Cracking the AQ Code

ADEQ Arizona Department of Environmental Quality
Air Quality Forecast Team

November 2016 Volume 2, Issue 9

Arizona Prescribed Burns

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In a previous issue of *Cracking the AQ Code*, the ADEQ Forecast Team discussed wildfires, but there are other types of wildland fires that affect air quality and are tracked in Arizona. Carrying on with a fire and smoke theme, we will now explore the concept of the less intense cousin of the wildfire: the prescribed burn (Rx burn, hereafter).

Why Do Prescribed Burns Exist?

Rx burns are a unique type of wildland fire, because unlike wildfires, they involve intentional fire ignitions on a landscape, but not before extensive planning and predetermined goals have been established. Prescribed burn projects dot many areas of our state (Figure 2) and often take many years of collaboration between scientists and fire managers following the National Environmental Policy Act (NEPA). In the end, they essentially agree on a "prescription" bringing particular lands back to their natural state free of invasive plant species and chocking amounts of fuels (Figure 1).

Figure 1: Accumulating dead fuels being gathered for removal in the Catalina Mountains near Tucson, Arizona. Photo: Melanie Lenart.

About "Cracking the AQ Code"

In an effort to further ADEQ's mission of protecting and enhancing the public health and environment, the Forecast Team has decided to produce periodic, in-depth articles about various topics related to weather and air quality.

Our hope is that these articles provide you with a better understanding of Arizona's air quality and environment. Together we can strive for a healthier future.

We hope you find them useful!

Upcoming Topics…

- $PM_{2.5}$ in Arizona and Around the World
- Stratospheric Ozone Intrusions

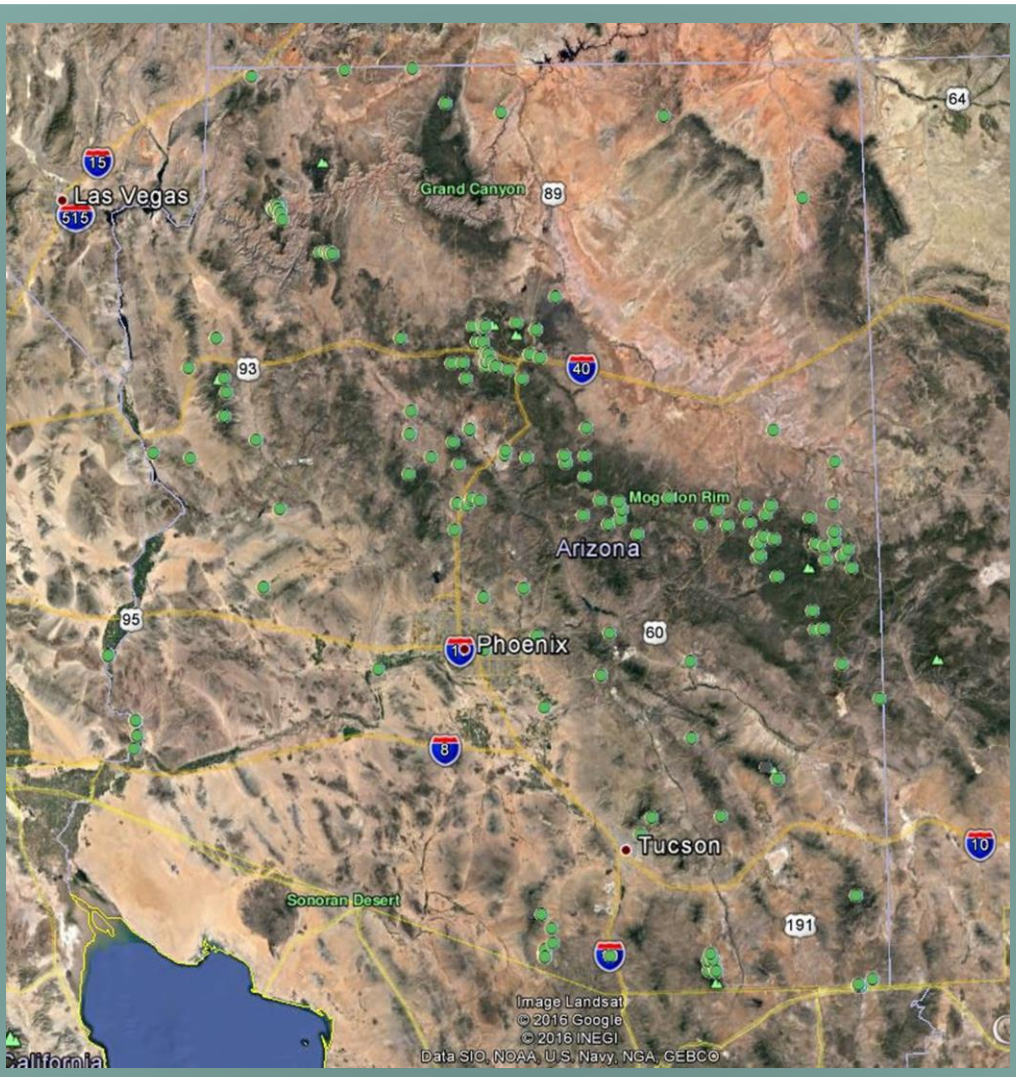

Figure 2: Locations of Rx burn projects in Arizona. As of 2016, over 300 projects are registered with the Arizona Department of Environmental Quality (ADEQ). Most are located in northern Arizona where large tracts of forested land are present; however, burns in desert terrain, or even along highways, are also prescribed by federal and state land managers.

The term “fuels” is a common one among the fire community. So what are “fuels”? In short, they represent any organic matter that can combust. Trees, brush, dead vegetation, pine needles, dropped leaves, and decaying logs all add to the fuel loading of an area over time. Fuel loading is often described as tons per acre and can vary greatly from one location to another and from year to year. Climate and elevation are key factors influencing how much vegetation exists across the nation and Arizona (Figure 3).

The introduction of prescribed fire is sometimes vital to clean up accumulated fuels in an ecosystem that has traditionally relied on periodic but low intensity wildland fires to complete this task. A more detailed review about the complexities of fuel loadings are discussed by the National Wildfire Coordination Group.

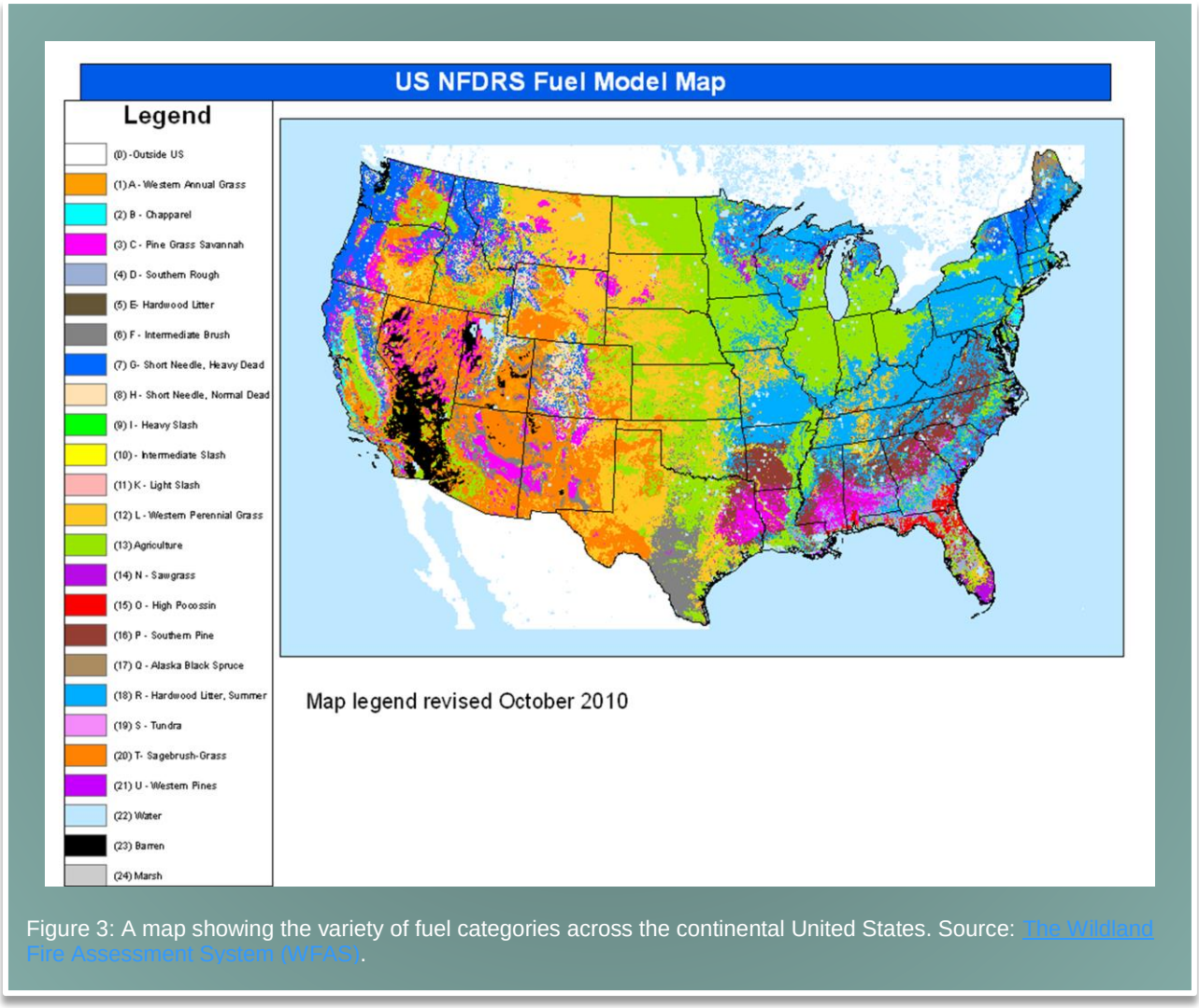

Figure 3: A map showing the variety of fuel categories across the continental United States. Source: The Wildland Fire Assessment System (WFAS).

Now back to the policy behind prescribed burn projects. Once the NEPA process is finished and environmental impact statements are reviewed, a Rx burn project can be started as long as prescription conditions are met at the planned time of burning. Specific ranges for temperature, humidity, wind speed, and fuel moisture are involved in a project's prescription.

The diversity of intended goals, vegetation types, and weather restrictions among Rx burns really allow Rx burn activity to be possible across all seasons throughout the year. Figure 4 shows an example of a Rx burn being accomplished on a winter's day. In this case, trimmed fuels were piled together, likely from surrounding thinning projects, and then ignited. Piles can be constructed either by mechanical equipment or by hand.

When it comes to Rx burns, it's not just the environment that reaps benefits, but communities too. Many folks like to be near nature. Unfortunately, this translates to quite a few Arizona homes butting up against fuels ready to feed a fire. The term Wildland Urban Interface (WUI) refers to this notion. Another aim of select Rx burns is protecting these susceptible population centers by creating effective fire breaks in declared WUI zones. If a wildfire were to break out, the lack of burnable material between an advancing fire and residences (i.e., a fire break) would halt, or at least slow, its movement. Overall, a potential emergency situation becomes more manageable, both for fire officials fighting the wildfire and also by providing more time for affected public to evacuate out of harm's way, if necessary. Eliminating excessive fuel loading through low intensity Rx burns are a means to accomplish this goal in a safer manner for firefighter staff. Figure 5 shows the stark contrast between the tamed nature of Rx burns and raging wildfires. Additional benefits of prescribed fires are described here.

Figure 4: The North Kaibab Ranger District Piles prescribed burn project (2013). Snow at the base of mechanically or hand piled fuels can be used to prevent unwanted fire spread from the base of a pile burn. Image: *InciWeb*.

Figure 5: Visual comparisons between the Government Prairie (top left) and McCraken (top right) prescribed burns carried out in Arizona's Kaibab National Forest versus the 2004 Willow wildfire (bottom left) and 2011 Wallow wildfire (bottom right). Note the difference in fire intensity, fire behavior, and smoke output between prescribed fires and wildfires. Image source: InciWeb (top left and right). Photos: PiperWarrior (bottom left) and Jayson Coil (bottom right).

Who Performs Prescribed Burns?

Although Rx burn projects could range from only a few acres up to thousands, the ultimate outcome is healthier ecosystems becoming resilient to the feared catastrophic wildfire. The recognition of this makes for numerous governmental agencies who are tied to land management having involvement with Rx burns in some capacity.

A majority of Arizona's Rx burns are conducted by the United States Forest Service, but other agencies partaking in Rx burn projects have included tribal nations, United States Fish and Wildlife Service, Arizona State Forestry, Arizona Department of Transportation, national parks, state parks, Bureau of Land Management, and even the Department of Defense (Figure 6).

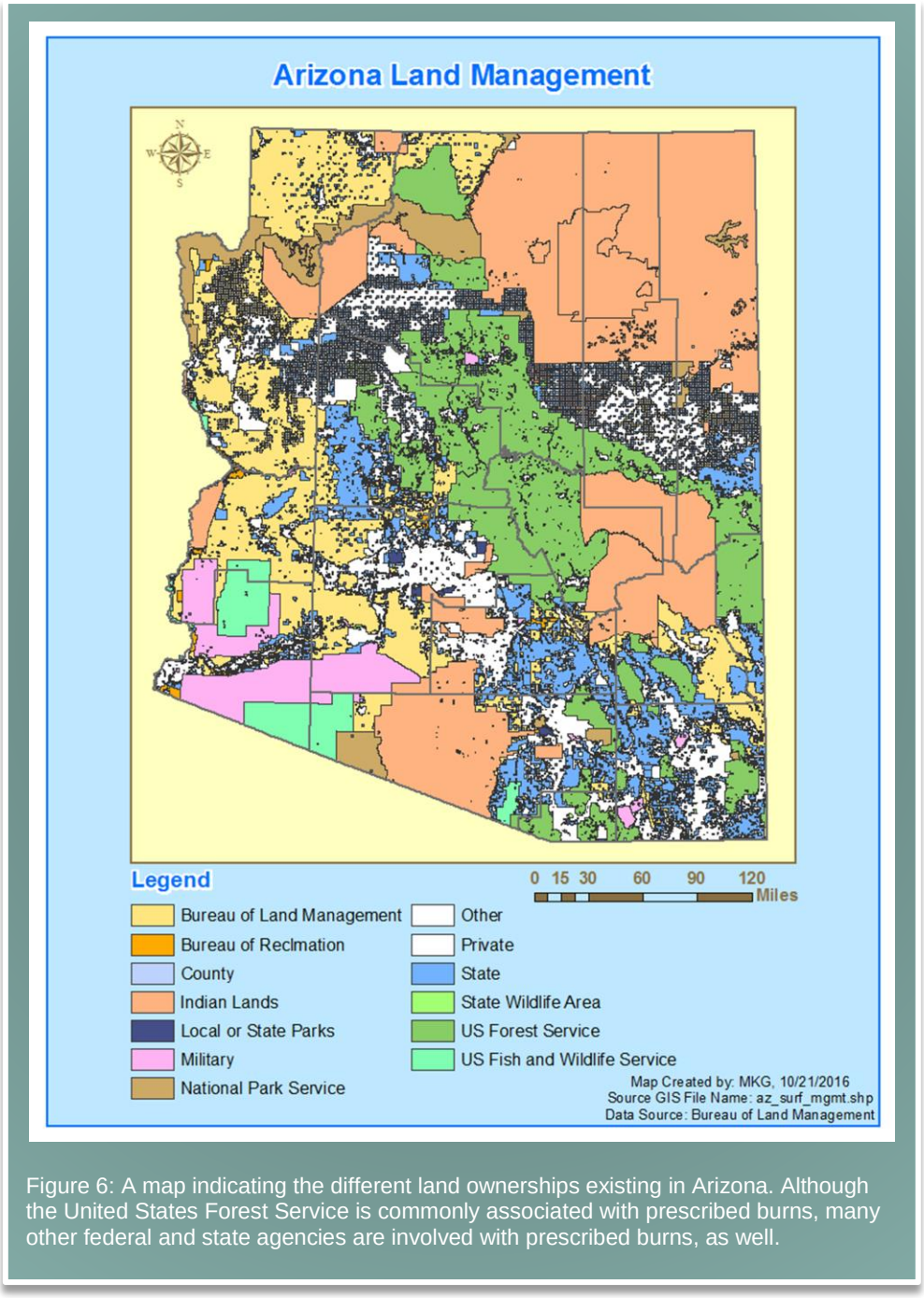

Figure 6: A map indicating the different land ownerships existing in Arizona. Although the United States Forest Service is commonly associated with prescribed burns, many other federal and state agencies are involved with prescribed burns, as well.

ADEQ and Prescribed Burns

Often times, the tradeoff for direct fire threat mitigation and wildland restoration using Rx burns is visible smoke in the skyline. Where there is fire, smoke production is going to be unavoidable. With the help of weather and smoke dispersion forecasting, though, smoke impacts to sensitive populations can be greatly limited or avoided altogether. This is where the ADEQ Forecast Team gets involved in the execution of Rx burns, the point right before ignitions would be made.

By Arizona Revised Statute, ADEQ is assigned to oversee our state's Rx burn smoke management program, which does not apply to declared wildfires situations. Major aspects specific for Rx burns entail: 1) forecasting for adequate smoke dispersion or reduced smoke impact potential, 2) approving daily burn requests, and 3) tracking burn emissions. It can take numerous burns over many years to complete a Rx burn project. The result is hundreds of burns being recorded for any given year (Figure 7). Because of this, coordination among ADEQ and fire managers becomes vital to prevent unnecessary smoke impacts.

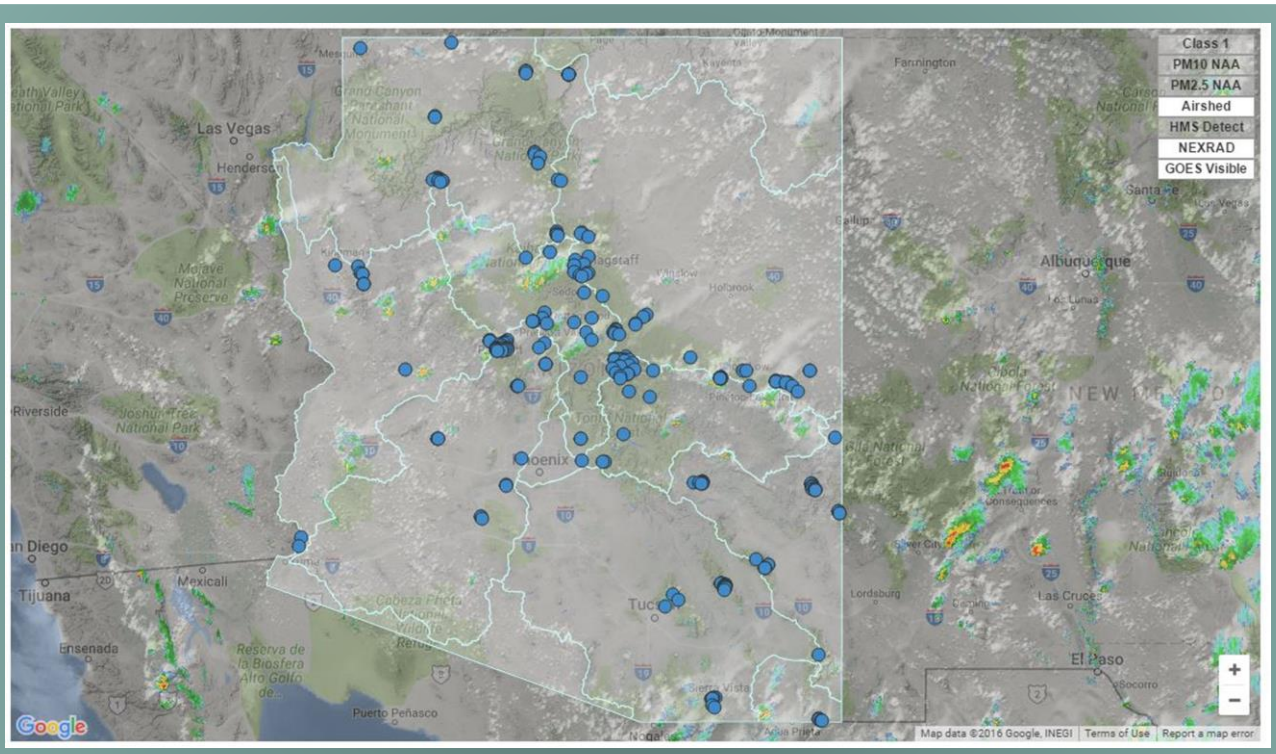

Figure 7: Spatial distribution of Arizona prescribed burns (blue dots) between January and August 2016. The state's eleven designated airsheds are shown as light blue boundaries. During periods of light winds or stagnation, wildland or residential smoke will tend to become trapped within an airshed. Airsheds would be analogous to watersheds. Map created using the Arizona Smoke Management Database (*AZ SMD*).

Approving Prescribed Burns

Fire managers are often anticipating what are called "burn windows" or "clearing events". This concept refers to periods of breezy winds that ideally are also accompanied by some form of precipitation (rain or snow). Breezy winds help disperse smoke during an active burn or serve to flush out recently trapped smoke after a burn, while precipitation would strip particulates from the air.

Clearing events in the cool season usually result from passing cold fronts (Figure 8, top panel), while monsoon thunderstorms are the likely way to reduce smoke in the summer months (Figure 8, bottom panel). Clearing events can be thought of as nature's way of pressing the reset button for our airsheds. Regardless of season, weather is a key consideration for Rx burn approval.

Figure 8: Examples of air quality “clearing events” in Arizona. Strong winds and precipitation are excellent ways of cleaning out the airshed of pollutants, including previously trapped smoke. A winter storm affecting the Grand Canyon region (top) and a monsoon thunderstorm bringing gusty outflow winds and rain near Monument Valley (bottom) are shown. Photos: *Michael Quinn* of the National Park System (top) and *Pixabay* (bottom).

Because too strong of winds can encourage dangerous fire behavior and counter the benefits of low intensity burns, the preferred timing of Rx burns is usually just ahead of a clearing event, or before the most vigorous winds associated with a weather system arrive. However, even without a clearing event taking place, or one immediately on the way, a Rx burn located in the “middle of nowhere” can be approved. If smoke generated stands little chance of ever entering populated zones, especially to a point of creating health concerns, than an approval can be given in the absence of what would be considered good atmospheric ventilation.

The latest prescribed burn approvals are posted daily through the Arizona Smoke Management Database (AZ-SMD): smoke.azdeq.gov. Here, you not only see how large an approved Rx burn is, but also the approximate location of it. Historical placement of prescribed burns (beginning in 2016) can be viewed, as

well. A graphical review of Arizona prescribed burn activity over the last five years is provided in Figures 9 and 10. Changing weather patterns are a major driver for year-to-year variability for Rx burns.

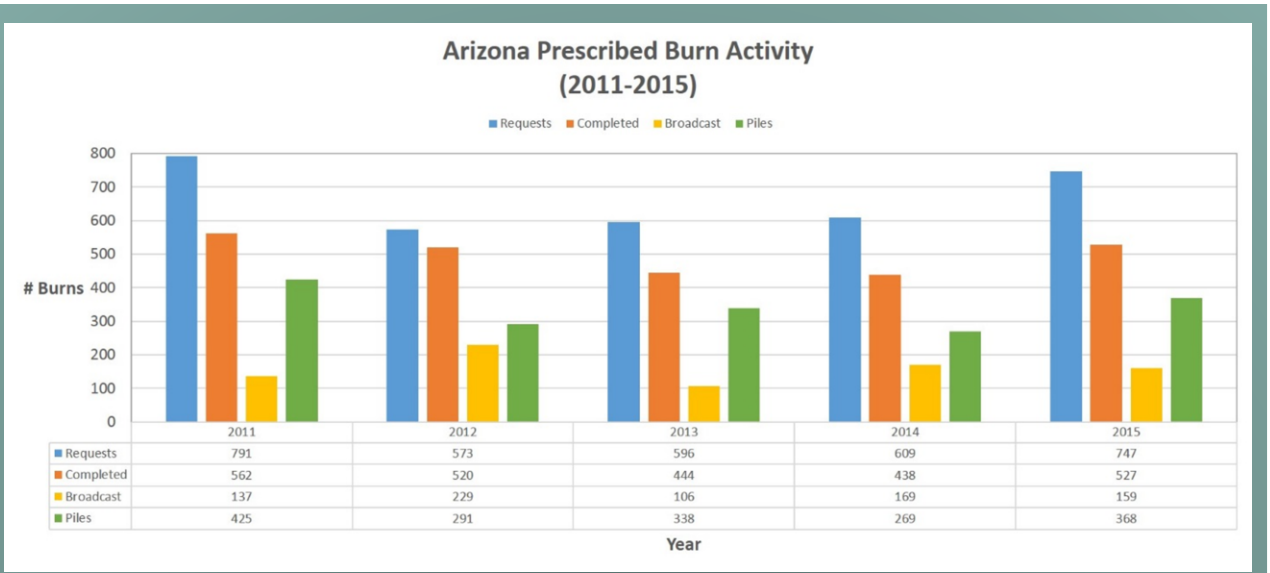

Figure 9: Arizona prescribed burn activity from 2011 to 2015. Values compared from year-to-year are 1) the amount of daily prescribed burn requests submitted to ADEQ, 2) those requests that were completed, and 3) the amount of broadcast versus pile burns. All approved prescribed burn requests are not always acted on. Reasons for not burning could range from being a logistical matter to a change in weather conditions that has or could force a burn out of its "prescription" requirements. Note: broadcast burns may involve all fuels within a land area designated as a prescribed burn project (e.g., top left panel of Figure 5), while pile burning refers to when fuels are collected together and brought to a single location (e.g., Figure 4).

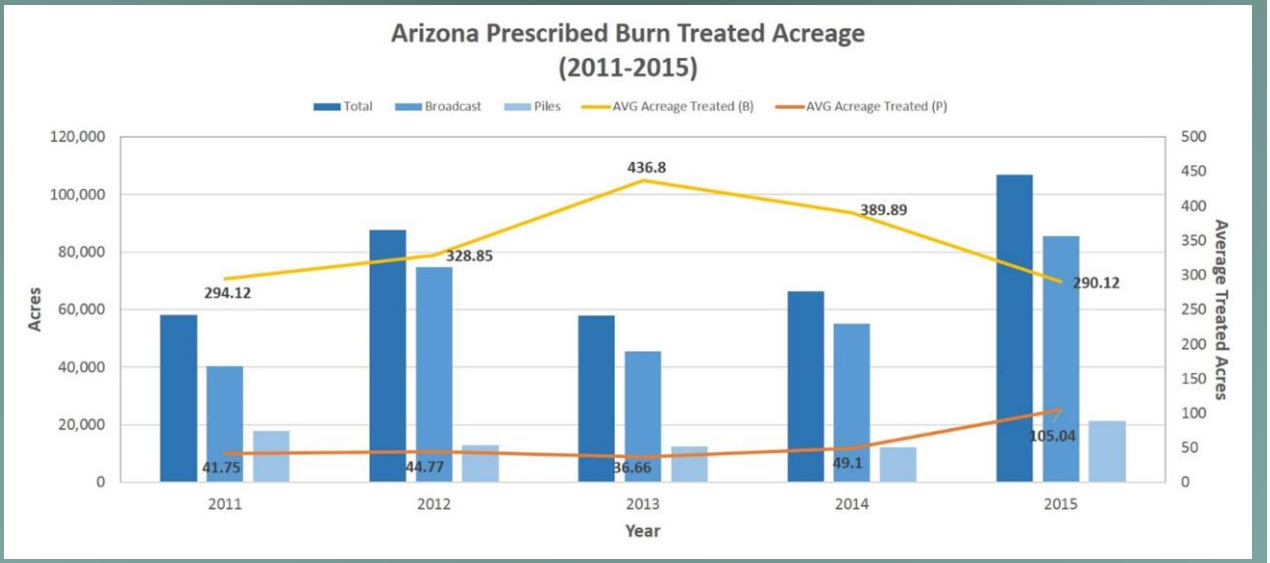

Figure 10: Arizona prescribed burn "treated acres" from 2011 to 2015 between broadcast and pile burns. The average size of completed burns are shown, as well.

Prescribed Burns and Air Quality

Each Rx burn comes with its own obstacles for granting approval. Knowing that weather forecasting is not yet an exact science makes it that much more challenging to hone in on those optimal burn windows. Evaluation is truly done on a case-by-case basis. In the event that smoke does reach a community, there are measures to take for assessing and limiting smoke exposure.

Figure 11: 5-3-1 visibility method for estimating smoke exposure. Source: New Mexico Environmental Public Health Tracking

First, you would want to determine if the amount of smoke present could cause adverse health effects. The two ways of doing this are either through direct monitoring of fine particulate matter concentrations found in smoke (i.e., $PM_{2.5}$) or by using visibility reduction guidelines (e.g., Arizona Department of Health Services or "5-3-1 Rule") (Figure 11).

Monitored $PM_{2.5}$ concentrations are available for some communities in Arizona via ADEQ's E-BAM monitoring network. Unfortunately, due to many logistical limitations, access to near real-time monitored concentrations is just not always feasible for all locations. For this reason, visibility guidelines are the preferred way to gauge local smoke rather than relying on a single instrument, which in reality, can be located miles away from the majority of people.

Arizona has such complex terrain and numerous drainages (Figure 12) where smoke can travel or be restricted within that any one monitor likely won't be representative of a large area. In fact, smoke impacts can vary drastically even within a town, such as Prescott or Flagstaff because of local terrain features. The high cost of buying and maintaining a portable particulate monitor means that it's impossible to account for every one of these drainages.

When using visibility guidelines, any restriction under five miles is when individuals who are sensitive to fine particulates may start noticing health effects. Determining visibility needs to be done with caution, though. Estimating visibility impairment is accomplished most accurately when you are facing away from the sun and the atmosphere is dry. The influence of the sun and moisture are significant.

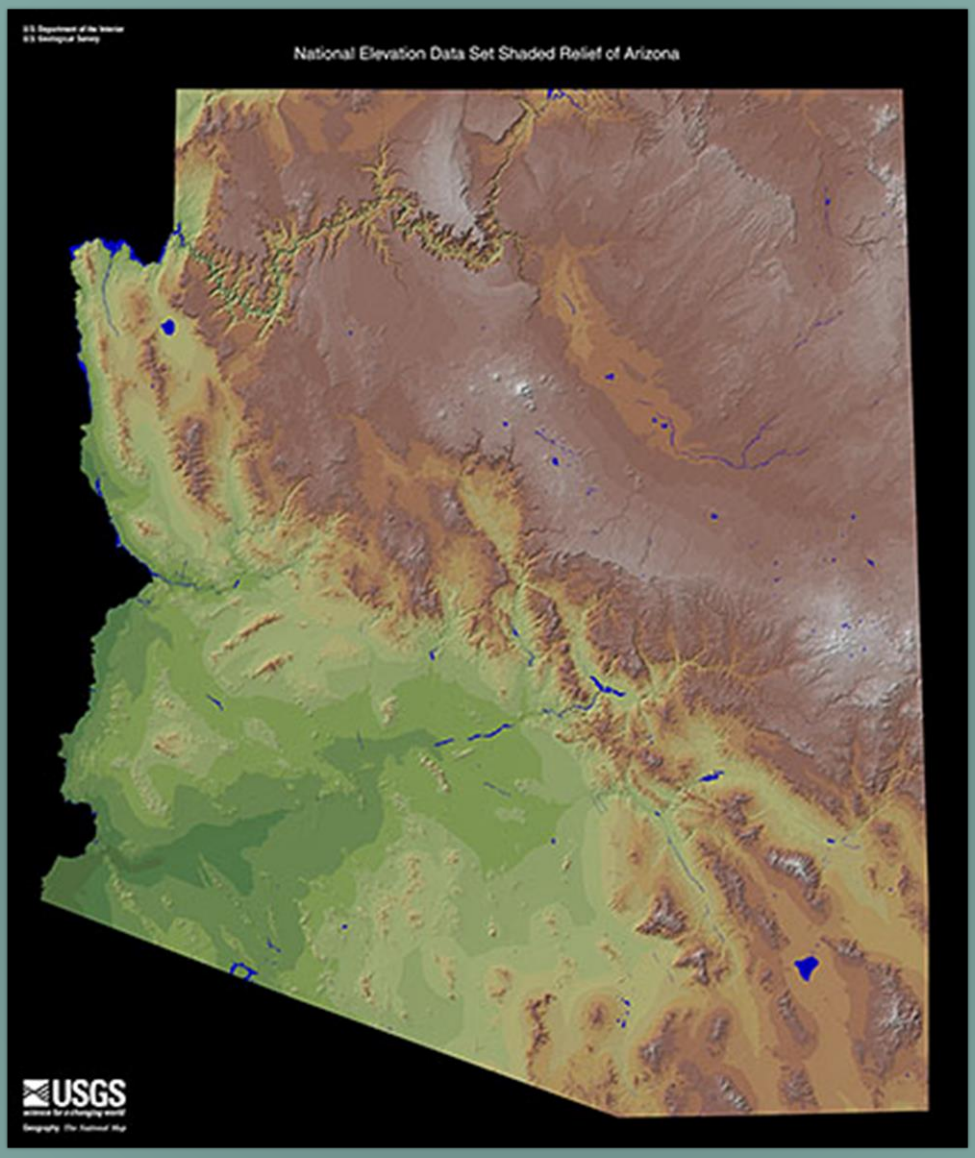

Figure 12: Shaded relief map of Arizona indicating the extreme range in elevation from near sea-level (dark green) near the southwestern corner of the state to over 7,000 feet (white) in mountainous areas of Arizona. The complex nature of terrain results in a plethora of local drainages available for smoke transport. Map created by the United States Geological .Survey (USGS).

First, let's discuss moisture. Humid air masses cause visibility to appear much worse than if it were dry. This has to do with aerosols in the atmosphere (i.e., tiny suspended particles like dust, salts, or smoke) being able to cling to water vapor molecules. In fact, during periods of high moisture, such as our monsoon season, an apparent haze can exist when no smoke is actually present. You may have noticed a similar "moisture haze" being common if you spent anytime near coastal areas.

Adding a source of light to the mix only makes apparent visibility worse. Excessive moisture alone can create severe reductions to visibility due to water's effectiveness at scattering light, whether it's from the sun or a vehicle's headlights. Dense fog would be an extreme example. For these reasons, it is important to consider moisture levels in the air and to look away from the sun when using visibility guidelines for gauging $PM_{2.5}$ (smoke) concentrations, since inaccurate interpretations of perceived smoke and associated health effects could be made.

On many occasions, the cause of an erroneous haze is not an air quality concern, but rather a benign product of optic meteorology, where more sunlight from a low sun angle is being scattered by the various aerosols in the air. The effect can limit visibility greatly, giving the impression that humid or dry air has been polluted. If you have ever driven toward the sun then you could probably attest to the diminished line of sight. Another example of "false" haze would be the sunbeams in a forest that often occur in the early morning hours or late afternoon as the sun begins to set (Figure 13).

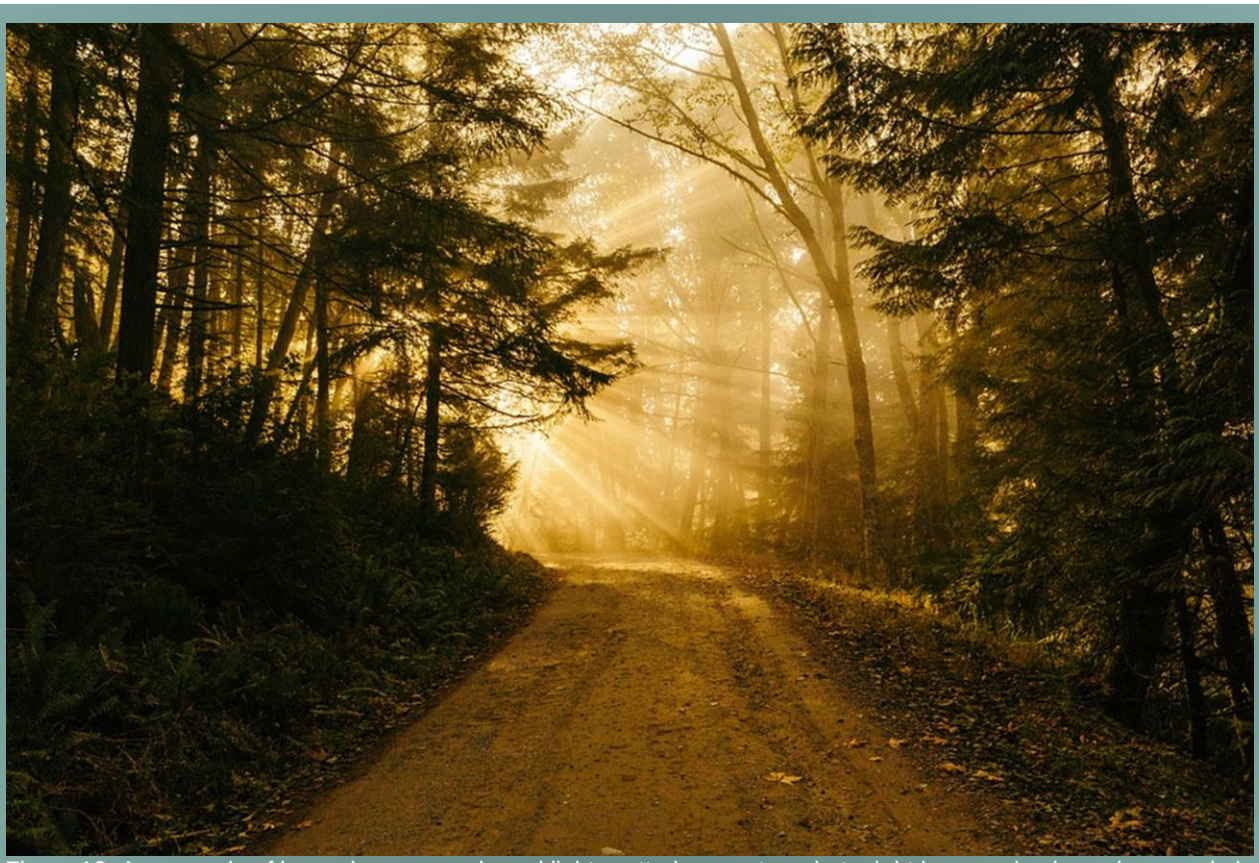

Figure 13: An example of how a low sun angle and light scattering creates what might be perceived as a haze and air quality concern. Photo: Pixabay.

So why is "haze" less noticeable during the afternoon hours? Higher sun angles, versus low sun angles, means sunlight entering the top of the atmosphere can reach the ground over a shorter distance, hence less scattering of sunlight and improved visibility. Even minor smoke concentrations on the horizon during the daytime tend to appear much worse than reality under a sunrise or sunset backdrop from enhanced light scattering.

With all of this in mind, our region is not exempt from experiencing concentrated dust or smoke creating an actual haze. Such haze would be present regardless of time of day, but may not actually reach the surface to warrant health concerns. Smoke can naturally become trapped in the different layers of air existing above the ground. Temperature changes with height cause these layers. One smoke management technique is figuring an appropriate time that would force Rx burn smoke into an above ground layer. Again, smoke would be visible, but poses a minimal health risk.

Regardless, if you think smoke is affecting your health in the short-term, then contacting your health care provider is always a prudent measure to take. How fine particulates from smoke affect health is available here for review.

As a word of caution, if you are traveling through an area with planned Rx burn projects be prepared for sudden roadway visibility restrictions caused by smoke. Even when smoke is not impacting a roadway, there still could be fire personnel and equipment around managing the scene. Using caution by heeding posted traffic signs (e.g., Figure 14) and reducing speed when appropriate are always encouraged.

Figure 14: A prescribed burn notification sign posted along a highway. Source: *United States Fish and Wildlife*.

Finally, it is worth mentioning that the bulk of our Rx burns typically overlap with the time of year when many folks in communities are using woodstoves for heating purposes. As a result of this wood smoke being commonplace for many towns during cooler months, there has been a misperception at times that prescribed burn smoke is ongoing and impacting these areas on a continual basis, even when no Rx burn projects are active. The online Arizona Smoke Management Database would indicate where and when daily Rx burns may be. For local wood smoke, the same visibility guidelines for estimating health impacts from wildland fires are applicable.

We hope you enjoyed learning a little more behind the scenes information about prescribed burns in Arizona!

Sincerely,

Jonny Malloy

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September 2015: North American Monsoon
October 2015: The Genesis of a Thunderstorm: An Arizona Perspective
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August 2016: Dust in Arizona and Around the World
September 2016: Tropical Cyclones
October 2016: Arizona Tornadoes

Here's a look at what we'll be discussing in the near future…

-$PM_{2.5}$ in Arizona and Around the World
-Stratospheric Ozone Intrusions

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