

INTRODUCTION

The purpose of these four modules is to provide information and resources for individuals and agencies interested in learning more about fire mitigation in the shrub steppe. The modules are designed to share knowledge about the shrub steppe and about wildfires to provide a foundation for thinking about how communities can become more fire adapted. The intention is to strike a balance between humans and nature. Wildfire is a natural process on the landscape that communities must learn to coexist with. The key to a sustainable future is finding a way to manage wildfire that keeps ecosystems healthy without compromising human well-being in the shrub steppe.

Anyone who has searched for information about creating defensible spaces in the shrub steppe knows that it can be particularly challenging to get access to resources and information. Much of the literature that exists in the wildfire management sector focuses heavily on forested communities and those in the wildland urban interface (WUI). Unfortunately, what is useful in these environments cannot always be applied to the shrub steppe. The shrub steppe is an exceptional environment that requires a unique approach to managing wildfire. Typically, it is an approach that must consider rural livelihoods, agriculture, non-forested ecosystems, and reduced availability and access to resources.

The content in these modules includes an introduction to (1) exploring the shrub steppe ecosystem; (2) understanding the role of wildfire in the shrub steppe; (3) creating and maintaining defensible spaces in the shrub steppe; (4) and developing a site-specific plan to be more fire adapted. These modules can be used to help train agency staff who serve communities and landowners in the shrub steppe environment. They also can provide the basis for presentations such as public workshops, college courses, K-12 classroom lessons, outdoor schools, afterschool programs, scouting activities, club activities, and summer camps. Sample lesson plans, a three-day school camp curriculum adapted for virtual presentation, and hybrid activities are included at the end of the modules in the appendices.

The modules can be presented in a systematic format (such as a workshop) or they can be used in an individual, self-paced format. The modules also lend themselves well to on-site, web-based, or hybrid platforms. While the modules provide a framework for building a more fire adapted community in the shrub steppe of North Central Washington, they are highly adaptable to accommodate the unique characteristics of the entire shrub steppe ecoregion. This range spans across the northern, mid-latitude region of western United States and includes 11 different states.

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MODULE 1: INTRODUCTION TO THE SHRUB STEPPE ECOSYSTEM

Outline

- A. Introduction to the Shrub Steppe Ecosystem
 - Goals and Objectives
- B. What is the Shrub Steppe?
- C. Physical Characteristics of the Shrub Steppe
- D. Geography of the Shrub Steppe
- E. Soils of the Shrub Steppe
- F. Plants and Animals of the Shrub Steppe
- G. Endangered Plants and Animals of the Shrub Steppe
- H. Invasive Plants of the Shrub Steppe
- I. The Special Case of Cheatgrass
- J. Importance of the Shrub Steppe
- K. Problem Statement
- L. Conservation Efforts

MODULE 1 GOALS

The goal of this module is to introduce participants/readers to the ecosystem of the shrub steppe. The topics covered include the definition of the shrub steppe as well as the physical characteristics, geography, plants, and animals that are found within it. Additionally, the importance of the shrub steppe to humans, the current threats the shrub steppe faces, and some of the efforts to conserve the shrub steppe will be discussed.

The objectives for this model are to:

- Increase participants' general knowledge about the shrub steppe
- Increase participants' specific knowledge about the soil, plants and animals that inhabit the shrub steppe
- Increase participants' understanding about the importance of the shrub steppe to plants, animals, and humans
- Increase participants' knowledge about the effects of wildfire on the shrub steppe
- Increase participants' ability to identify shrub steppe conservation efforts
- Increase participants' involvement in conservation activities

WHAT IS THE SHRUB STEPPE?

Put simply, the shrub steppe is a treeless grassland, characterized by a plant community of shrubs usually dominated by sagebrush. It is hot and dry in the summer, and cold and windy in the winter. That said, there are several different, but common, names used somewhat interchangeably in the literature to describe the shrub steppe, including sage steppe or sagebrush steppe, and the steppe. These terms can be distinguished as follows:

Steppe – Considered an ecoregion, a steppe is a dry, grassy plain supporting only short grasses given its low accumulation of rainfall.

Sage Steppe or Sagebrush Steppe – This is a type of shrub steppe ecosystem that is distinguished by its large proportion of sagebrush species.

Shrub Steppe – This is an overarching ecosystem spanning over large portions of arid environments in the intermountain West. It is characterized by its capacity to support both steppe species like short grasses, but also small shrubs like sagebrush.

In this series of modules, the environment will be referred to as the shrub steppe as it is the most all-encompassing terminology. It is also the most widely known term in the North Central Washington region.

PHYSICAL CHARACTERISTICS OF THE SHRUB STEPPE

The shrub steppe covers more land area than any other type of rangeland in the United States. It is diverse in structure and species composition with over 350 vertebrate species and hundreds of plant species. The number of species at any given site within a region can vary greatly. For example, Wrangle (Wrangle.org retrieved May 12, 2021) reports as few as 13 at one of its study sites in Wyoming while Sanderson and Ballinger (Wenatchee Naturalist retrieved October 24, 2021) report as many as 215 in the foothills of Wenatchee, Washington.

Sagebrush is the most common plant in the shrub steppe. The most common species of sagebrush is big sagebrush and related subspecies. Two other commonly occurring species are three-tip sagebrush and low sagebrush along with rabbitbrushes, bitterbrush, and horsebrush.

Sagebrush is found alongside many species of native grasses such as bluebunch wheatgrass, which is probably the most widespread and important perennial grass in the region. It is a grass well adapted to less productive soil and is a palatable food source for cattle. Other principal grasses in the shrub steppe are Idaho fescue, Sandberg's bluegrass, basin wildrye, western wheatgrass, junegrass, needle-and-thread grass, bottlebrush, and squirreltail.

A variety of herbaceous flowering plants, known as forbs, grow alongside sagebrush. Some common forbs include arrowleaf balsamroot, hawksbeard, phlox, western yarrow, lomatium, lupine, groundsel, and mulesears. Also found in the shrub steppe are microphytic crusts comprised of lichens, algae, micro-fungi, and cyanobacteria. Referred to as biocrusts,

they can fix atmospheric nitrogen and protect against soil surface erosion. Biocrusts are often present in the interspaces between the perennial plants of the shrub steppe.

GEOGRAPHY OF THE SHRUB STEPPE

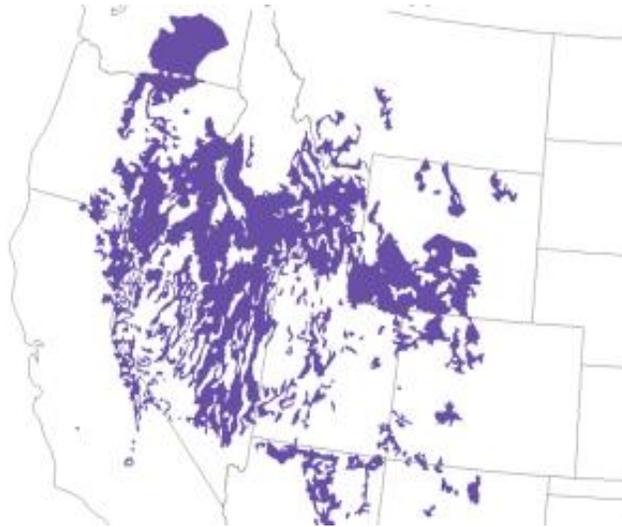


Figure 1: Distribution of shrub steppe (Wrangle)

The shrub steppe covers about 165 million acres across 11 states. It is generally agreed that all or part of the following states are part of the shrub steppe: Washington, Oregon, California, Idaho, Utah, Montana, Wyoming, Colorado, Nevada, Arizona, and New Mexico.

The topography of the shrub steppe is as varied as the states where it is located. It is comprised of four very distinct, yet interrelated landscapes: (1) the Columbia-Snake River Plateau; (2) the Basin and Range; (3) the Great Basin; and (4) the Colorado Plateau. The following graphics and narratives give a brief overview of each.

The Columbia-Snake River Plateau



Figure 2: Columbia-Basin in Context of US



Figure 3: Columbia Basin and Range of the shrub steppe

The Columbia-Snake River Plateau of eastern Washington, eastern Oregon, and southern Idaho ranges from very flat to rolling hills with a layer of fine, mineral-rich material (loess) covering layers of lava and basalt. Elevations in the Plateau range from 500 to 5000 feet.

The Basin and Range

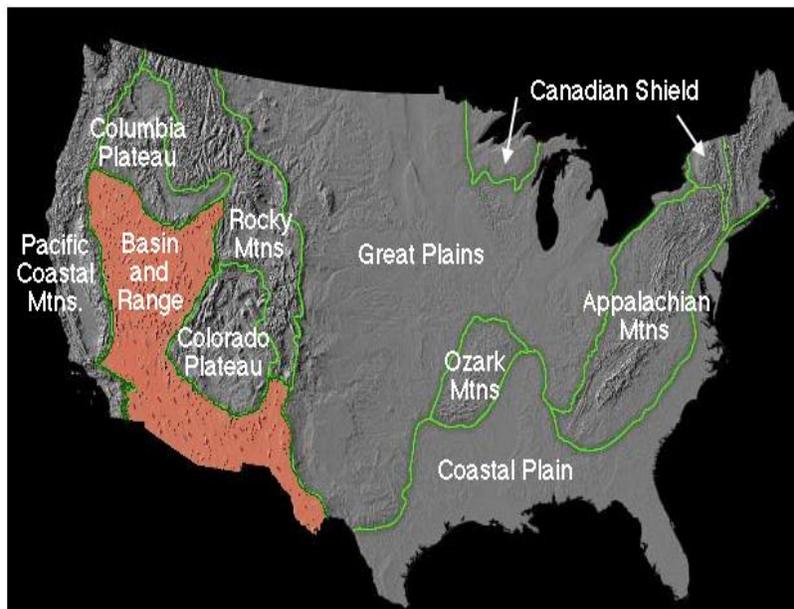


Figure 4: Basin and Range region of the shrub steppe

The Basin and Range covers most of Nevada, western Utah, southern Idaho, southeastern Oregon, the eastern part of California, and south to the Sonoran Desert. This region is characterized by mountain ranges that run north to south separated by broad alluvial valleys called basins. The prevailing rock outcroppings along the fault escarpments are limestone, sandstone, shale, and dolomites. Elevations on valley floors are lower than 5000 feet while mountain peaks may reach seven to ten thousand feet.

The Great Basin



Figure 6: Great Basin region of the shrub steppe

The Great Basin is comprised of the north half of the Basin and Range, which includes all most all of Nevada, and parts of Oregon, Idaho, Utah, and California. The Great Basin was formed by geologic forces that created many north-south trending mountain ranges, including the Cascade and Sierra Mountain ranges, with elevations as high as 11,000 feet. These mountain ranges are separated by flat valleys called basins. The valleys or basins are dominated

by sagebrush and small shrubs. The Great Basin supports a diverse population of plants and animals in its deserts, forests, and alpine regions.

The Colorado Plateau.

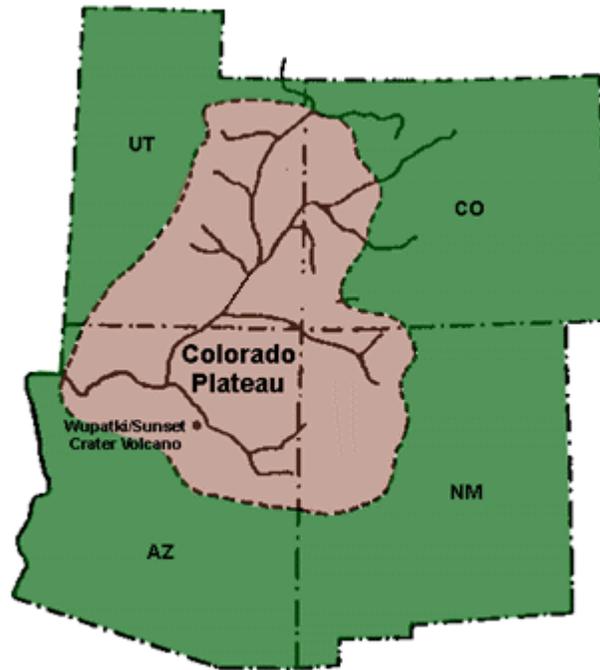


Figure 7: Colorado Plateau region of the shrub steppe

The Colorado Plateau is situated where Arizona, Colorado, New Mexico, and Utah come together. Commonly known as Four Corners, the region consists high plateaus, mesas, deep canyons, volcanic and domed mountains, sand deserts, shale deserts, and badlands. The Colorado Plateau has elevations that range from 5,000 to 11,000 feet, not including canyon bottoms.

SHRUB STEPPE SOILS

Soil is the unconsolidated material matter that covers the land surface of the earth. Soil regulates water, sustains life, acts as a filter of organic and inorganic materials, and provides support for vegetation and man-made structures.

Soil formation and type depend on the parent material present, topography (location), climate, macro- and micro-organisms and time. The viability of soil is determined by both physical chemical properties such as permeability and pH. There are six basic soil types: (1) granular; (2) blocky; (3) prismatic; (4) columnar; (5) platy; and (6) single grained. The following graphics from the Institute of Applied Ecology (retrieved May 24, 2021) show examples of soil formation and soil porosity and permeability.

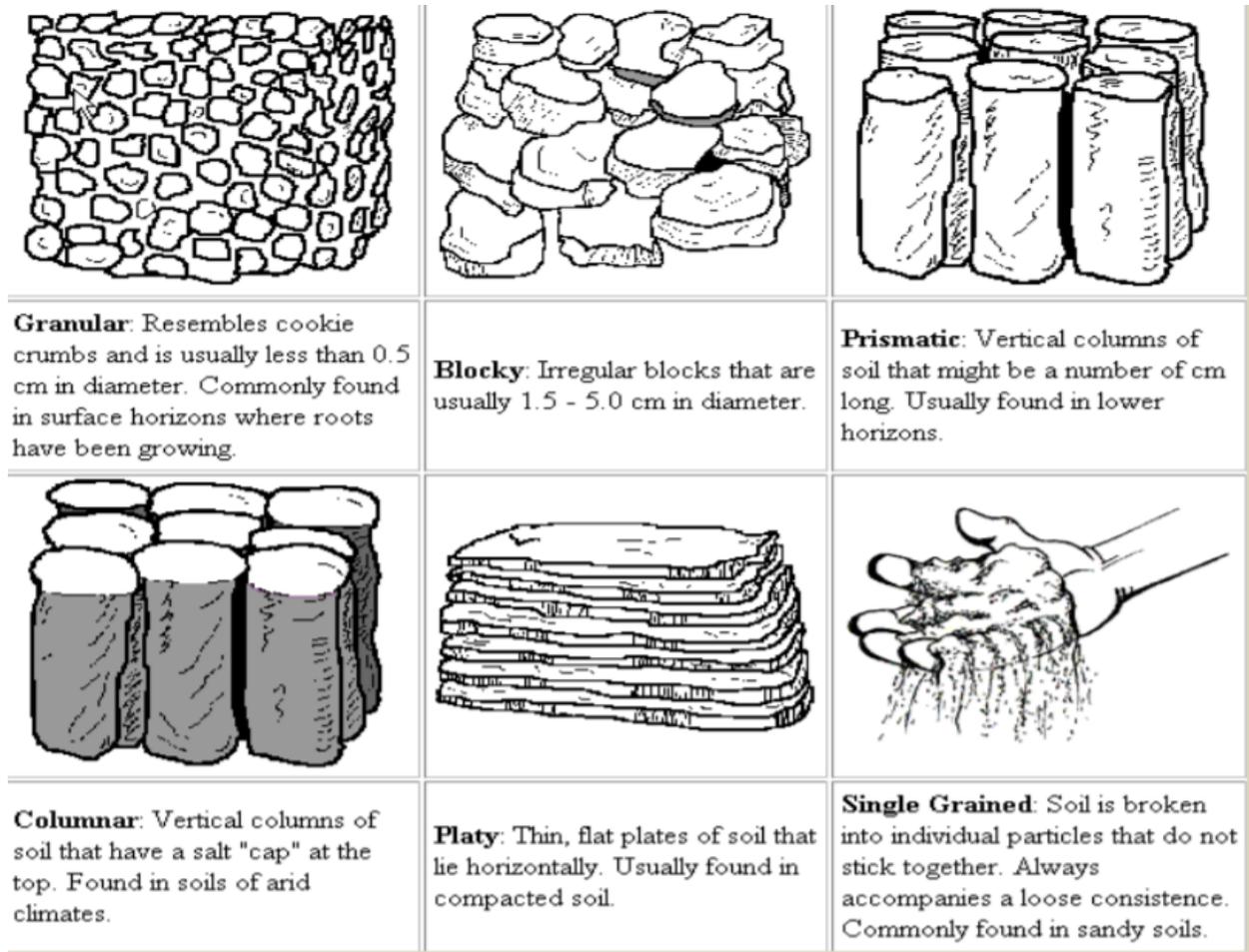


Figure 8: Soil Types

Porosity and permeability are determined by pore spaces. No pore spaces mean there is no porosity. Pore spaces that are not connected means the soil is porous but not permeable. Soil that is both porous and permeable has connected pore spaces. See examples below.

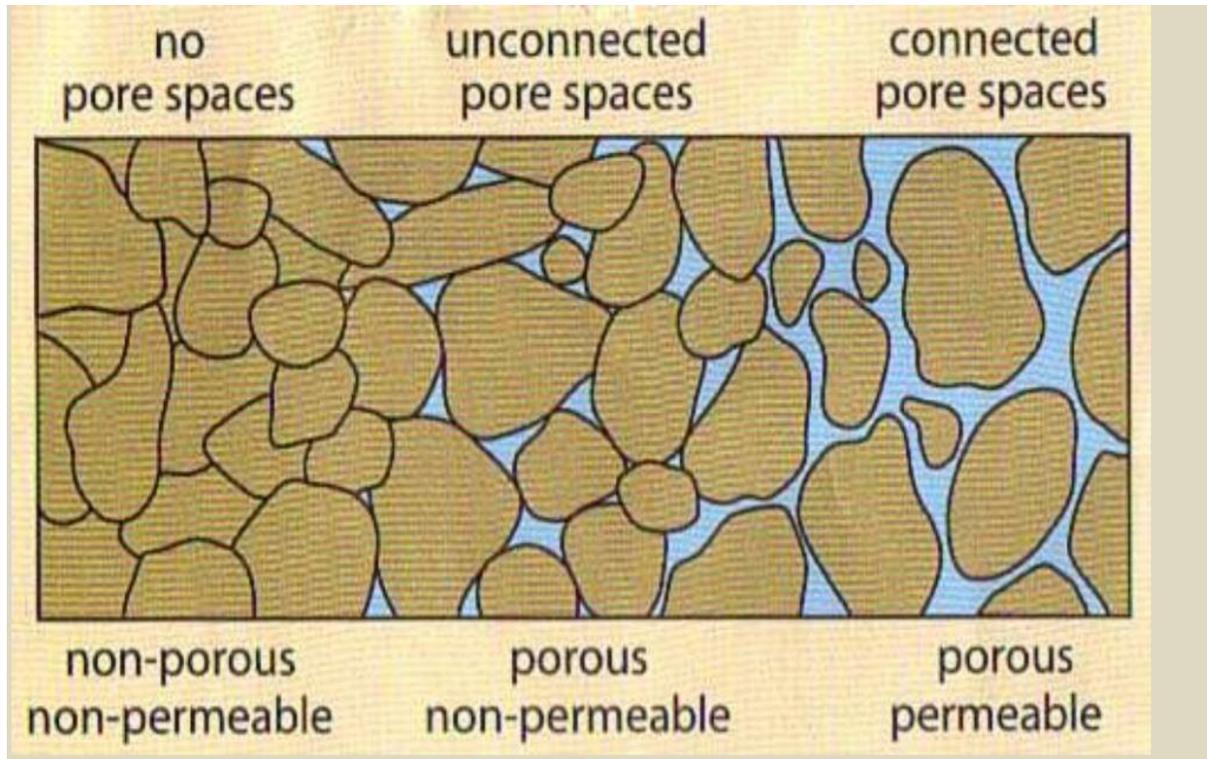


Figure 9: Soil Porosity and Permeability

Like the topography of the shrub steppe, the soils of the shrub steppe are very diverse. They range from deep loessal and alluvial soils of the Columbia-Snake River Plateau to shallow skeletal soils, derived from the volcanic ash of the Great Basin to sandy, gravelly soils of the Colorado Plateau.

According to the Food and Agriculture Organization, there are ten factors that threaten soil function: (1) soil erosion; (2) soil organic carbon loss, (3) nutrient imbalance, (4) soil acidification, (5) soil contamination (6) waterlogging; (7) soil compaction; (8) soil sealing, (9) soil salinization; and (10) loss of soil biodiversity. The shrub steppe soils are subjected to additional unique threats. The most common include habitat conversion; over 60% of shrub steppe lands have been converted (WNPS, 2018). Those conversions are to things like farms, housing developments, roadways, and other human land use activities. Altered fire regimes have destroyed sagebrush ecosystems and increased the proliferation of cheatgrass and the presence of other invasive species.

PLANTS OF THE SHRUB STEPPE

The shrub steppe is composed of diverse plants whose survival depends on soil type, slope, aspect, and geomorphic characteristics of each region. The shrub steppe ecosystem is dominated by shrubs such as sagebrush, hopsage, greasewood, and bitterbrush and bunchgrasses such as Bluebunch wheatgrass, needle-and-thread, Idaho fescue, and Sandberg's bluegrass. Perennial wildflowers such as phlox, mariposa lily, fleabanes and locoweeds also thrive in spaces between shrubs and bunchgrasses. They provide a protective layer that slows erosion by wind and water and inhibits the establishment of invasive plant species

Thin soiled basalt formations support lichens, mosses, and algae as well as bitterroot, several buckwheats, and penstemon. Bluebunch wheatgrass, and sagebrush grow in deeper soils, with a moderate amount of precipitation (10-20 inches annually). Plants such as Indian ricegrass, Sandberg's bluegrass, sagebrush, and winterfat shrubs are found in drier, sandier areas that receive even less precipitation.

At higher elevations, grasslands dominated by lupine and balsamroot intermingle with ponderosa pine and Gary oak. Riparian areas support trees such as cottonwood, alder, birch, and a wide variety of shrubs such as mock-orange, willow, dogwood, and bunchgrasses. Although extremely rare, moist meadows do exist in the shrub steppe. Sedges, rushes, and a variety of wildflowers can be found in these areas.

ANIMALS OF THE SHRUB STEPPE

The animal species of the shrub steppe are as diverse as the plant species and include birds, reptiles, insects, mammals, and amphibians. Owls, golden eagles, and sage grouse are among some of the iconic birds of the shrub steppe. Sagebrush lizards and several species of snakes dominate the reptile inhabitants of the shrub steppe. Mammals of the shrub steppe include coyotes, badgers, pygmy rabbits, jack rabbits, and hooved ungulates such as wild horses, deer, pronghorn, and elk. Smaller mammals include the sagebrush vole and kangaroo

rats. Like plants, animals of the shrub steppe have evolved traits and behaviors over time to cope with the rugged heat and drought conditions. To avoid heat, many animals are active during cooler periods of the day like dawn, dusk, or night. Others burrow, seek plant cover for shade, or hide amongst the rocks during the heat of the day. These behaviors help moderate body temperatures and provide refuge from predators. In addition to the native animals of the shrub steppe, it is worth mentioning the livestock animals (e.g., cattle, horses, sheep, goats, llamas, pigs, and chickens) that humans have brought into this environment for the economic goods and services they provide. The most prominent and influential domesticated stock animal in this region is the cow. Cattle are the dominant grazers in this ecosystem and, if not carefully managed, are responsible for much of the soil degradation and overgrazing of native vegetation.

ENDANGERED PLANTS OF THE SHRUB STEPPE

“The cumulative effects of vegetation degradation, fragmentation and conversion, loss of watershed functioning, and loss of native plant and animal species have placed sagebrush ecosystems, particularly those in the Great Basin, among the most endangered in the United States” (Wrangle, retrieved May 10, 2021). While not all are on the endangered species list, over 133 plant species, 63 vertebrates, and 11 invertebrates (Wrangle, retrieved May 10, 2021) associated with shrub steppe environments were identified as at-risk species of concern by a recent survey. From that survey, all of the plant species and ten of the invertebrate species are known to be restricted to small areas. This is of concern because the smaller and more isolated a species population becomes the more difficult it is for it to adapt and recover from the environmental and human impacts that threaten it. Inbreeding becomes a severe threat when species populations get low enough and, without diversity in the gene pool, species are more susceptible to external factors such as disease, disturbance, and competition.

The shrub-steppe is home to several rare and endangered plant species that are found nowhere else in the world. Two examples are slickspot peppergrass that grows in limited sites

in Idaho and the White Bluffs bladderpod which is confined to a small pocket of land on the Hanford Reach National Monument in Washington state.

Wrangle (retrieved May 10, 2021) provides the following information about slickspot peppergrass: “It is a federally listed threatened species, limited to small-scale sites of water accumulation (“slick spots”) in shrub steppe communities in the southwestern Snake River Plains of Idaho. There are only 42 populations known to exist, and many are very small. Slickspot peppergrass has the highest documented extinction rate of any of Idaho’s rare plant taxa, due to a variety of threats, including weed invasion, wildfire, off-road vehicle traffic, livestock grazing, and land conversion. Many management practices after wildfires, i.e., use of preemergent herbicides, seeding equipment that disrupts the soil surface, and exotic revegetation species such as forage kochia (*Kochia prostrata*), can also have negative impacts on this rare forb.”

A central Washington example of an endangered plant is the White Bluffs bladderpod, which only grows on the Hanford Reach National Monument located on the bluffs above the Columbia River. This low-growing plant was declared an endangered species in 2013. It is a perennial with gray green leaves and yellow flowers.



Figure 10: White Bluffs bladderpod

PC: Tim McCracken, US Fish and Wildlife Service

These plants, known to grow only along a nine-mile strip of land on the steep, dry hillsides, that overlook the Hanford nuclear reservation, have had their numbers reduced by wildfires, human recreation, and competition from invasive species (Cary, 2021).

Threats to these plants have been reduced by installing fences to prevent access to off-road vehicles, and increased enforcement by local officials. Other threats, including the increased frequency of wildfires, the proliferation of cheatgrass and landslides have not been curtailed. As a result, non-native species are crowding out White Bluffs bladderpod in some areas and landslides have permanently destroyed areas of White Bluffs habitat.

Efforts to save the White Bluffs bladderpod include installing water control structures to prevent water saturation above the slope and introducing the plant to areas close to where it grows naturally. In addition, the University of Washington, in partnership with the National Genetic Laboratory Resource Preservation in Colorado, have stored about 30,000 seeds collected by Fish and Wildlife and Washington Rare Care, through a plant conservation partnership program (Cary, 2021). The Fish and Wildlife Service expects it to take at least 20 years and \$2.7 million to recover the White Bluffs bladderpod (US Fish and Wildlife Service 2021).

ENDANGERED ANIMALS OF THE SHRUB STEPPE

Many species of animals residing in the shrub steppe are at risk. Scientists, conservationists, and members of the public are sounding the alarms on how serious the threat of losing the shrub steppe is. Among the at-risk animals mentioned by Wrangle (retrieved May 10, 2021) were lizards, snakes, raptors, owls, passerine birds, rodents, rabbits, and pronghorn antelope.

The Greater Sage Grouse is the most well-known of these at-risk species. Widely regarded as an icon of the west, Sage grouse depend on large areas of contiguous sagebrush for breeding, nesting, rearing their young, and wintering. They are seen as an umbrella species in the shrub steppe, meaning that conserving this bird will benefit many other species in the

ecosystem. After adult sage grouse select a suitable area to live and breed in, they rarely move to another area. They are not a migratory species that will regularly fly great distances to seek out new habitat, so this limits their ability to adapt to big changes in their environment.



Figure 11: Greater sage grouse
PC: Jack Simonson

Sage Grouse populations have declined because of habitat loss due to fire and human encroachment. From 2005 to 2014, 8,028 fires burned in Greater Sage Grouse habitat throughout the western United States. Of these, 5,760 were lightning-caused (72%), and 2,268 were human-caused (28%) (Innes, 2019). Their vulnerability is exacerbated by predation, disease, and parasites as well as issues related to land management. The Greater Sage Grouse has been proposed as a candidate for protection under the Endangered Species Act of 1973.

Public agencies and private organizations are working to develop regulations and plans for abating threats to sage grouse habitat. Conservation and restoration efforts may benefit other species, as well, including the endangered Brewer's sparrow and the pygmy rabbit.



The Brewer's Sparrow makes its home exclusively in the shrub-steppe of Washington State. It prefers higher elevations, usually above 2600 feet, that get more precipitation and provide more grass cover than in the lower, arid basins.

*Figure 10: Brewer's Sparrow
PC: Tom Munson*

The population of Columbia Basin pygmy rabbit in Washington is extremely small and protected under the U.S. Endangered Species Act. Conservation threats include loss and degradation of shrubsteppe due to conversion and fragmentation of this habitat to cropland and development. It relies on sagebrush as a food source during the winter and shelter to hide its burrow system.

*Figure 11: Columbia Basin Pygmy Rabbit PC:
Conservation Northwest*



INVASIVE PLANTS OF THE SHRUB STEPPE

The composition and structure of vegetation within an ecosystem provide food and cover for the animals that live there. The changes in vegetation groups caused by invasive plant species establishment in an area can impact food resources by limiting access to food and increase the risk of predation. Invasive plants in the shrub steppe are primarily non-native species from Eurasia. They include annual grasses and forbs such as cheatgrass, medusahead, yellow starthistle, and biennial thistles such as musk thistle and Scotch thistle. Perennial forbs like knapweed, rush skeletonweed, perennial pepperweed, leafy spurge, and Dyer's woad are also resident noxious weeds of the shrub steppe. The expansion of regional native species such

as broom snakeweed, junipers, and pinyon pines has also had a negative impact on shrub steppe communities. “The fast-paced encroachment of conifer trees, such as juniper and pinyon pine, into sagebrush habitats is changing the dynamics of this delicate ecosystem in ways that have negative impacts for many species of native wildlife” (USFWS, 2021). They shade out native perennial grasses and forbs, contribute to reduced water availability, deplete the survival rate of nesting birds, and increase the available fuel for wildfires.

Unmanaged livestock grazing and other land uses (for example, energy and mineral development, urban/exurban development, and off-road vehicle use) have decreased the herbaceous component of sagebrush communities and facilitated annual invasive grass expansion at lower elevations and the aforementioned conifer encroachment at higher elevations. These two scenarios are considered the greatest invasive species threats to the shrub steppe and sagebrush shrubland vegetation types (Wrangle, retrieved May 15, 2021).

Invasion of noxious plant species can lead to enormous costs. When left unmanaged, invasive weed species reduce plant diversity and wildlife habitat by outcompeting the native species. They can alter the soil’s composition and pH, which can limit the productivity and establishment of native plant populations. These changes can alter fire regimes in ecosystems, making them more susceptible to large, more intense wildfires. Additionally, noxious weeds can accelerate rates of soil erosion and contribute to the increased movement of sediment into drainways and streams, which can harm sensitive species that rely on healthy water to survive.

Socioeconomic costs of noxious weed invasions can affect everyone from rural and urban landowners to government agencies that manage large tracts of land such as the United States Forest Service (USFS), Bureau of Land Management (BLM), and US Fish and Wildlife Service (USFWS). Also in this mix are local conservation districts and other non-profit organizations that work in some capacity with noxious weeds.

Wrangle (retrieved May 15, 2021) states that instances of invasion by noxious plants “have reached historic rates”. It is estimated that 100 million acres of public and private lands are infested with invasive plants, the worst of which being cheatgrass, medusahead, and ventenata. If human caretakers allow this weed invasion to go unchecked, it will lead to: (1) more frequent and intense wildfires—with a greater loss of physical structures and greater threats to human

safety; (2) additional plant invasion—especially after fire, perpetuating both a loss of biodiversity and a cycle that places an additional financial burden on landowners and land managers; (3) increased economic disruption of small, rural communities, local businesses, and landowners because of reduced crop yields and lost livestock forage; (4) altered habitats and migration routes; and (5) a decrease in public access for the purpose of recreation.

THE SPECIAL CASE OF CHEATGRASS

Cheatgrass is among the most destructive and persistent invasive species in the shrub steppe. An annual grass native to Europe and eastern Asia, it was brought to North America by settlers in the 1800s. According to the United States Forest Service (retrieved April 12, 2021), cheatgrass is now found in at least 49 states. It's greatest impact, however, is in the semi-arid Great Basin that includes parts of Utah, Nevada, Idaho, Oregon, and California where this invasive grass thrives in areas with wet winters and hot, dry summers. The Methow Conservancy (retrieved May 20, 2021) describes cheatgrass as one of the most invasive grasses in North America and likely the most common plant in the Columbia Basin. Cheatgrass can be found along roadsides, pastures, rangeland and both disturbed and undisturbed soil as well as in Ponderosa pine and Douglas fir forests.

The cheatgrass invasion was exacerbated by the westward movement of settlers and the introduction of domesticated livestock into the shrub steppe. As cattle and sheep farms expanded and encroached upon the shrub steppe, they brought with them cheatgrass that thrived, and continues to thrive, on overgrazed land and disturbed soils—prime conditions that allow cheatgrass to outcompete native grasses and forbs.

Along with its ability to thrive on disturbed soils, the life cycle of cheatgrass gives it a competitive advantage in the arid high desert. It is a winter annual, meaning it grows throughout fall and winter (when there is more precipitation), a time when many other grasses die back. Additionally, its shallow root system increases the rate of soil erosion on the landscape. Without a larger root system, it is unable to bind soil particles together and store key nutrients needed for other native forbs and wildlife. Cheatgrass is also not a sustainable

food source, which means wildlife struggle to survive or migrate from the area and domestic animals must be provided alternative food sources at great cost to the landowners.

Not only does cheatgrass create a monoculture that affects wildlife and livestock, but it also exacerbates the threat of fire. Cheatgrass seed heads are highly flammable, accelerating the frequency and severity of wildfire. For example, there are annual reports of wildfires caused by individuals driving a vehicle over a dry patch of cheatgrass. Native plant communities are not adapted to frequent, large intensity wildfires; consequently, fire leads to even more cheatgrass on the landscape. It is a vicious cycle of fire creating an inviting landscape for cheatgrass, which in turn creates a rich environment that promulgates destructive fires.

IMPORTANCE OF THE SHRUB STEPPE

The shrub steppe is important to plants, animals, and humans alike. It serves as home for a broad range of unique wildlife and plant species. In fact, many species, such as the iconic Greater Sage Grouse, cannot be found anywhere else in the world. There are even much smaller regions within the shrub steppe ecoregion where certain species exist, such as the aforementioned Umpqua Desert buckwheat and White Bluffs bladderpod, found solely in a small area of central Washington shrub-steppe—they exist no place else on earth! These precious species play a role in supporting the unique web of life in the shrub steppe, whether to serve as a pollinator, a food source, a component of medicine, or some other intrinsic or cultural benefit. Losing them means losing the critical services and functions they serve within the shrub steppe ecosystem that keep it flourishing and resilient to changing conditions.

The shrub steppe is not only important to wildlife and domesticated animals; It has been important to humans since Native Americans first occupied this region. The rich multigenerational history, culture, and customs of indigenous groups have long influenced the shrub steppe environment. Turner et al. (1980) describe how Native Americans have influenced the land as local tribes, such as the Okanogan, traveled in the Columbia Basin to gather food, utilitarian items, and sacred materials invaluable to their way of life. Today, domestic and ritual gathering of native and agricultural goods continues as a viable cultural activity among

indigenous peoples who are members of tribal nations across Washington State. With the westward movement of early Americans, however, many native traditions such as hunting, fishing, and root-gathering were profoundly compromised, as was their relationship to the land.

Our history tells us how indigenous values and practices often collide with the values and practices of Anglo-Europeans. For example, indigenous peoples believe that the “land owns us” (Global Oneness Project Retrieved November 10, 2021) as opposed to the perspective of most Anglo-Europeans who believe they own the land. Native Americans believe the land sustains every aspect of their lives—spiritual, physical, social, and cultural. The health of the land and water is central to their culture, and they believe that gives them a responsibility to care for it. In the words of Chief Seattle, “Humankind has not woven the web of life. We are but one thread within it. Whatever we do to the web, we do to ourselves.”

Since European settlement, “owning the land” has meant the shrub steppe has taken on an economic value that has grown far beyond the eco-centric ways of life practiced by indigenous people. Human encroachment in the form of agriculture (farming and ranching), energy development (coal, gas, oil, and more recently wind) and recreation development (camping, hunting, skiing,) has helped grow and support local economies. While the economies have grown, the shrub steppe ecosystem has been seriously degraded and drastically reduced in size. In fact, a recent report concluded that the west loses on average 1.3 million acres of its iconic sagebrush steppe every year (Doherty et al., 2022). Roughly 40% of the shrub steppe has been converted to cropland; in Washington state only 12% of the natural shrub steppe remains and, in the Columbia Basin, less than 50% of the original 10.4 million acres (approximately 4,160,000 acres) remains (Dobler et. al. 1996).

One way in which indigenous cultures and Anglo-European cultures interface is their relationship with fire. Historically, Native Americans depended on fire and periodically set fire to the grass in the shrub steppe to keep woody vegetation at bay. This increased their ability to successfully hunt game and improved conditions needed to grow food crops. Innes (2019) states that “Fires were used to improve forage for game, drive game animals, increase production of edible plants and seeds, maintain desirable plant communities, improve visibility, clear campsites, control pests, communicate over distances, and defend against or attack

intruders." Today, many agencies responsible for stewarding the land are reassessing the value of fire in maintaining the health of the lands for which they are responsible. From an ecological perspective, fire can be used to control overgrowth, to benefit the landscape and make farmlands and communities safer.

It is critical to remember the shrub steppe is a unique landscape to America. The U.S. Fish and Wildlife Service (retrieved May 12, 2021) stated it this way: "[The shrub steppe] occupies a special spot in our natural heritage and reminds us of the wide-open spaces that continue to define a large portion of our national geography, shared history, and culture of the West".

SO ... WHAT IS THE PROBLEM?

Although the shrub steppe is commonly referred to as a tough and hardy environment, it is a fragile ecosystem. Like many other ecosystems, the shrub steppe is very susceptible to a multitude of anthropogenic impacts. It is critical to identify and understand these stressors, so that action can be taken to mitigate negative impacts. Many of the vulnerabilities related to the greater shrub steppe ecosystem are caused by one or more of the following eight factors, all which involve or impact the threat of wildfire. These vulnerabilities extend across all of the shrub steppe, including Washington.

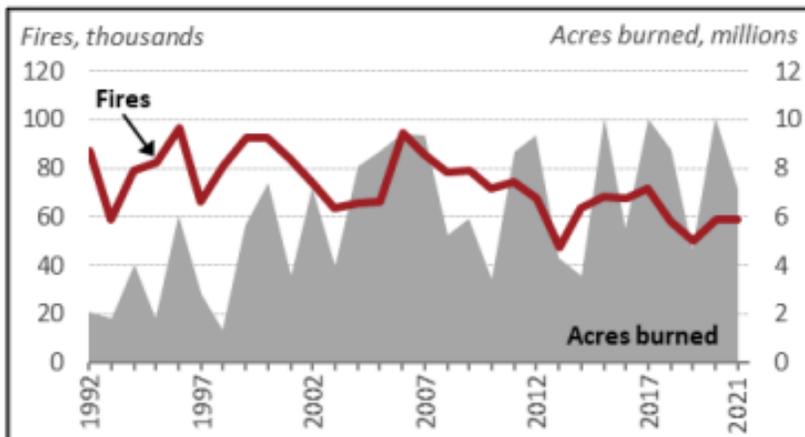
1) Invasion of noxious weeds: Noxious weeds are a human-made issue in just about any ecosystem throughout the world. In the shrub steppe, annual grasses such as cheatgrass, medusahead and ventenata are three of the top concerns (Applestein, 2022). The spread of noxious weeds has been exacerbated by the capacity of humans to travel great distances by land, sea, or air. Whether intentionally or unintentionally, humans have introduced foreign plants into highly adapted, fragile ecosystems they would otherwise never reach. This has resulted in the disruption of natural processes and compromised many functions within the shrub steppe ecosystem. Noxious weeds damage agricultural viability too, costing farmers millions of dollars in control efforts and lost production in Washington alone (NWCB, 2020). Many noxious weeds are outcompeting native plant and animal communities for limited

resources in the shrub steppe. This paper will focus on one in particular; cheatgrass (*Bromus tectorum*). If left untreated, noxious weeds like cheatgrass could continue to spread across the landscape and disrupt many ecosystem processes, inhibiting native wildlife from providing the ecological services and functions, and reducing agricultural productivity.

2) Overgrazing of the shrub steppe landscape by domestic farm animals: Overgrazing is considered one of the main causes of land degradation in arid and semi-arid regions worldwide (Zhang, 2018). Historically, grazing practices were often not environmentally sustainable and changing grazing approaches over time has had limited success (Davies, 2022). Overgrazing occurs when domestic animals, primarily cattle in the shrub steppe, are confined to a small area of land for too long. Cattle eat the grasses down to the point where the plant can no longer recover, leading to diminished vegetative cover. Overgrazing contributes to the aforementioned cheatgrass invasion by reducing the abundance of native perennial grasses, disturbing intact soils and complex biological soil crusts, and dispersing cheatgrass seed (Meyer et al., 2020). Successful grazing operations are designed to regularly move livestock to new pasture and leave enough time between grazing rotations to let the vegetation recover. Overgrazing results in the loss of vegetation cover and increased erosion because low vegetation cover provides low protection from soil erosion and a high risk for degradation (Peters, 2013). If the shrub steppe loses both soil and plants through erosion, the loss of adequate forage and shelter can ultimately result in a loss of native animals. In addition, it negatively impacts the livestock that are critical to the livelihood of ranchers, serving a key role in the food industry.

3) Fire suppression practices of the past: There is a long history of fire suppression in the west. Changing attitudes and policies on fire resulted in fire suppression practices throughout most of the 20th century (Marlon, 2013). The accumulation of more combustible plant material across large swaths of land escalated the risk of bigger, hotter fires. In recent years, specifically the past two decades, humans have seen the repercussions of those suppression activities. Extreme, high-intensity wildfires are burning at higher frequencies spanning more area than ever previously recorded. Figure 3 shows acreages and numbers of fires since 1992 and Figure 4 shows the top five years with largest wildfire acreage burned.

Figure 1. Annual Wildfires and Acres Burned, 1992-2021



Source: NICC Wildland Fire Summary and Statistics annual reports.

Note: Data reflect wildland fires and acres burned nationwide, including wildland fires on federal and nonfederal lands.

Figure 3. Annual wildfires and acres burned over a 20-year period in US (NICC, 2022).

**Top Five Years with Largest Wildfire
 Acreage Burned Since 1960**

Year	Acres burned (millions)	Number of Fires
2015	10.13	68.2
2020	10.12	59.0
2017	10.03	71.5
2006	9.87	96.4
2007	9.33	67.8

Source: NICC Wildland Fire Summary and Statistics annual reports.

Note: Number of fires in thousands.

Figure 4. Top five years with the largest amount of wildfire acreage burned in US (NICC, 2022).

4) Growth and development of industries: Another contributor to the vulnerability of the shrub steppe is the growth and development of commercial and resource-extractive industries such as wind and solar power as well as the expansion of agriculture (livestock grazing, irrigation, farming) and open-pit mining (Monsen, 2000). Additionally, building of roads, power lines, and houses have expanded. Historically, these industries have been disproportionately interested in economic gains over ecological health and well-being. Development often comes at the expense of the environment, bringing with it increased pollution and physical degradation of land by machinery, human-made infrastructure, and other extractive processes. Furthermore, with different industries comes an increase in different land uses and ownership patterns. Complex land usage and ownership becomes an issue when coordinating and managing wildfire due to jurisdictional boundaries and the increased range of stakeholders involved. More stakeholders means more diversity of interests and values folks have regarding management of natural resources. With a wide-range of motivations and management interests on the landscape, communication across many different interests becomes more difficult yet more important amongst different industries.

5) Influx of humans moving into wild spaces: As the human population grows, so does the rate of development and resource extraction. Many of these activities take place in areas in or near the Wildland Urban Interface (WUI). As defined by the US Fire Administration (2022), the WUI is “the zone of transition between unoccupied land and human development. It is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels”. Pushing into wildland areas that are historically prone to wildfires means individuals and communities are potentially exposed to life-threatening situations. This is a problem that will continue to be encountered as the human population grows and urban sprawl pushes further into rural areas of shrub steppe.

6) Extreme weather caused by climate change: Climate change is yet another factor that threatens the ecology of the shrub steppe. Climate change is projected to impact precipitation

and temperature regimes worldwide, with especially large effects in sagebrush ecosystems (Palmquist, 2016). Increased drought and temperature impact everything in the shrub steppe such as increasing frequency and intensity of wildfire, displacing and damaging wildlife populations, decreasing water supplies, and therefore increasing rates of erosion. This in turn diminishes the community's values and livelihoods in this region, creating unsafe and unsustainable living conditions.

7) Lack of knowledge, research, and literature on shrub steppe ecology and wildfire:

While there is considerable information on wildfires in forested ecosystems, it is difficult to find the same quantity of information about the impacts of wildfire in the shrub steppe, specifically rural, agricultural communities. The lack of research and literature about wildfire in the shrub steppe is an area that warrants more attention and investment. The reality is that fires occur in these areas every year, burning large swaths of sagebrush habitat across thousands of rural land. National wildland fire policies concerning fire suppression and fuels management have primarily focused on forested lands for most of the 20th century (Crist, 2023). The danger is that the shrub steppe is not as valued as a forest environment is. Forested environments support more overall biomass and economically lucrative industry, such as timber, whereas shrub steppe environments are more arid, and have been subjected to intensive agricultural use (livestock grazing and irrigated and mechanized farming practices) since the early 1900s, degrading the landscape and leaving very little intact shrub steppe (Dobler et al., 1997). What's left is an arid, resource-depleted landscape less capable of supporting larger industries and populations. While it may not match the economic values of forests, that should not outweigh the ecological, social, and cultural values that shape the native fragments of shrub steppe that remain. More research and information sharing is key in order to better understand this ecosystem, mitigate impacts on the shrub steppe, and plan for a future with wildfire on the landscape.

8) Insufficient emphasis on ecological stewardship of the shrub steppe: Those concerned about the vulnerability of the shrub steppe recognize the fact there is not enough emphasis on stewarding it. It is estimated that about 12% of a functional shrub steppe ecosystem remains in Washington, and less than 1% is protected in ecological conditions similar to the original

vegetation (Washington Native Plant Society, 2018). The need is urgent to conserve and protect what little remains of intact shrub steppe. The urban-rural divide has deepened in recent decades as the relationship between many Americans and the natural world has frayed, but the connection between rural landscapes and the multigenerational ranchers who work them has not (Charnley, 2014). People who work the land, such as producers in shrub steppe environments, have an incentive to steward the land in a way that provides long-term ecological benefits because their livelihood depends on it. This knowledge of local producers, coupled with the working knowledge of agencies and university experts, hold the ability to to improve and better steward the land, but they are running out of time and space, as shrub steppe habitats continue to be converted into other forms of land use, such as agriculture, wind, or solar. In other words, the knowledge and ability to emphasize more stewardship in the shrub steppe is available, it just needs to be shared more widely and acted on with more urgency. Part of the challenge lies in the rural nature of this landscape, with fewer visitors and fewer residents, many of which choose to live a more isolated lifestyle away from population centers and with limited access to resources. All things considered, the lack of adequate recognition warrants investment in building a more robust stewardship ethic that is widely recognized in the communities within and surrounding rural shrub steppe landscapes.

The impact of each of these eight factors on the shrub steppe is enormous, however, the central theme existing in each is the role fire plays in all of them. While fire is a natural and essential phenomenon in the shrub steppe ecosystem, the increased intensity and frequency of fire in recent years is unprecedented. Increased mega-fires and wildfires is a global issue that is expected to become worse with climate change, and the extensive nature of rangelands limits the use of many fuel treatments to mitigate wildfire impacts (Davies, 2016). The increased scale of wildfire impact pushes both plant and animal communities to limits they are not adapted to cope with.

Humans living in the shrub-steppe are also impacted by these changes, which exacerbates the problem when viewed through a socioeconomic lens. Given the mixed land use, tied up largely in agriculture and rangeland, communities in the shrub steppe may become extremely vulnerable. Declining crop productivity and unsatisfactory conditions to support farming and

ranching may result in families unable to maintain operations and lifestyles that have been prevalent in these areas for many generations.

The outlook is not good for the impact of future deterioration of climatic conditions on the shrub steppe. It is important to address the role that climate change plays in this equation and begin taking steps to prepare for the inevitable changes that the region will likely face. It is also important to simultaneously build a culture of greater awareness, understanding, and stewardship among communities living in the shrub steppe to assure its place in the greater ecosystem is preserved for future generations.

CONSERVATION EFFORTS

The shrub-steppe ecosystem is fragile and is closely connected to the watershed within which it exists. Many private and public agencies have programs that aim to protect the shrub steppe through conservation activities. These conservation and preservation efforts occur at the local, state, regional, and national levels and include many agencies concerned with nature and the environment. Work includes preserving, enhancing and/or creating habitat. This involves planning and managing land to help preserve wildlife by practices like mapping and controlling invasive plant species. Creating more resilient and adaptable communities is paramount for the long-term sustainability of this region and its way of life. Examples of a few current conservation efforts include:

- Increasing stocks of native seeds to support stabilization, rehabilitation, and restoration of sagebrush habitat on public and private lands (Nevada).
- Conserving land through expansion of and enrollment in the Conservation Reserve Program (CRP). CRP is a land conservation program administered by the Farm Service Agency (FSA). In exchange for an annual rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality.
- Defining conservation measures for rangeland restoration for Sage Grouse, which includes invasive species management (Oregon).

- Forming a cooperative weed management area, overseen by a voluntary committee, to help develop and implement a plan to manage the spread of invasive species (Washington).
- Building partnerships to further collaborative efforts to manage invasive species, improve rangeland health, provide livestock forage, and improve habitat for mule deer, elk, pronghorn antelope, and greater sage-grouse (Wyoming).
- Converting to no-till farming practices, which improves soil health and decreases emission of greenhouse gases from farm equipment. In addition, this practice reduces soil erosion and runoff that degrades stream habitat.
- Re-introducing wildlife species of concern such as the Columbia Basin Pygmy Rabbit in Washington.