MODULE 2: AN INTRODUCTION TO WILDFIRE

Outline

A. Introduction to Wildfire
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MODULE 2 GOALS

The goal of module 2 is to define fire regimes and describe both the general and specific elements of wildfires. The topics covered in this module include the wildfire triangle, the physical characteristics of fire, fire regimes, and the various types of fire that impact the landscape in different ways. This module also includes data from national and regional fires that provide information about the historic impacts of wildfire and the associated risks and implications for future fire management.

The objectives for this model are to:

- Increase participants' specific knowledge about the wildfire triangle
- Increase participants' knowledge of the terminology used to describe parts of a fire
- Increase participants' knowledge and understanding of fire regimes
- Increase participants' ability to understand the differences in fire behaviors - forested settings versus the shrub steppe
- Increase participants' understanding of the socioeconomic, psychological, cultural, and ecological impact of wildfire
- Increase participants' awareness of various risks associated with wildfire

THE WILDFIRE TRIANGLE

Figure 1: Wildfire Triangle
PC: Science ABC

There are three key components of a fire—fuel, oxygen, and heat. The elements are interdependent and all three must be present or fire cannot occur. When any one of the elements is missing (insufficient heat, fuel is exhausted, removed, or isolated, or the oxygen supply is limited) the triangle is broken, and the fire will extinguish.

Heat is required to ignite, maintain, and spread the fire. It can be naturally occurring (e.g., lightning), human-caused (e.g., failure to extinguish a campfire), or both (e.g., a glass bottle on the side of the road heated by the sun). When heat removes the moisture from surrounding fuel, warms the air, and preheats fuel in its path, the fire can spread with ease. Removing heat by applying a heat reducing substance such as water, water enhancer, or chemical retardant means the triangle is broken and the fire can be extinguished.

Fuel can be defined as any combustible material. In the natural landscape, fuel refers to any raw biological materials composed of organic matter, namely plants (woody and herbaceous) but not excluding animals, fungi, or animal waste. The effectiveness of a fuel is determined by its moisture content, size, shape, quantity, and the way it occurs across the landscape. Fuel can be removed naturally through consumption or manually by removing fuel from the area through mechanical or chemical means. Pre-emptive removal of fuel sources is a fundamental fire mitigation activity.

Oxygen is the third element needed in the chemical reaction that feeds a fire. A fire requires at least 16% oxygen content in the air to burn (www.smokeybear.com retrieved May 1, 2021). A fire can be extinguished by eliminating its oxygen supply.

Because there must be a chemical reaction between the three components mentioned above, experts have modified the triangle to include a fourth “chain reaction” element. It is the chemical reaction between the three classic components that allows the fire to sustain. As soon as one of the elements is eliminated, the fire is extinguished. To illustrate this, the following example is provided

A group of campers builds a campfire in the outdoors (oxygen) with the wood and bark of a downed tree (fuel). They are sitting around the firepit. One group member has a book of matches (heat) in hand, but this does not mean a fire is automatically created. The match must be struck (an action) to provide the spark that ignites the fuel in the campfire. If the campers do not have a match, do not strike the match, or do not touch the match to the fuel source, the chain reaction fails and there will be no fire at this campsite.

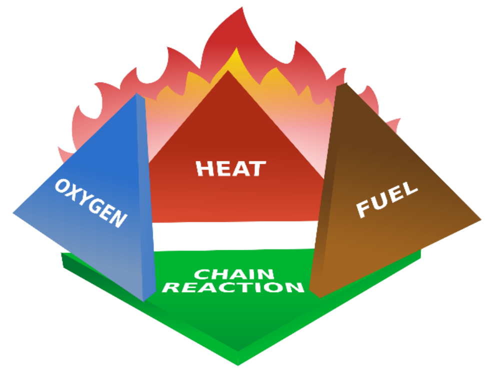

Figure 2: Fire Chain Reaction
Fire Risk Assessment Network

ANATOMY OF A FIRE

The terminology used to describe the parts of a fire is generally agreed upon with a few minor exceptions. All fires have a starting point, commonly known as the **point of origin or the ignition point.** This is the place within the fire perimeter where ignition first occurred, and combustion was sustained. The **fire perimeter** is defined as the outside edge of the fire or burned area. The perimeter includes the head of the fire, the tail or heel of the fire, fingers, shoulders, islands, and spots. The following paragraphs will discuss each of these separately.

Head—The head of a fire is the front of the fire. It usually has the greatest flame length, flame depth, and spread rate. When a fire is spreading with the wind or moving upslope, it is referred to as a heading fire.

Base—The part of the fire opposite the head is called the tail, heel, or base. It is the slowest moving part of the fire with the shortest flame lengths. When a fire is spreading against the wind or downslope it is referred to as a backing fire.

Flank—The right and left sides of the fire are described as its flanks. Flanks are perpendicular to the head of the fire. Since they are less aligned with the wind, the intensity and rate of spread is not as great as the head.

Shoulder—The shoulder of a fire is the place where the flanks meet the head.

Fingers—Fingers project from the main body of the fire much as fingers project from the palm of a human hand. Fingers may have been the head of the fire that spread in a different direction due to a shift in wind direction.

Pockets—Pockets, sometimes called bays, describe the unburned areas of vegetation along the fire edge formed by fingers and slow burning areas.

Islands—Islands are unburned areas within the fire perimeter that were not combusted.

Spots—Spot fires are fires ignited outside the perimeter of the main fire. They may be caused by windblown embers and can potentially occur several miles in front of the fire head.

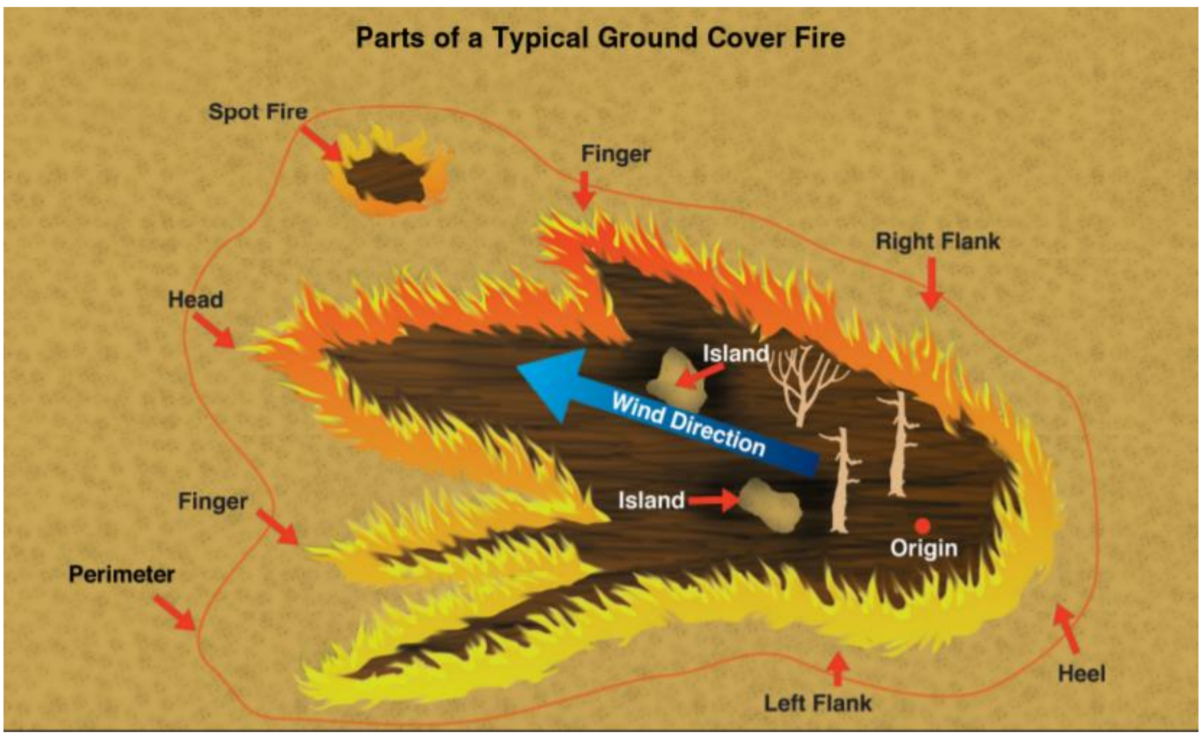

Figure 3: Typical Ground Cover Fire. PC: International Fire Service Training Association

FIRE REGIMES

A fire regime describes the patterns of fire in a specific area of an ecosystem. Fire regime descriptions take into consideration occurrences, frequency, size, severity, vegetation, and effects of a fire. Fire regimes can change based on variations in topography, climate, and fuel. Because fire elements are often repeated and those repetitions can be counted and measured, fire regimes are sometimes referred to as cycles. (National Wildfire Coordinating Group, retrieved April 10, 2021). Understanding the cyclical and historical nature of fire regimes helps to predict future fire regime changes and the interactions more accurately between fire and regional climates at different scales. Knowledge of a fire regime can allow for an integrated approach to identifying the impact of fire at the most basic level and help improve the systems that deal with potential fire-related issues.

There is no standard classification for fire regimes, however, there are characteristics that are commonly used to describe them. Although they may vary due to regional differences, fire regimes are generally assessed according to their severity and frequency. These terms are often expressed as fire intervals or fire rotations. Fire severity is determined by the impact of the fire on an ecosystem — the intensity of the fire, the measure of vegetation destroyed, the depth of the burn, and other factors which may be site-specific such as climate, topography, slope, and ignition (human or natural). Some regime classifications include fire type (to be discussed later in this module), fire size, seasonality, and the degree of variability. Fire rotation is a measure of the amount of fire in a landscape over time. Fire rotation statistics are best used in large areas that have mapped historic fire events. Other factors that characterize fire rotations are post-disturbance successional stages and previous management practices. Fire interval refers to the number of years between fires. If fires are too frequent plant communities may be destroyed before they have sufficient time to recover. If fire is too infrequent, fuel loads will increase. This excess of fuel may lead to large intensity fires that burn too hot and too fast, making recovery difficult for plants and animals of the shrub steppe. It's important to remember that fire can be beneficial. Many ecosystems have evolved with fire, meaning that numerous species depend on occasional fires for survival. Historically, fire would have burned often, but burned slower and less intensely across a landscape, burning in a more patchwork pattern where species could recover easier.

An example of a shrub steppe plant that responds well to fire is Bluebunch wheatgrass (Pseudoroegneria spicata). This perennial grass has developed a deep root system and below-ground buds that are protected from fire by its dense above-ground leaf base (Wenatchee Naturalist, 2016). After a fire, the buds re-sprout utilizing nutrients from their burned above-ground leaves, made readily available by the fire. This contributes to hastening the re-growth of the plant, that then provides a food source for animal species such as mule deer.

Figure 4: Bluebunch wheatgrass in shrub steppe community. PC: PRBO Conservation Science Shrubsteppe Monitoring Program.

Bluebunch wheatgrass is a palatable and protein-rich food source that mule deer rely on in the shrub steppe. Furthermore, bunchgrasses like the Bluebunch wheatgrass provide excellent cover in the shrub steppe for ground nesting birds such as the Vesper Sparrow.

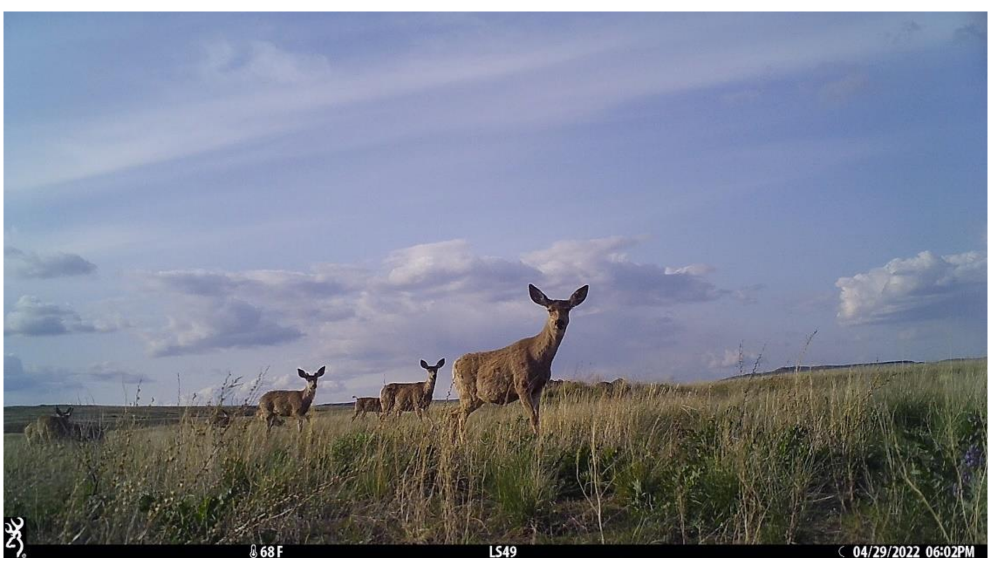

Figure 5: Mule deer in Douglas County, WA. PC: Nate Schmidt

Figure 6: Vesper Sparrow female nursing two chicks in a ground nest. PC: American Bird Conservancy

Vesper Sparrows build nests under the larger overhanging edges of this grass, and they depend on the safety and cover it provides as a place to rear their young (Jones, 2002).

While perhaps not directly dependent on fire, these examples show that the regenerative ecosystem services provided by fire do benefit many species by recycling nutrients back into the soil so that native plants can grow and continue to be a reliable source of food and habitat for species in the shrub steppe.

In recent years, altered fire regimes have begun to make significant impacts on plants and animals all over the world. Climate change is one of the factors affecting fire regimes globally. Kareiva & Marvier (2015) state “scientists broadly agree that human caused emissions of greenhouse gases — gases that stay within the lower atmosphere — are responsible for recent warming trends in global climate.” Warmer, drier climates are predicted to contribute to increased numbers of fire events that are likely to decrease plant recruitment, growth, and survival. As regimes change, so does the structure and composition of the ecosystem, impacting its ability to capture and store carbon from the atmosphere. Woody plants are expected to experience significant impact, potentially leading to greater risk of extinction.

Warmer climates, increased fire activity, and a longer fire season are already having effects on the shrub steppe in the US. The number of extreme fire hazard days has increased throughout the arid west and is expected to increase even more as temperatures continue to rise, relative humidity decreases, wind speeds accelerate, and fuel loads increase. Fires are predicted to be more intense and more severe in the future. Greater fire severity accompanied by shortened fire intervals means plant species have less time to recover. This also creates conditions that favor recruitment of more flammable invasive species like cheatgrass that degrade the landscape, depleting its biodiversity, recoverability, and resilience to fire. It also raises concern for invaluable shrub steppe species, like big sagebrush, that reproduce by seed and need many years to re-establish following a fire. If plants aren't mature enough to produce seeds before the next fire hits, they are at elevated risk of significant, irrecoverable population loss due to the depletion of the seed bank.

ANALYSIS OF FIRE BEHAVIOR AND ITS ROLE IN ECOSYSTEMS

First and foremost, wildfires are **uncontrolled** and occur in rural or wilderness areas where abundant vegetation grows. Wildfires, like other types of fires, are defined by physical characteristics such as rate of spread, combustible material present, and the effects of wind and weather. Depending on the type of vegetation being burned, a wildfire may be called by other names such as brush fire, bushfire, forest fire, desert fire, grass fire, hill fire, peat fire, vegetation fire, or a veldfire (Natural History Museum of Utah, retrieved May 22, 2021). Wildfires differ from other fires (e.g., campfires and structure fires) in several ways. They are larger, they spread more quickly from the ignition site, they are unpredictable and can change direction unexpectedly, and they can breach gaps such as fire breaks, roads, and rivers.

According to the article ***All About Wildfires: The Science Behind Wildfires*** (Natural History Museum of Utah, retrieved on May 22, 2021), wildfires occur on every continent except Antarctica. Thousands of wildfires can occur in any given year, burning millions of acres of land depending on conditions. Wildfires result from both natural events and human behaviors. Natural causes of wildfires include lightning, volcanic eruption, sparks from rockfalls, and spontaneous combustion. Human activity that causes wildfires includes sparks from machinery or equipment, railroads and power lines, parking vehicles on dry grass, cast-away cigarette butts, failure to properly extinguish campfires, debris burning, and arson.

Fire plays a critical role in recycling and redistributing nutrients that aid in maintaining biodiversity of forests and grasslands. In both ecosystems fire removes underbrush, duff and debris from the ground, exposing the ground to essential sunlight and creating nutrients to nourish re-emerging plants. Fire also reduces the number of plants competing for nutrients. In forests, this provides more space for established trees to grow stronger and healthier so they can provide critical services such as filtering carbon dioxide (CO_2) from the air, sequestering large amounts of carbon from the atmosphere, and producing their critical by-product, oxygen.

Forest vs Shrub steppe

Wildfires in forests and the shrub steppe differ in several significant ways. Forest fuel loads and moisture content are high, while shrub steppe fuels and moisture tend to be less. Wildfires in grasslands or shrub steppe tend to be high intensity and spread faster because they are drier and have fewer total combustibles to burn through. The residence time of a fire in a shrub steppe area of more grassland character is much shorter, often less than 15 seconds (Neary, 2020). Forest fires burn more vertically, given that several species of tree commonly found in the west can reach 100+ feet tall, while grass and shrub fires won't get nearly as tall. Given the vertical differences in structure, larger amounts of biomass per unit area can be burned in a forested ecosystem. Additionally, fires can spread strictly through the canopies of trees in a forest whereas grassland and shrub steppe fires stay at ground-level. Older, larger trees in a forest can withstand some fire as several species develop a thick, protective bark layer and have deep, well-established root systems that allow them to survive. In a grassland or shrub steppe environment, there's typically nothing that remains intact above the surface after a fire rolls through. Neary (2020) states: "In grassland ecosystems, high-severity fires have been shown to increase the amount of nutrients mobilized and alter the hydrologic response of catchments. The combination of these factors makes sites more susceptible to erosion of soil and the release of nutrients into stream(s) and lakes where they could potentially affect water quality". This fact adds to the growing concern about the ecological impacts of wildfire in shrub steppe environments.

In figures 7-9 below are pictures of the different fuel loads of forests and shrub steppe grasslands in addition to their structural differences. One can notice the many visual differences in how fire would behave in these given ecosystems.

Example of Forest Fuel Load

Figure 7: Dense conifer forest in North Central Washington. PC: WDNR/John Marshall

Example of Grassland Fuel Load

Figure 8: Mixed grassland in Douglas County with wheat crop on the left side and native bunchgrass on the right. PC: Nate Schmidt (FCCD)

Example of Shrub Steppe Fuel Load

Figure 9: Stand of sagebrush and intermittent grasses in shrub steppe of Douglas County, WA. PC: Nate Schmidt (FCCD)

Figures 10 and 11 below are example of actively burning wildfires in forest and in the shrub steppe. Notice the vertical and horizontal characteristics of the flames. Forest fires generally have more vertical reach as compared to the low, side-to-side reach of flames in the shrub steppe ecosystem.


Figure 10: Washington Forest fire (left) and Figure 11: A grassland fire in the shrub steppe (right) in Tri-cities, WA. PC: Washington Forest Protection Association and USFWS Sheri Whitfield.

Post-Fire

The devastation after a wildfire is always very dramatic and jarring to see the visual difference. Many forest fires leave charred snags and other large woody debris that had a thick enough layer of fire-resistant bark to not completely succumb to the flames. On the other hand, shrub steppe fires often leave next to nothing in their wake. All the smaller vegetation typically gets burnt to a crisp depending on how fast the fire is moving. Refer to the pictures below to see the visual differences of post fire in the two ecosystems.

Forest:

Figure 12. The Norse Peak fire near Crystal Mountain. PC: Steve Ringman/The Seattle Times

Figure 12 shows the edge of a burn area from the Norse Peak Fire in the Cascades of Washington state. Looking carefully, you can see where the fire stopped burning by looking at the visual change in the forest canopy, transitioning from green, to orange, to ash. Most of the trees in this forest stand were killed. Although many trees in a forest fire are killed, plenty of fire-resistant woody debris is likely to remain on the landscape even if it is highly damaged.

Shrub Steppe:

Figures 13 (left) and 14 (right) show the before and after pictures taken from very similar locations in Moses Coulee, WA before and after a wildfire. PC: The Nature Conservancy

In Figures 13 and 14 are before and after photos taken in Moses Coulee, Washington. This fire completely erased a large tract of healthy sagebrush habitat. Below is an after shot of a smaller fire within a couple miles of Figures 13 and 14 taken just days after a fire burned through similar sagebrush habitat. Fires in the shrub steppe often leave in their wake a moonscape with hardly any noticeable organic material left intact. Figure 15 below clearly depicts just how little is left in the wake of a recently burned chunk of land in the shrub steppe.

Figure 15. A couple days after a fire in Moses Coulee, WA. PC: Nate Schmidt (FCCD)

Table 2 below presents additional characteristics that distinguish grasslands, shrub steppe, woodlands, and forests. One can notice the similarities that exist between grasslands and shrub steppe as well as the similarities between woodland and forest ecosystems.

TABLE 2: POST-FIRE CHARACTERISTICS OF FOUR ECOSYSTEMS				
	GRASSLAND	**SHRUB STEPPE**	**WOODLAND**	**FOREST**
Dry Ravel*	Moderate	Moderately High	High	Very High
Hillside Debris Flow	Very Low	Low	High	Very High
Ash Deposit	Low	Moderate	High	Very High
Water Repellency	Low	Moderate	Moderately High	Very High

Water Erosion	Low	Moderately Low	Moderately High	Very High
Water Run-Off	Low	Moderately Low	Moderately High	Very High
Wind Erosion	Moderately Low	Moderately High	High	Very High

* Dry ravel is a general term used to describe the rolling, bouncing, and sliding of. Individual particles down a slope and is a dominant hillslope sediment transport process in. steep arid and semiarid landscapes.
**Adapted from Stavi, I. (2019) *Wildfires in Grasslands and Shrublands: A Review of Impacts on Vegetation, Soil, Hydrology, and Geomorphology*

WILDFIRES IN THE UNITED STATES, WASHINGTON, AND SHRUB STEPPE

Wildfires occur in virtually every state in the United States; however, some states are plagued by more wildfires that burn more acres, are of greater intensity, and cost more in lives and personal property than others. The National Interagency Fire Center (NIFC) tracks fires by state on an annual basis. Below are some wildfire statistics in the United States. Table 1 gives some averages in the statistics around wildfire frequency and acres burned dating back to 1983, when wildfire data officially began being tracked using current reporting processes. A glaring figure in this data is the considerable jump in the average number of acres burned from the first timespan (1983-2001) compared to the more recent time span (2002-2021). The number of average acres burned more than doubles, while the average number of fires decreases.

TABLE 1: WILDFIRE STATISTICS AVERAGES FOR THE UNITED STATES 1983-2021

YEAR RANGE	AVERAGE # OF FIRES	AVERAGE ACRES BURNED
2002 - 2021	68,378	7,236,989
1983 - 2001	71,706	3,240,593

Table 2 gives some more current data on wildfires in the past 7 years. This includes the 3 worst years on record as far as acres burned (2015, 2017, 2020).

TABLE 2: WILDFIRE STATISTICS FOR THE UNITED STATES 2015-2021		
YEAR	**# OF WILDFIRES**	**TOTAL ACRES BURNED IN MILLIONS**
2021*	58,733	7.8
2020	58,950	10.1
2019	50,477	4.7
2018	58,083	8.8
2017	71,499	10.0
2016	65,575	5.5
2015	68,151	10.1

*From January 1, 2021 to December 31, 2021 Source: Insurance Information Institute and NIFC (retrieved Jan. 4,2022)

Table 3, from the NIFC, demonstrates just how expansive wildfires in the U.S. were in 2020—they burned in every state.

TABLE 3: 2020 WILDFIRE STATISTICS FOR THE UNITED STATES BY STATE					
STATE	**# OF FIRES**	**ACRES BURNED**	**STATE**	**# OF FIRES**	**ACRES BURNED**
Alabama	836	20,557	Montana	2,433	369,633
Alaska	349	181,169	Nebraska	41	7,611
Arizona	2,524	978,568	Nevada	770	259,275
Arkansas	655	12,552	New Hampshire	252	88
California	10,431	4,092,151	New Jersey	1,981	11,919
Colorado	1,080	625,357	New Mexico	1,018	109,513
Connecticut	586	383	New York	192	1,123

Delaware	426	1,356	North Carolina	2,364	12,875
Florida	2,381	99,413	North Dakota	651	3,782
Georgia	1,699	5,677	Ohio	649	1,551
Hawaii	58	472	Oklahoma	1,241	102,302
Idaho	944	314,352	Oregon	2,215	1,141,613
Illinois	19	240	Pennsylvania	1,488	2,997
Indiana	11	313	Rhode Island	113	85
Iowa	126	2,168	South Carolina	465	1,754
Kansas	52	34,581	South Dakota	852	19,636
Kentucky	524	7,950	Tennessee	391	4,207
Louisiana	401	5,880	Texas	6,713	256,826
Maine	1,156	1,032	Utah	1,493	329,735
Maryland	2	930	Vermont	96	126
Massachusetts	1,189	834	Virginia	410	5,596
Michigan	409	1,131	Washington	1,646	842,370
Minnesota	1,372	8,838	West Virginia	1,230	8,196
Mississippi	729	22,035	Wisconsin	781	1,785
Missouri	1,090	17,940	Wyoming	828	339,783

In 2020. the highest number of wildfires (10,431) and burned acres (nearly 4.1 million) occurred in California. In key shrub-steppe states (Washington, Oregon, California, Idaho, Nevada, Montana, Wyoming, Colorado, and Utah), there were a total of 21,840 wildfires—23,343 if North and South Dakota are included, which is 39.3% of all fires recorded in 2020. The total acreage burned was just over 10.2 million; of that total just over 8.3 million acres were in the nine western states. That means, in 2020, 81% of all wildfires occurred in states that comprise shrub steppe habitat. The Audubon Society (2021) estimated that more than 3.65 million acres of Greater Sage-grouse habitat (mainly shrub steppe) burned in the three-year timespan from 2018 to 2020. In Washington alone, rangeland fires burned nearly 800,000 acres of sagebrush habitat, including critical breeding grounds for sage grouse, other shrub-steppe birds and the state and federally listed endangered pygmy rabbit.

In the United States it is estimated that human-caused fires occur six times more often than those by a natural ignition source. Between 2016 to 2020, it was estimated that 88% of all wildfires were human-caused (Audubon, 2021). The number of acres burned due to natural ignition in any given year, however, can be far greater than those that result from human causes. As high winds, temperatures, and drought conditions increase due to climate change, so will the likelihood of more frequent natural fires. Anthropogenic influences may promote increased natural fire ignition as well, as human populations spread and impact the landscape. Whether it's rising temperatures from greenhouse gas emissions creating drought conditions or new housing developments adding more fuel to a growing wildfire, human impacts - direct or indirect – contribute considerably to dangers associated with wildfire.

Wildfires can burn vast land areas and cause extensive damage to the landscape by destroying large tracts of wildlife habitat and depleting and/or displacing many plant and animal populations. In addition, wildfires can destroy the built environment, easily burning homes and other structures, damaging critical infrastructure such as power lines and, in severe cases, taking human lives as well. Below in Table 4 is a history of human-caused fires since 2001. The table shows the number of fires and acres burned each year that resulted from human-caused ignition.

TABLE 4. HUMAN-CAUSED FIRES		
YEAR	**# OF FIRES**	**ACRES BURNED**
2020	53,563	5,998,813
2019	44,115	1,217,324
2018	51,576	5,640,489
2017	63,546	4,830,476
2016	60,932	3,766,610
2015	58,916	2,012,461
2014	55,679	1,582,770
2013	38,349	1,261,980
2012	58,331	2,500,249
2011	63,877	5,356,771
2010	64,807	1,303,449
2009	69,650	2,072,746
2008	70,093	3,429,991
2007	73,446	3,449,360
2006	80,220	4,404,844
2005	58,430	1,521,327
2004	54,101	964,800
2003	50,815	1,922,249
2002	62,022	3,077,119
2001	70,066	1,748,661

Table 5 shows the top ten states ranked according to the number of reported wildfires. California, as expected, ranks first. Montana, Oregon, and Washington are also among the top ten. Table 6 ranks states according to the total number of acres burned in 2020. Every state in these top ten is a shrub steppe state, revealing a strong correlation between fire and the shrub steppe environment.

TABLE 5: TOP 10 STATES RANKED BY # OF FIRES				TABLE 6: TOP 10 STATES RANKED BY ACRES BURNED		
RANK	STATE	# OF FIRES		RANK	STATE	ACRES BURNED
1	California	10,431		1	California	4,092,151
2	Texas	6,713		2	Oregon	1,141,613
3	Arizona	2,524		3	Arizona	978,568
4	Montana	2,433		4	Washington	842,370
5	Florida	2,381		5	Colorado	625,357
6	North Carolina	2,364		6	Montana	369,633
7	Oregon	2,215		7	Wyoming	339,783
8	New Jersey	1,981		8	Utah	329,735
9	Georgia	1,699		9	Idaho	314,352
10	Washington	1,646		10	Nevada	259,275

Washington

The fire season in Washington State typically lasts from April through the end of October. In 2020, the Department of Natural Resources responded to 1,851 fires (CrossCut.com retrieved July 4, 2021). Of the fires reported, 59% of them occurred east of the Cascade Mountains (primarily in the sagebrush steppe) and burned nearly 500,000 acres. In recorded fire history, only 2014 reported a greater number of acres burned. According to records of the Department of Natural Resources (DNR), most fires (61%) in Washington started on private land followed by public lands managed by the DNR and U.S. Forest Service managed lands.

Not all areas east of the Cascades are affected in the same way by wildfire. In fact, 40% of fires that occurred in eastern Washington (where shrub steppe habitat exists) over the last 12-year period, occurred in just three counties: Spokane, Stevens, and Okanogan. In 2014, the largest fire to ever occur in Washington happened in Okanogan County. The Carlton Complex fire burned 256,108 acres, 353 homes, and the total estimated damages came to $98 million. This fire started from four separate lightning strikes, originally the Stokes fire, the French Creek fire, the Gold Hikes fire, and the Cougar Flat fires respectively. These smaller fires merged and spread rapidly, due to a combination of high air temperatures, wind gusts that reached 30 miles per hour, a low snowpack, lack of spring precipitation, and low humidity. Eventually, the fire became large enough to generate its own weather and, at one point, growing at 3.8 acres every second. Fire crews from around the country joined efforts to contain the Carlton complex fire. By the time rain eventually helped to suppress the fire, there was an incredible 3,000 firefighting personnel working on the fire. It took over one month from initial ignition, but the Carlton Complex was declared 100% contained on August 24, 2014.

Two other large fires occurred in Okanogan and Douglas Counties—the North Star fire in 2015 and the Cold Springs/Pearl Hill fire in 2020. The North Star fire burned 218,00 acres, of which 165,000 acres were land owned by the Confederated Tribes of the Colville Indian Reservation. The Cold Springs/Pearl Hill fire burned a total of 410,000 acres and was part of a series of Labor Day fires influenced by an intense windstorm that occurred during the driest part of the year, setting up perfect conditions that allowed the fires to spread quickly across the landscape.

A recurring theme in these examples is the sequence of fire-prone conditions across the landscape. Although fire is needed and beneficial in the shrub steppe, the frequent, high-intensity burns experienced in recent years pose a major threat to the flora and fauna of the region. The shrub steppe ecosystem has evolved the ability to adapt and recover after longer intervals, low-intensity burns, but is not equipped to handle the unprecedented conditions of multiple large-scale fires at shorter intervals. The next section examines fire risks more strongly associated with wildfires, particularly in Douglas and Grant Counties of Washington state.

THE HISTORY OF FIRES IN DOUGLAS AND GRANT COUNTIES

Although a comprehensive list of wildfires occurring in Douglas County and Grant County does not exist, it is possible to find some history of wildfires in both counties. Table 6 displays information about fires that burned 5,000 acres or more in these two counties, from 1996 to 2020.

TABLE 6: FIRES IN DOUGLAS AND GRANT COUNTY BY YEAR			
YEAR	**NAME OF FIRE**	**COUNTY**	**ACRES BURNED**
2020	Pearl Hill Fire	Douglas	223,730
2020	Road 11 Fire	Douglas	11,000
2018	Grass Valley Fire	Douglas	77,000
2015	Douglas County Complex	Douglas	22,337
2015	Saddle Lake Fire	Grant	14,357
2012	Barker Canyon Complex	Douglas	81,343
2012	Crane Road Fire	Douglas	12,500
2012	Milepost 10 Fire	Douglas	5,445
2010	Baird Springs Fire	Grant	7,693
2008	Badger Mountain Fire	Douglas	15,023
2008	Smith Lake Fire	Douglas	12,573
2007	Overlook Fire	Grant	27,071
2006	Rocky Ford Fire	Grant	5,000
1996	Baird Springs Fire	Grant	14,000

The most destructive fire in Douglas County was the Pearl Hill fire, burning 223,731 acres in northern Douglas County in about 36 hours. It started from the embers of the Cold Springs fire in neighboring Okanogan County, which blew south over the Columbia River and ignited in Douglas County near Bridgeport. In total, these two fires took three lives, burned over 410,000 acres (about half the area of Yosemite National Park), and destroyed 195 structures. The second most destructive fire, in terms of acres burned, was the Barker Canyon Complex fire that occurred in 2012 and burned 81,343 acres. The fire, fueled by high winds and low moisture content in the vegetation, jumped the Columbia River at several points and threatened the city of Grand Coulee, site of the Grand Coulee Dam and power station.

As temperatures rise and drought conditions become more frequent, the shrub steppe of Douglas and Grant Counties is at a much greater risk of excessive wildfire and lasting damage.

Firefighting agencies, conservation districts, land management entities, and landowners are all concerned about current wildfire trends and seek ways to mitigate wildfire in local areas. A good starting point is a thorough assessment of all the risks involved.

ACKNOWLEDGING THE RISKS OF WILDFIRE

The human relationship with fire is a delicate one. On one end, fire is a severe threat to livelihoods and on the other it is a necessary process that humans, wildlife, and natural environments depend on. Balancing the two is no easy task and presents us with many challenges and future considerations. This module has highlighted how important and impactful fire was, is and will be in the years to come. Through data collection and careful scientific research accumulated over many years, the impact of fire on the landscape, both natural and man-made, is beginning to be understood on a deeper level. How people interpret this information and what value they place on it will influence future behavior and actions to manage risks associated with fire.

What rarely gets addressed is how important it is to recognize the risks that fire can have on human psychology. With fire becoming much more prevalent on the landscape, the everyday thoughts and actions of many people are being influenced by a growing anxiety about the threat of wildfire burning property and causing fatalities in fire-prone areas. The degree and immediacy of a loss due to wildfire is more than just a physical loss; it is a traumatic life event that can affect well-being for years. It can also take an extraordinary mental toll on firefighters who are on the ground, continually putting their lives at risk, and seeing firsthand the devastation that fires cause.

In fire-prone areas, many people are trying to adapt their way of life to reduce the threat of future fires. They are having to make decisions about things that would normally never cross their minds. For example, living in or near a fire-prone area can be dangerous for those with respiratory health issues, as poor air quality for extended periods of time can exacerbate a condition such as asthma. While a fire burns nearby and smoke drifts into a community folks may be urged to stay inside and limit physical exercise to prevent the smoke particulates from damaging their lungs. On top of the loss of wildlife, habitat, agriculture, livestock rangeland and property value, considerable psychological and emotional strain can be experienced.

Changing how we think, interact with, and respond to fire at all scales (local, regional, national, and global) will be key to planning for and responding to future fires. In high-risk communities, education and appropriate assistance will help address and manage the growing threat of wildfire and the risks it poses. An increased awareness and understanding of fire behavior and our associated response is required, encompassing fires effects on both the natural and human environments.

Building an adaptive capacity into our way of life that integrates fire safety and awareness will go a long way in managing risks of wildfire. It will be important to develop a pro-active relationship with fire and have respect for its role in nature, rather than an aversion to or fear of fire. The threat of fire will always be with us, in some form or another, so continuing to develop resources and support systems that address the risks, impacts and recovery will be critical to a sustainable future. The next couple of modules will explore approaches to mitigating risk and building fire-resilient homes, properties, and communities in the shrub steppe.