout the Panhandle (white-tail deer, antelope, Eastern fox squirrel, Eastern cottontail, desert cottontail, ring-necked pheasant, bobwhite quail, scaled quail, lesser prairie chicken, wild turkey, and mourning dove) have evolved with frequent fire events and have adapted to withstand direct fire effects. However, patchiness or mosaics of burned and non-burned areas (typical of low or moderate burns) are generally the most beneficial to habitat. The patterns they create offer non-burned areas for nesting and cover, and open burned areas for grass and seed feeding. The ideal non-burned patch size for maintaining local populations is difficult to define because animals' home ranges vary. Undoubtedly, the most vulnerable species are the small and relatively immobile animals that are restricted to small isolated habitats.[5] However, these animals can find refuge in the non-burned patches, whether in holes, crevices, under rocks, or in aboveground shrub foliage and tree hollows.

Many studies have argued that prescribed burning can substantially restrict the spread of large wildfires. Given the variable burn severity across the three 2017 fires, a prescribed burn program might have reduced the wildfire potential by diminishing volatile fuel accumulations. Prescribed burning might also have provided safe areas from which to launch suppression operations. Though prescribed burning can enhance wildlife and livestock habitat and mitigate wildfire damage, the central challenge for biodiversity management is to better understand and deliver fire patchiness, especially in relation to rapid accumulation of grassy fuels.

Conclusions

- Burn severity is defined as the "degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and fire residence time".[3]
- Burn severity is a composite of direct and indirect fire effects that arise within one growing season. It relates principally to visible changes in living and nonliving plant material, fire byproducts (scorch, char, ash), and soil exposure.
- Plants respond in different ways to fire, depending on variables such as post-fire climate conditions, species characteristics, and site productivity.
- Typically, native perennial grasses that were found in all the burn severity classes of the 2017 wildfires are exceptionally fire resistant

and resilient due to the belowground accumulation of dormant and active vegetative buds.

- Burn severity can be mapped and provides a framework for future grazing and range management decisions. Learning how a fire behaved and where it burned is key to a broader understanding of rangeland management in the Texas Panhandle.

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