EXTENSION

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Fire effects: Big game animals of the Great Plains

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Fire is an often misunderstood and overlooked process important to the maintenance of North American ecosystems. It creates and maintains specific habitat characteristics for a broad range of wildlife species. Fire is not inherently good or bad; rather, it simply brings about short- and long-term changes, which can be both positive and negative to plant communities and wildlife populations. To better understand the positive and negative outcomes of fire, we need to explore the closely connected relationship that fire and wildlife have. Well-researched and charismatic big game animals provide an opportunity to examine how fire impacts this specific group of wildlife directly, as well as indirectly through habitat modifications.

Figure 1. Direct effects of fire are infrequent because big game animals, like the white-tailed deer, can escape the advancing flames of a fire or seek shelter within unburned areas inside the fire perimeter. Image courtesy of Liz Julian, USFWS.

Big game species rely on vegetation for food and cover. In most cases, plant structure, composition and forage quality are modified by fire (Wright, and Bailey, 1982). Because of climate and disturbance patterns occurring over time and across landscapes, plant composition and structure are subjected to constant change. With every disturbance event, there will be wildlife winners and losers. Landowners and land managers can influence the wildlife species that win or lose on their land. Fire can reclaim sites, moving it from one state back to an earlier successional state (e.g., woodland to grass or shrub rangeland). This shift can benefit some species while being detrimental to others. Fire can also maintain a site in a specific state to conserve desired habitat conditions for specific species of interest. A lack of periodic fire or a decrease in fire frequency, over many decades, could lead to habitat conditions benefitting more generalist species by allowing for a transition to occur from one state to another (e.g., rangeland to woodland). This occurs at the cost of losing habitat conditions required by the more specialized, disturbance-dependent species that previously benefited from the original state. This is common in the Great Plains where fire suppression and tree planting were the norm, following settlement and woody encroachment by native and non-native trees has converted much of our grasslands and shrublands to woodlands. Fire, a historically recurrent process, shaped plant and animal life on earth for millennia. It indirectly affects wildlife composition and abundance across the ranch, the landscape, the Great Plains and the world, as much today as it did thousands of years ago.

Fire has the potential to cause direct injury and mortality to individual animals, although this is rare even in high-intensity wildfires. More importantly, plant community changes caused by varying fire frequencies and seasons, or the complete exclusion of fire, can indirectly affect entire animal populations through habitat modifications. These indirect effects of fire on populations are far more important to consider than the direct effects on individuals. More importantly, choosing not to burn and excluding fire is a management decision in itself. When considering impacts, it is important to keep in mind that fire, like other management practices, is used to manage wildlife populations, not individuals. The effects of fire on big game animals are numerous and vary significantly for each species. The goal of this publication is to outline the direct (i.e., mortality and injury) and indirect (i.e., alteration of habitat and forage nutrients) effects that fire, both prescribed and wildfire, has on big game animals found in

the Great Plains. Research from broader regions were included for species that reside in the Great Plains as the impacts of fire on vegetation structure and subsequent wildlife use would likely also apply in the Southern Great Plains.

Direct effects

The direct effects of fire on animals are described as injury or mortality from the flaming front of a fire or from smoke inhalation (Engstrom, 2010; Harper et al., 2016; Sanderfoot et al., 2022; and Shaffer and Laudenslayer, 2006). Direct effects are rare and associated with individual animals, rather than populations. Several factors of fire, as well as landscape characteristics, can determine the ability of an animal to survive. Factors determining an individual's fate during a fire include topography and aspect of the land, fire size, season of the year, fire intensity and ignition pattern (Engstrom, 2010; Harper et al., 2016; Jolly et al., 2022; Lyon et al., 1978; Shaffer and Laudenslayer, 2006; Singer et al., 1989; Wright and Bailey, 1982). It is common that big game animals survive fires because of their ability to detect and move to avoid it. If an animal is unable to escape the immediate area of a fire, it is common for the individual to retreat to a place of refuge in an area that will not burn, ultimately surviving. Features such as drainages, riparian areas, wet bottomlands, bare or rocky areas and previously burned patches are all places animals have been observed moving to when avoiding fire (Ivey and Causey, 1984).

The wildfires within the Greater Yellowstone Area (GYA) in 1988 are an example of the direct effects of a high-intensity wildfire on big game animals. Overall, 2.4 million acres burned throughout the GYA, and approximately 45% (988,422 acres) of Yellowstone National Park (YNP) burned that summer (Christensen et al., 1988) in a complex of quick-moving, high-intensity wildfires. After the fires subsided, researchers began surveying the land and observed 261 animals killed from the fire, including 2 moose, 4 mule deer, 9 bison and 246 elk. This seemingly high number of elk, moose, bison and mule deer killed by the fire was insignificant when compared to the thousands that die there each year during a typical winter (Frank, 2000). Most observed mortality was in areas with either large fire fronts (over a mile wide) of high-intensity fire, in open grasslands where the fire moved rapidly or areas where animals could not escape because of topography and the direction the fire was moving. Smoke inhalation was confirmed as the cause of death for many individuals and only two animals, one elk and one bison, were killed as a result of burns (Singer et al., 1989). Interestingly, researchers concluded that less than 1% of the elk population summering within YNP experienced direct mortality from the fires (Singer et al., 1989). An even lower percentage of the other big game species residing within YNP (moose, bison and mule deer) were directly affected by the fires. There were no documented direct effects on pronghorn within the park. In environments that historically burned frequently, animals have adapted and developed behavioral responses, such as fleeing or seeking refuge in areas unable to burn, to avoid and survive fire (Jolly et al., 2022).

Indirect effects

Fire indirectly affects wildlife by changing food and cover availability. Both fire suppression and the use of prescribed fire change vegetation characteristics across landscapes, which affect wildlife species at population levels (Harper et al., 2016). Indirect effects of fire influence a larger proportion of wildlife populations than direct effects and should be carefully considered when making management decisions. Some indirect effects can be observed right after a fire has occurred. Other indirect effects from fire may not manifest on the land for years after or until multiple fires have occurred on the same site. Similarly, a species may not use an area immediately following fire, but the same area may serve as ideal cover or forage for the species in subsequent years. The use of fire in different seasons, frequencies, scales and intensities have ecological outcomes that can benefit or hinder various wildlife species in fire-adapted systems.

Figure 2. Prescribed fire coupled with timber thinning to allow sunlight to intercept the forest floor can produce exceptional forage and bedding cover for species like white-tailed deer. Image courtesy of Adam Ray.

Fire changes where big game species forage

The interaction of fire and grazing, known as pyric herbivory, is the attraction of foraging animals to plant regrowth following a fire. This interaction has been documented in Africa, Asia, Australia, Europe and North America (Allred et al., 2011). For some wildlife species, the attraction to vegetation regrowth following fire is very strong. Bison, for example, dramatically change where they forage based on how recently it was burned (Allred et al., 2011). This is also the case with pronghorn, which have been observed at 26-times greater densities on burned versus unburned winter rangeland in the shortgrass prairie of Colorado (Augustine and Derner, 2015). Pronghorn also responded similarly in the mixed-grass prairie of Alberta, Canada, where burned areas were used more than unburned during the fall, winter and spring. Research suggests that access to higher quality vegetation during this time could improve pronghorn body condition and survival with green, actively growing plants on burned areas later into the fall and green-up beginning earlier in the spring than on unburned locations

(Courtney, 1989). Elk also displayed similar behavior by increasing their use of burned areas for multiple years following fire. In one Montana study, their use of the burned area increased from 115 elk use days immediately after the burn to 281 days two years later. Plant species diversity, forage biomass and protein were all increased by the burn (Can Dyke and Darragh, 2007). Elk preference for the unburned area decreased for three years following the burn, which can have positive implications for areas where elk overgraze, like along streams. Historically, fire played an important role in moving animal use across the land and limiting their overuse of preferred areas.

In the Great Plains, productivity, nutritional quality and palatability of forage plants used by big game species are dramatically improved through burning. Removing old, unpalatable vegetation and allowing sunlight to intercept the soil stimulates and increases productivity of the native plant community (Cherry et al., 2017). Improvements to forage quality and increases in forage quantity provided by fire have been shown to benefit all big game species found in the Great Plains. Researchers in New Mexico found female mule deer selected prescribed burned areas during fall, spring and summer and wildfire burned areas in spring. Prescribed burned areas were preferred while newly (<5 yrs. old) thinned forests were avoided. Preference was greater for recent prescribed burns where the nutritional content of the vegetation was higher (Roerick et al., 2019). Recently burned vegetation provides high quality foraging resources, which can have positive effects on over-winter survival, reproductive success, body condition and antler growth (Fulbright and Ortega-Santos, 2013; Hensley, 2010; Hobbs and Spowart, 1984; Koncerak, 1996; Shaffer and Laudenslayer, 2006; and Zimmerman et al., 2006). These nutritional differences are greatest in late fall, winter and early spring when unburned vegetation is often below many animals' nutritional requirements in the Great Plains.

Figure 3. Fire occuring in the fall can benefit big game animals and provide good control of plains prickly pear cactus. Fire singes off the spines and allows big game animals like pronghorn to eat the pads, which are a high-quality forage plant, over the winter months. Researchers have found that with fall burning and browsing by pronghorn, prickly pear cactus density can be reduced as much as 47% in some cases (Augustine and Derner, 2015). Image courtesy of Shawn Billerman, used under CC-BY 4.0.

Fire not only changes where animals forage but what they are consuming

A study in the tallgrass prairie of Minnesota examined white-tailed deer use of native prairie legumes. Researchers found that burning increased preference for white and purple prairie clover (*Dalea candida* and *D. purpurea*, respectively) along with roundhead lespedeza (*Lespedeza capitata*). While showy tick-trefoil (*Desmodium canadense*) was strongly preferred in unburned areas, its relative preference decreased in burned areas as deer increased the use of clovers and lespedeza due to improved quality following fire (Nisi et al., 2015). Burning of native plants has been shown to reduce secondary compounds and other low-quality characteristics like tannins, monoterpenes and hemicellulose which can limit foraging by wildlife. The improvements in plant quality allow wildlife to select from a broader number of plant species than when only provided with unburned vegetation. This has long-term implications for animal performance and survival.

Other indirect effects of fire include prey animals' ability to detect predators

A study of white-tailed deer in Florida showed females that used burned areas were not killed by cougars, while several females that preferred unburned areas were killed. The researchers believed that the female's increased movement rates in burned areas and open sightlines created by the burn may have helped reduce predation risk by the ambush predator (Cherry et al., 2018). Another Florida study had similar results, showing that females that selected flooded areas, forest edges, trails and edge habitats were less likely to survive the fawning season than females selecting recently burned areas where stalking cover was reduced (Abernathy et al., 2022).

Fire modifies plant community species and structure while limiting parasites

Woody plant encroachment is a process that occurs when fire is removed from the landscape. In the last century of wildland fire suppression, woody plant encroachment has become a widespread problem across the Great Plains and is responsible for loss of desirable habitat conditions for big game as well as many other wildlife species. For example, pinyon-juniper woodlands are encroaching into grasslands in New Mexico because of fire suppression. One study there found mule deer body condition was negatively related to the amount of pinyon-juniper in deer home ranges, as the trees limit understory forage grasses and broadleaves from growing (Bender et al., 2007). Fire suppression and the subsequent woody plant encroachment that follows are two factors contributing to the decline in bighorn sheep through the loss of habitat, along with the proliferation of lungworm parasites

in isolated herds (Donovan et al., 2021; Scasta, 2015; Wagner and Peek, 2006; Wakelyn, 1987). Canadian researchers found that bighorn sheep with access to burned areas had 10 times lower lungworm loads than those with no access to burned areas. In South Dakota, white-tailed deer fawn survival was negatively influenced by density of forest cover (Grovenburg et al., 2012). Absence of periodic fires and the associated effects of woody plant encroachment have led to lower survival rates, increased predation, loss of habitat and expansion of parasites and disease among many populations of big game species. Researchers have found that fire is an effective method of control for ticks, fleas, flies, lice, mites and internal parasites like lungworms and meningeal worms. Fire suppression has negatively influenced the long-term trajectory of most big game populations.

Summary

Fire is a natural process that profoundly influences the plant and wildlife species that inhabit the Great Plains. While fire can directly affect wildlife through injury or mortality, evidence indicates that the direct effects of fire are very rare occurrences, often exaggerated and overemphasized. In contrast, indirect effects of fire impact a greater number of animals within a population and even communities of multiple species. Indirect effects can be both positive and negative, carrying with them widespread and long-term outcomes. Many times the difference between positive and negative impacts on species can be measured by short intervals of time since fire. Policies and decisions tied to fire management should not be made based upon the potential negative effects on individuals without also accepting the potential indirect effects on entire wildlife populations. The advantages of meeting wildlife habitat objectives for big game species by applying fire to the landscape far outweigh the potential negative impacts to a very small number of individuals.

Figure 4. Bighorn sheep require high-visibility where they can spot predators from a distance. Bighorn sheep select for high severity burned forests, grasslands and pine savannahs maintained by periodic fire (DeCesare and Pletscher, 2006; Donovan, et al., 2021). Bighorn sheep avoid dense forests that are visually obscuring and a higher risk of predation is present. Image courtesy of Amiel Hopkins, used under CC-BY-NC 4.0.

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