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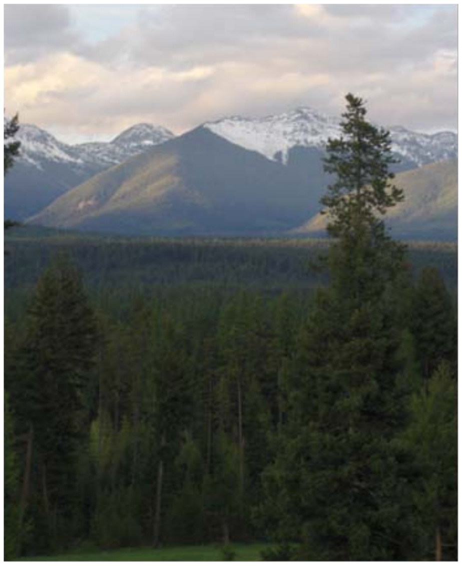
Native Terrestrial Ecosystem Diversity of the Blackfoot Watershed

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INTRODUCTION

Montana's outstanding natural environment and biodiversity have been and continue to be vital to the economy of the state while also providing a variety of ecosystem services that benefit Montanans and the general public alike. As human population levels continue to grow and demographics change, demands on Montana's natural environment and working lands will increase, making it more difficult and challenging to maintain these economic values while also protecting its biodiversity. As an added challenge, the projections for future climate change will further complicate these efforts. For one region of Montana, the Blackfoot watershed, private landowners and community organizations are working together with state and federal agencies to develop a conservation plan for maintaining the future of their wild and working lands as well as the biodiversity of this outstanding region. To facilitate this process, additional information is required on the past and present biodiversity of this region.

The Convention on Biodiversity defines biodiversity as "***the variability among living organisms from all sources including,* inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*.**" Stated more simply, the biodiversity of an area is considered the native ecosystems, species, and genetic variability inherent to an area. Maintaining the diversity of native ecosystems provides the underpinnings for maintaining all other levels of biodiversity, and should be a fundamental component of all conservation strategies and planning efforts (Haufler et al. 2002). The ability to define and quantify native ecosystem diversity also provides an efficient and effective basis for determining cumulative effects to landscapes (Haufler et al. 1999). It provides a science-based process for prioritizing conservation objectives and helps make sense of conflicting habitat needs among species (Haufler 1996).

Native ecosystem diversity can be defined as the variety of plant communities (each similar community is considered a functional ecosystem) and their associated animal populations that would occur within a defined area as a result of the combined influences of climate, the abiotic environment, and historical disturbance processes. Ecosystem diversity, if properly characterized, provides habitat for all of the species, both plant and animal, that have evolved and adapted to the conditions present in an area. Maintaining adequate representation of all native ecosystems means that the habitat needs of all native species historically viable in an area will be provided, the biggest single challenge for maintaining overall biodiversity at local and regional scales.

Conservation planning should emphasize maintaining and restoring resilient native ecosystems (Noon et al. 2003). Restoration means returning a plant community to some previously existing set of conditions. Maintaining or restoring native ecosystem diversity, as well as determining the best locations for restoration requires an understanding of the abiotic environment and its interaction with historical disturbance processes that produce the resulting plant communities (Nichols et al. 1998). More specifically, it means understanding the dynamic range of native ecosystems that occurred historically.

One of the greatest threats to native ecosystem resiliency is the failure to properly and sufficiently understand and quantify how disturbances historically shaped community compositions, structures, and functions.

Conservation planning that includes restoration as a component requires an understanding of what existed historically in the targeted landscape, as well as what is present today as compared to this historical reference. Native ecosystems that are lacking in an area or that are in substantially different amounts than occurred under historical disturbance processes are likely candidates for conservation or restoration. This also provides the ability to quantify and describe the cumulative changes that have occurred across a landscape. Such analysis needs to be done at a scale that allows for the use of site level classifications and ecosystem descriptions that can provide specific guidance for restoration. Many broad-scale efforts are good for regional analysis, but are too large and the resolutions used too coarse to provide the types of information needed for more localized planning and conservation actions (Flather et al. 2009, Poiani et al 2000). With an understanding of the cumulative effects of change, planning can prioritize and target where the most significant changes have occurred, and provide more detailed descriptions of historical conditions that today are lacking in the landscape (Gutzwiller 2002, van Jaarsveld et al. 1998).

Native ecosystems, described in terms of compositions, structures, spatial arrangements and functions provide clear objectives for restoration. Restoration planning should also consider the likely influences of climate change to ensure that the restored or protected ecosystems will be sustainable and resilient under predicted future conditions (Saxon 2003). For example, a specific native ecosystem may be identified as in need of restoration within a landscape. However, if this plant community, when evaluated against downscaled climate change predictions for the landscape, is found to be unlikely to be sustainable into the future, then the future desired species compositions can be adjusted to make the ecosystem more resilient under predicted future climate conditions, but kept functionally similar to the historical plant community.

The Blackfoot Subbasin Plan

Over the last several years, a group of diverse stakeholders met regularly to develop a strategy for conserving, restoring, and enhancing the natural resources of the Blackfoot watershed. The result of that effort was the Blackfoot Subbasin Plan (Blackfoot Challenge and Trout Unlimited 2009). The core of the Blackfoot Subbasin Plan consists of a comprehensive set of conservation objectives and strategic actions designed to abate the critical threats to subbasin conservation targets, resulting in healthy, viable conservation targets. Conservation objectives were identified that include the following:

- Emphasis should be placed on protecting the highest quality habitats, which should be identified and prioritized by 2012.
- Maintain or restore the viability of native grassland and sagebrush communities based on historical conditions across the Blackfoot Subbasin.

- Maintain or restore the viability of native forest communities based on historical stand conditions across the Blackfoot Subbasin.

Meeting these objectives will require a description of native ecosystem diversity and a determination of the native ecosystems that are lacking in the watershed or that are in substantially different amounts than occurred historically. This will further provide the ability to quantify and describe the cumulative changes that have occurred across the Blackfoot watershed.

PROJECT DESCRIPTION

This project will describe and quantify the native ecosystem diversity for terrestrial ecosystems of the Blackfoot watershed. In addition to providing important information for conservation planning and restoration, the findings will also help describe the ecological sites of the watershed, and the various reference plant communities.

Objectives

Specific project objectives include:

1) Identify and develop baseline or reference conditions for native terrestrial ecosystem diversity in the Blackfoot watershed using the best available data and information, as well as a spatially explicit landscape model known as SIMPPLLE.
2) Use existing GIS layers and associated databases in combination with reconnaissance level field surveys to produce and quantify information on existing ecosystem conditions.
3) Demonstrate how native ecosystem diversity can be used in conjunction with information on existing ecosystem conditions to produce a cumulative change analysis and identify conservation needs and priorities, as well as make restoration recommendations.
4) Demonstrate the application of this information to the objectives of the Blackfoot Subbasin Plan, local land managers and producers, as well as other interested organizations within the Blackfoot watershed.

Project Area

The Blackfoot watershed includes nearly 1.5 million acres in northwest Montana and is located near the center of the physiographic province of the Northern Rocky Mountains and west of the continental divide. It occurs in portions of four counties that include Missoula, Lewis and Clark, Powell, and Granite (Figure 1). Elevations range from roughly 9200 feet in the upper portion of the watershed to 3280 feet at the base of the watershed where the Blackfoot river merges with the Clark Fork River. Primary ownership patterns in the watershed include US Forest Service and other federal agencies at 735,835 acres, State of Montana at 115,118 acres, and private ownership at 625,084 acres (Figure 2).

The vegetation of the pre-settlement Blackfoot watershed was dominated by forest ecosystems at 84% of the landscape followed by grass-shrub ecosystems at 10% and riparian, wetland, and aquatic ecosystems at 6%. Primary land uses have been and continue to be timber production, ranching, and growing forage crops. The Blackfoot watershed also provides exceptional opportunities for outdoor recreation. Elk, moose, mule deer, and white-tailed deer are abundant and offer excellent big-game hunting. Camping, world-class fishing, and water recreation activities can be found along the Blackfoot and Clearwater Rivers, as well as numerous large and small lakes, ponds, and smaller streams. Recreational cabins are also a common feature along many of these waterbodies.

In the north-central part of the watershed, State Highway 200 runs west and east. In the center of the watershed, State Highway 141 joins State Highway 200 and runs southeast. Numerous secondary and access roads exist throughout the watershed.

The climate of western Montana is semi-arid but relatively cool (Sims et al. 1978). The patterns of temperature and precipitation mainly determine climate. The soils are varied but most have minimal water-holding capacity during drought cycles because of their coarse, skeletal texture (NRCS National Soil Survey Center 2004). Bare ground is often a significant component of vegetation communities so that the soils are particularly susceptible to erosion when disturbed (Kaiser 1961).

The topography of the Blackfoot watershed is irregular resulting in a mountain and valley landscape characteristic of the Rocky Mountain physiographic province. Also, typical of mountain and valley landscapes, large variations in temperatures and precipitation can be observed in relatively short distances. Seasonal variations in climate are significant but general patterns based on average conditions indicate that the valleys are drier during colder months and wetter during warmer months. The valley's are characterized by a moist season generally occurring during May to July, while the mountain's are characterized by a moist season occurring from midwinter to early spring. At the higher elevations the wettest periods are fall, winter, and spring. Precipitation during the colder half of the year usually occurs as snow and, under average conditions, is often light and steady. During the warmer months, precipitation usually occurs as rain with showers and thundershowers dominating. Strong winds are uncommon in the area with gusty winds usually associated with strong or rapidly moving frontal systems (USDA Natural Resources Conservation Service 2006). Table 1 provides a summary of average temperatures, precipitation, snowfall, and snow depth for 6 weather stations located at various elevations throughout the watershed.

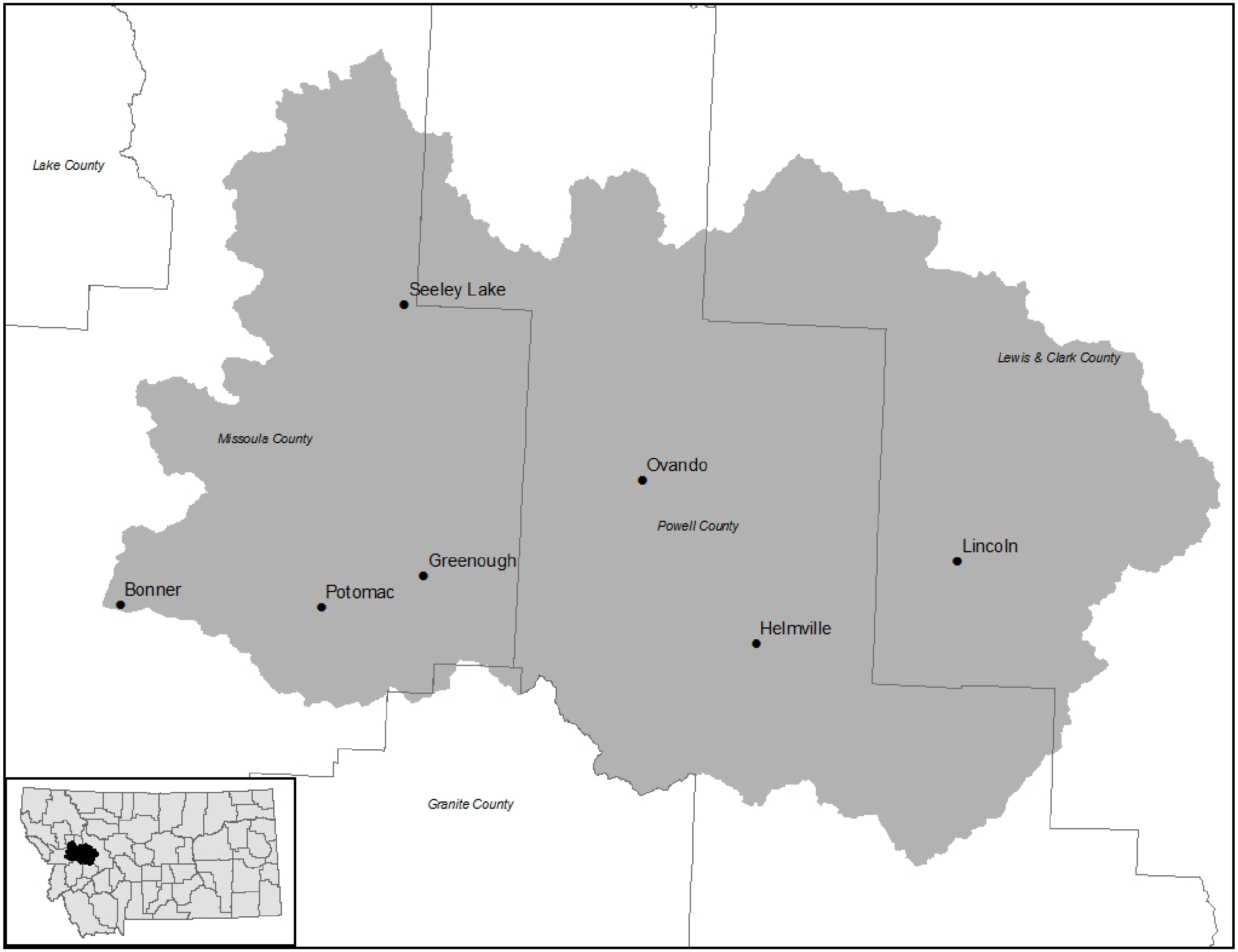


Figure 1. Location of Blackfoot watershed in north-central Montana.

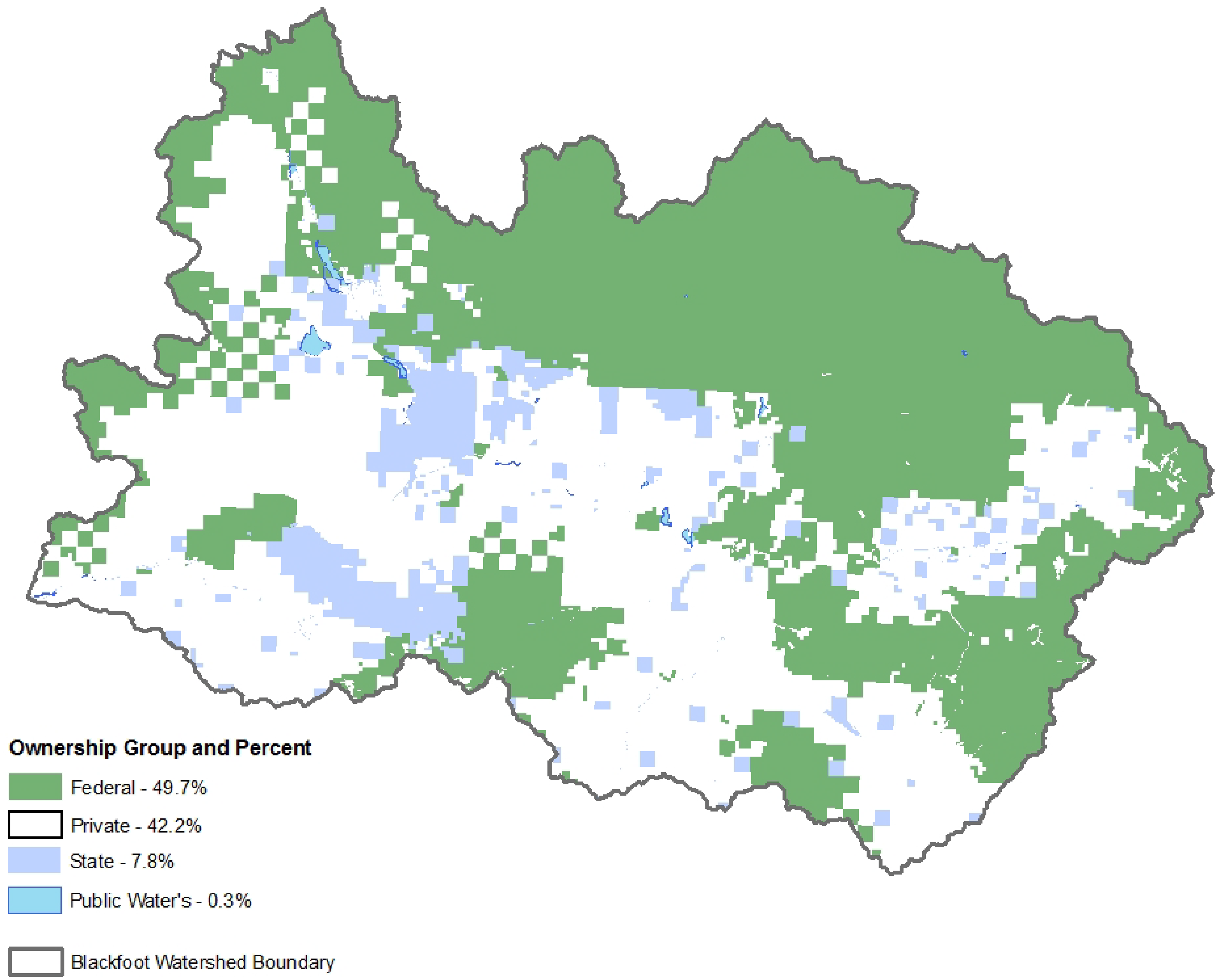


Figure 2. Land ownership patterns and percent ownership by landowner type in the Blackfoot watershed.

Table 1. A summary of average weather information for 6 weather stations located in the Blackfoot watershed, Montana (Source: National Climatic Data Center, www.ncdc.noaa.gov).

Station (Elevation)	Average Values	Jan	Jul	Year
Garnet (6043)	Max Temperature (F^{o})	28.3	78.0	48.7
	Min Temperature (F^{o})	10.0	42.1	24.4
	Total Precipitation (in.)	2.5	1.4	26.4
	Total Snowfall (in.)	30.1	0.0	180.4
	Snow Depth (in.)	28.0	0.0	14.0
Lincoln Ranger Station (4575)	Max Temperature (F^{o})	30.3	81.3	54.8
	Min Temperature (F^{o})	10.7	42.4	26.7
	Total Precipitation (in.)	1.9	1.2	18.5
	Total Snowfall (in.)	20.5	0.4	85.1
	Snow Depth (in.)	12.0	0.0	4.0
Lincoln 14 NE (5154)	Max Temperature (F^{o})	25.0	77.8	51.2
	Min Temperature (F^{o})	-1.6	38.6	22.5
	Total Precipitation (in.)	1.4	1.1	21.2
	Total Snowfall (in.)	21.9	0.0	127.4
	Snow Depth (in.)	17.0	0.0	7.0
Mike Horse (5052)	Max Temperature (F^{o})	24.3	63.4	49.8
	Min Temperature (F^{o})	5.3	37.2	26.4
	Total Precipitation (in.)	2.3	3.2	24.3
	Total Snowfall (in.)	19.5	3.5	125.5
	Snow Depth (in.)	21.0	0.0	8.0
Ovando (4109)	Max Temperature (F^{o})	27.2	81.9	54.2
	Min Temperature (F^{o})	5.4	41.6	24.5
	Total Precipitation (in.)	1.7	1.0	16.9
	Total Snowfall (in.)	20.1	0.0	78.6
	Snow Depth (in.)	7.0	0.0	2.0
Potomac (3620)	Max Temperature (F^{o})	30.9	83.0	56.3
	Min Temperature (F^{o})	9.4	41.5	25.3
	Total Precipitation (in.)	1.4	0.9	14.6
	Total Snowfall (in.)	15.8	0.0	55.0
	Snow Depth (in.)	8.0	0.0	2.0

Source: Western Regional Climate Center (www.wrcc.dri.edu)

NATIVE ECOSYSTEM DIVERSITY

Native ecosystems represent the combination of communities of living organisms with the physical environment in which they live. The range of ecosystem conditions, or native ecosystem diversity, occurring across a landscape and available as habitat for plants and animals is the result of disturbance processes (e.g., grazing, fire, etc.) interacting with site conditions and climate. Native ecosystem diversity is often described by the range of vegetation communities occurring on similar sites, as these are often the most obvious characteristic to the observer when trying to delineate differences among sites. While ecosystems can be clearly distinct from each other, more frequently they have less clearly defined edges that transition from one ecosystem type to another. However, in order to describe and quantify the amounts of these ecosystems for assessment and management purposes, it is necessary to map a line between ecosystems while recognizing that these delineations may not always be obvious to the naked eye without more detailed field surveys or assessments.

HISTORICAL DISTURBANCE AND THE HISTORICAL REFERENCE

An important factor in identifying the native ecosystem diversity that occurred on a landscape is an understanding of the influence of historical disturbance regimes on vegetation structure, species composition, and spatial distribution (Aplet and Keeton 1999, Morgan et al. 1994, Haufler et al. 1999). Some of the more common disturbance regimes within North America include fire, insects, disease, hurricanes, windthrow, grazing, and flooding. Understanding the role disturbance plays in ecosystem dynamics is critical to understanding the consequences of current and future management choices (Averill et al. 1995, Pickett and White 1985, and Agee 1993). Some have suggested that management that attempts to emulate historical disturbance regimes will produce plant community compositions and structures that are similar to the conditions that supported all of the native biodiveristy (Hunter 1993, Swanson et al. 1993, Cissel et al. 1994, Haufler et al. 1999, Landres et al. 1999, Kuuluvainen 2002). Prior to Euro-American settlement, the primary historical disturbance regimes occurring in the Blackfoot watershed that had a profound influence on the species composition, structure, and processes of terrestrial plant communities included fire and grazing. The influences of these disturbance elements on terrestrial ecosystem diversity are discussed in more detail in the following sections. Native Americans also interacted and influenced ecosystem diversity for thousands of years in the Blackfoot watershed. Typically their influence included using naturally occurring disturbance processes to benefit their subsistence strategies, such as using fire to create better wildlife habitat for hunted species or to open up travel corridors (Williams 2005, Arno et al. 1997). The influences of naturally occurring disturbance processes and their use by Native Americans, on historical ecosystem diversity are incorporated in what is known as the historical reference.

Historical references are utilized in ecosystem assessments to help identify, describe and quantify the native ecosystem diversity that occurred in a region. For the purpose of this assessment, an historical reference is defined as the ecosystem diversity that resulted from both historical disturbance (i.e., fire, grazing, etc.) and human-influenced disturbance (i.e., Native American) that created the dynamic conditions that plant and animal species were adapted to and dependent upon. It is based on the assumption that native species evolved within a limited range of conditions that resulted from the natural and human-influenced disturbance regimes and processes operating in that landscape (Holling 1973, Swanson et al. 1993, Reeves et al. 1995, Landres et al. 1999). Historical disturbance regimes are the patterns of frequency and intensity that can be quantified using ecological evidence. For example, both fire and grazing regimes are frequently described relative to frequency of occurrence and relative intensity. The historical reference incorporates the influence of climate extremes for the time period of reference. Future climate change scenarios can be evaluated against the historical reference to better understand the implications of future projections and their influence on native ecosystem diversity.

Another term often used in relation to historical reference is the historical range of variability. Historical range of variability is an important concept because it emphasizes that many ecosystems varied in amounts, compositions, and structures due to variations in climate and stochastic events that influenced historical disturbance regimes (Aplet and Keeton 1999, Haufler et al. 1999). For ecosystem assessment purposes relative to biodiversity objectives, historical references are usually confined to a period less than 1000 years prior to Euro-American settlement, as these reflect the habitat conditions most relevant to the plant and animal species that are present today (Morgan et al. 1994). Quantifying historical references may be a difficult task in some areas due to a lack of ecological information to help describe the effects of historical disturbance, such as fire regimes in grassland ecosystems for example. Furthermore, native ecosystems were not static during any defined reference period. Species distributions were changing, disturbance regimes were changing, and species themselves were adjusting, usually slowly, to these changes through behavioral and genetic adaptations. However, developing an understanding of the ecosystem diversity that occurred during an identified timeframe prior to Euro-American settlement provides critical reference information for defining and quantifying a baseline of what should be considered “natural” or “native” for an area.

Fire

Relative to terrestrial ecosystems of the Northern Rockies that include the Blackfoot watershed, fire was the primary disturbance agent directly influencing terrestrial plant species composition, structure, and spatial distribution (Agee 1993, Arno et al. 2000, Romme and Despain 1989, Fisher and Bradley 1987, Wellner 1970). While insects and disease were and continue to be important disturbance agents as well, their influences often precede and contribute to the occurrence and severity of fire as the end result. For the purposes of describing native ecosystem diversity in this landscape, we use fire as the primary historical driving force of large-scale disturbance and vegetation characteristics within this landscape.

Based on historical accounts (Arno 1980, Gruell 1983, Wellner 1970) and recent fire-scar studies (Agee 1993, Agee 1998, Agee 2004, Brown 1974, Fischer and Bradley 1987, Arno et al. 1997, Arno et al. 1995, Barrett 2002), fire in the Blackfoot watershed was a relatively frequent disturbance event prior to Euro-American settlement. Many anecdotal and scientific reports have documented the widespread occurrence of fire throughout the region. The causes of these fires were both natural (i.e., lightning) and human-initiated (i.e., Native Americans) (Pyne 2001).

Since Euro-American settlement, many human activities and land uses have functionally suppressed, eliminated or changed many of the historical disturbance regimes throughout North America. The result has been changes to many native ecosystems and their associated biodiversity. For forest ecosystems in the Blackfoot watershed, the primary influence in this regard has been the harvest of timber and the reduced role of fire regimes for nearly 100 years. Land use and land management programs and policies that have functionally suppressed fire in the landscape have had profound effects on many ecological communities, ecosystem processes, and the biodiversity dependent on the fire-influenced native condition. Understanding and quantifying these changes is critical to the success of ecosystem restoration programs to benefit biodiversity conservation, as well as understanding and mitigating the future potential impact of climate change.

The following sections discuss the role of fire in the Blackfoot watershed relative to the primary terrestrial vegetation types occurring in this landscape, forest and grass-shrub ecosystems.

Forest Ecosystems

Fire has been a natural part of the Northern Rockies landscape for thousands of years and many species of plants and animals have become fire-adapted or even fire-dependent over time (Agee 1993). Fire-adapted plant species or ecosystems such as ponderosa pine have developed physical adaptations such as thick bark to protect larger trees from low severity fires (Fitzgerald 2005). Fire-dependent species have developed life cycle strategies to take advantage of fire events such as the serotinous cones of lodgepole pine.

The term “fire regime” is often used to describe the different ways that fire interacts on the landscape to influence the structure and species composition of vegetation, as well as vegetation patterns on the landscape. The term “fire severity” is used to refer to the degree of impact that fire has on an ecosystem and is frequently defined using the degree of overstory tree mortality. Fire regimes incorporate the various levels of fire severity and intensity across similar sites and their effects on the dominant vegetation. In the Blackfoot region, researchers frequently describe the effects of fire using three broad classes of fire regimes: non-lethal, mixed-severity, and lethal. Factors that can influence fire regimes include climate, ecological site, and vegetation. Trends in historical fire frequency and extent are related to climatic trends in temperature and precipitation with temperature trends affecting fire frequency and precipitation trends affecting fire extent (Swetnam 1993, Swetnam and Baisan 2003). In general, more frequent fires occur on warmer sites and less frequent fires occur on cooler sites. Similarly, larger burn patches occur under dry conditions and smaller burn patches occur under moist conditions. In the Blackfoot watershed, non-lethal fire regimes are usually associated with low to moderate elevation warmer and drier sites, mixed-severity fire regimes are usually associated with mid- to high elevation warmer and moister sites as well as cooler and drier sites, and lethal fire regimes are usually associated with mid-to high elevation cooler and moister sites. Sites that are influenced by the non-lethal and mixed-severity fire regimes are also frequently less steep (<20% slope) than those sites influenced by the lethal fire regime. While these site characteristics are the more common drivers of fire regimes in this landscape, additional site influences such as frost pockets and juxtaposition to adjacent fire regimes, can create exceptions to these general rules.

The non-lethal fire regime is usually described as having relatively frequent, low to moderate severity fires that burn along the surface of the ground and remain within the forest understory, thereby being relatively non-lethal to the older trees in the overstory. Mean fire return intervals for non-lethal fire regimes are usually less than 25 years for forests in the western United States. The frequency of these fires influence both the species composition and vegetation structure within these forests. Fire-adapted species become dominant in the overstory and bunchgrasses become dominant in the understory. Under drought conditions, fires can occur over larger areas but still are unlikely to kill the overstory trees. The potential for insect or disease events are low and usually occur in small patches. The non-lethal fire regime contributes to the persistence of a multi-age stand, which in some cases may be composed of patches of even-aged groups. A wide range of age classes can occur, from saplings to old growth trees, but with relatively low numbers of trees per acre. However, when viewed at the stand level, forests influenced by a non-lethal regime typically have a clear presence of larger, older, fire-adapted trees in the overstory, even if their numbers are relatively low per acre (i.e., 8 to 30 tpa). For this reason, historical references to these forests often describe them as relatively “open and park-like”. Stand history studies conducted within forests historically influenced by the non-lethal fire regime demonstrate that they had relatively predictable species composition and structure (Smith and Fischer 1997) as this fire regime appears to act as an agent of ecosystem stability. The result is a fairly uniform forest pattern at both the landscape (i.e., 100’s to 1000’s of acres) and stand levels (i.e., roughly 50 acres).

The lethal fire regime is characterized by infrequent, high-severity fire that consumes most of the forest understory and overstory as it moves across the landscape. Lethal fire regimes result in a stand replacing effect on forest conditions, in contrast to the persistent, yet less obvious effects of the non-lethal fire regime. The result of this impact is to set the forest back to an early seral stage and release fire-dependent species stimulated by severe fire events such as lodgepole pine. Mean fire return intervals under the lethal fire regime are frequently described as greater than 100 years for forests in the western United States (Agee 1998). The forest then proceeds along an undisturbed successional trajectory for many years, depending on the ecological site. Tree densities are high and early seral conditions are usually dominated by single age-classes. Tree species that are susceptible to fire are a common component of the forest, particularly at late seral stages. Due to the higher densities of trees, the potential for insect and disease events is high. The resulting forest patterns are large patches of variable age-classes and seral states at the landscape level but relatively uniform age-classes and conditions at the stand level.

The mixed severity fire regime produces highly diverse forest conditions with elements of the non-lethal and lethal fire regimes occurring at a finer scale. It is described as having a complex mosaic of varying patch sizes of both the low severity and high severity fire effects. Some of these patches underburned as with a low severity fire and some had their overstory tree canopy mostly or completely killed as with a high severity fire. Within sites influenced by the mixed-severity fire regime, the amount of the non-lethal condition versus the lethal condition is likely dependent on the site. Warmer and drier sites exhibit a higher percentage of non-lethal conditions while cooler and moister sites would exhibit a higher percentage of lethal conditions. Sites with high relief exhibit the greatest fine-scale spatial variation in patchiness and age structures. Sites of low relief exhibit less variation in patch sizes and age structures. Mean fire return intervals for mixed-severity fire regimes are frequently described as ranging from 25 to 100 years for forests of the western United States (Agee 1998, Arno et al. 2000). The potential for insect or disease events are variable depending on tree densities. The resulting forest patterns are relatively uniform and stable at the landscape level but highly variable at the stand level.

A fire regime classification that is based on fire effects attempts to incorporate the physical attributes of the site and fire as well as the fire tolerance of the vegetation (Agee 1998). While recognizing that fire severities, and thereby fire regimes, occur along an environmental gradient and may not be stable over space and time (Agee 1998), a classification system can help to communicate and quantify the potential influences of different fire regimes on a landscape. To capture some of these influences and reduce some of the variability in the mixed-severity fire regimes of the Blackfoot watershed, we have chosen to further divide the mixed-severity fire regime into 2 classes; mixed-severity A and mixed-severity B. Figure 3 defines the resulting fire regime classification system for the Blackfoot watershed relative to overstory tree mortality as used in this assessment.

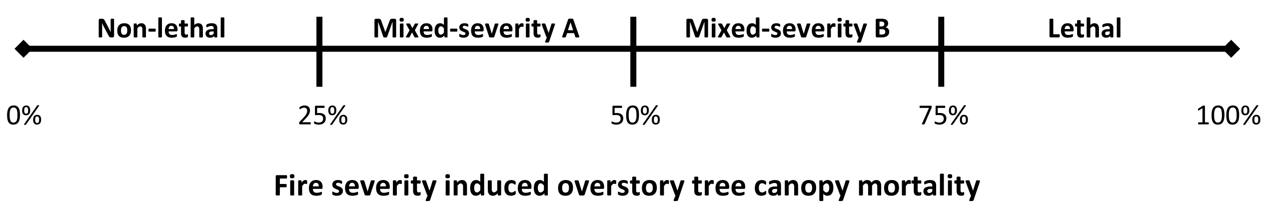


Figure 3. Fire regime classes identified for the Blackfoot watershed relative to the gradient of average fire severity induced overstory tree canopy mortality.

In addition, relative to forest patterns, the mixed-severity A fire regime is differentiated from the mixed-severity B fire regime by the pattern of low-moderate severity fire conditions versus high severity conditions occurring at the stand level. The mixed-severity A fire regime is dominated by a matrix of low-moderate severity fire conditions and smaller inclusions of the high severity fire conditions. Whereas the mixed-severity B fire regime is dominated by a matrix of high severity fire conditions and smaller inclusions of low-moderate severity fire conditions. Figure 4 provides a visualization of the average fire severity patterns expected for each of the four fire regime classes as well as the expected percent composition of low-to-moderate (for simplicity, future reference to this condition will be condensed to "low severity") versus high severity fire influenced conditions occurring in the Blackfoot watershed.

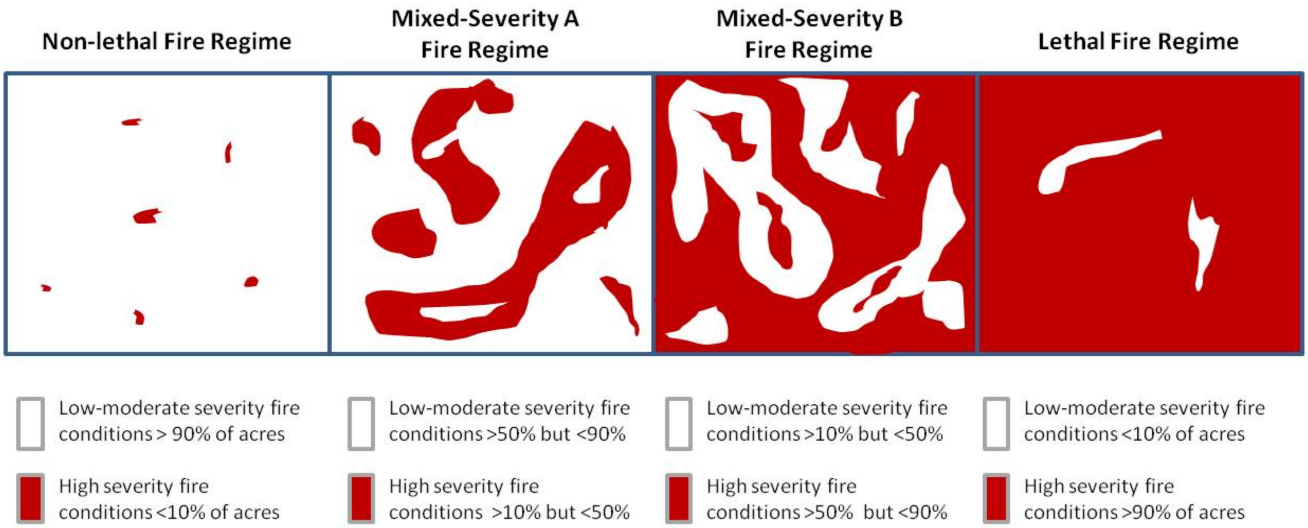


Figure 4. The average fire severity patterns expected to characterize the four fire regime classes of the Blackfoot watershed for stands of approximately 50 acres in size (as modified from Agee 2004).

Grass-shrub Ecosystems

In grass and shrub ecosystems of the Blackfoot watershed, fire is closely linked with climatic cycles as even brief dry periods can provide conditions that favor fire. For thousands of years, fire events have been an integral part of these ecosystems (Daubenmire 1968). In addition to lightning starts in grass-shrub ecosystems, burning was used by Native Americans to maintain or increase grass dominated areas and provide movement corridors favorable for bison herds to move among and into the mountain valleys from the nearby prairies (Kay et al. 1999).

Many plant species have developed strategies to benefit from fire, thereby contributing to a landscape mosaic of greater species and structural diversity resulting from the fire regime (Daubenmire 1968, Anderson 1990). Grass species in particular exhibit a number of characteristics and strategies that are suited to a fire-prone landscape, where low humidity and low soil moisture are more common (Daubenmire 1968). In general, fire-dependent ecosystems are expected to burn more easily than non-fire dependent ecosystems, as they have traits that make them more flammable (Mutch 1971). For example, grassland ecosystems often produce biomass that may not decompose in a given year or a multitude of years. If a site is not grazed to remove the year's growth, it will become more vulnerable to fire. Many studies have documented the significance of fire in maintaining a grassland's equilibrium (Collins and Barber 1985, Heisler et al. 2003, Anderson 1982). Yet, it is important to note that even in a single landscape, the differences between abiotic conditions influencing ecological sites can contribute to different fire regime characteristics in terms of frequency, severity, and patch size.

The effects of fire on grass-shrub ecosystems are a function of the fire's frequency and intensity, as well as the season that the fire occurred. Fire return intervals were often variable due to climate, site conditions or previous grazing disturbance. Lightning strikes, coupled with Native American burning, were a primary cause of natural occurring wildfire events in the Blackfoot watershed. Lightning caused fires occurred from May to October but the majority occurred during mid-to late summer (Handel et al 2010). Specific information on the spatial extent of historical fires in grass and shrub ecosystems is not available but fires occurring during the growing season are expected to have been limited in spread by green vegetation, grazed vegetation, and higher levels of humidity. Those fires occurring during drought conditions or after the growing season may have had the greatest spatial extent. Even within a fire-dominated landscape, microhabitats existed intermixed within wetland and riparian areas, and other fire-protected locations where fire-intolerant species could persist in relatively small amounts.

Fire influences grass and shrub vegetation in a number of ways. Depending on the season, fire can have a substantial effect on species diversity. For example, spring burning increases the dominance of bunchgrasses and reduces the cover of short-statured sodgrasses (Kucera 1978). Fires occurring during the growing season can limit spread or occurrence of shrubs and other woody vegetation outside of riparian and wetland areas (Kucera 1978). In the western US, fire regimes in grass-shrub ecosystems are often referred to as short and long fire return intervals. Short fire return intervals, usually <25 year mean fire return intervals (mfri), tend to favor dominance by grass species by frequently removing most of the shrub and woody vegetation. Long fire return intervals, usually >= 25 years mfri, allow shrub and woody vegetation to increase and become dominant or co-dominant with grass species.

Fire also releases important nutrients into the soil for root uptake as well as releases nutrients bound in litter. Removal of plant litter also changes light and temperature levels at the ground level, influencing plant productivity and growth conditions (Vinton and Collins 1997). Fire produces dark ash, which has a warming effect on the soil and thereby gives warm season grasses an advantage the following spring. In rough fescue dominated grasslands, long periods between fires combined with no grazing can result in larger clumps and higher fuel levels that reduce the survival and recovery of rough fescue for several years post-fire (Antos et al. 1983).

Grazing

The history of the bison in the grass-shrub ecosystems of the Rocky Mountains is not well-understood. Early trapper and explorer accounts of the bison in the Intermountain Region of the Rocky Mountains often made reference to the "mountain bison" (Cannon 2008). The mountain bison is described as having physical and behavioral differences from the plain's bison in that herd sizes were much smaller, 5 to 30 animals, migratory patterns were elevational, and animals were much warier of humans (Meagher 1973). Other researchers have suggested that the terrain of the Rocky Mountain region may have provided more opportunity for intermittent population isolation that resulted in phenotypic differences in appearance and behavior in response to environment (Wilson and Stroebeck 1999, Cannon 2008). Christman (1971) provided historical evidence for a subspecies of bison (*Bison bison*) referred to as the wood or mountain bison (*Bison bison athabascae*) that occurred in the Northern Rocky Mountains. The fossil record also supports the long presence of bison in the grass dominated ecosystems of the Rocky Mountain region (Burkhardt 1996). Christman (1971) and Burkhardt (1996) suggest that mountain bison were historically more numerous than observed at the time of explorers such as Lewis and Clark, but may have been significantly reduced in numbers during that time due to the acquisition of horses by the Native Americans in the late 1700's and the inherent vulnerability of smaller herds to this style of hunting, as well as a century of prior fur trapper concentration in the Rocky Mountains that may have also reduced the number of bison in this region. More specific to the Blackfoot watershed, bison sign and bison herds were documented by early explorers in or very near the watershed (Lewis and Clark 1806, as referenced in Burroughs 1995; and John Work 1831, as referenced by Lewis and Phillips 1923). The "mountain bison" are believed to have been functionally extinct in the regions by the 1840's (Meagher 1973) due to overhunting.

So while there is little disagreement that bison occurred in the grasslands of the Intermountain Region prior to their extermination, there is less agreement on the numbers of bison influencing the region. However, most researchers would agree that the numbers were considerably below the large bison populations occurring further east on the plains. Yet, where bison do occur, no single species has more ecological effects on grass-shrub ecosystem states and processes and it is for this reason considered a keystone species. Though, in the Intermountain Region, the reduced numbers of bison would suggest that these ecosystems did not experience the same prolonged and intense grazing that occurred on the Great Plains by large herds of bison (Malainey and Sherriff 1996, Kay et al. 1999, Daubenmire 1985). While grazing by bison and other herbivores was also likely to have occurred in the forest ecosystems of the watershed, particularly immediately adjacent to grass-shrub ecosystems, less information is available on its effects on plant species compositions and structures in these ecosystems.

In general, grazing levels in the Intermountain region are believed to have occurred at primarily light to moderate levels in the centuries prior to Euro-American settlement, as discussed below, with heavy grazing occurring more rarely and in small patches, or intermittently over larger areas when drought conditions would drive the plain's bison to moister regions. However, loss of bison from the Intermountain grasslands occurred before any meaningful research could be conducted on their foraging habits and movement patterns (Isenberg 2000), so their grazing effects on grasslands remain speculative. Much of the information we have today is extrapolated from herbivore studies of similar grazing systems around the world or from research conducted on the remaining small bison herds that are confined within relatively small portions of a landscape.

Studies of large herbivores and bison grazing have demonstrated that landscape level grazing is often influenced by slope, juxtaposition to water sources, and recent fire events that influence forage quality (Soper 1941, Bailey et al. 1996, Coppedge and Shaw 1998). Bison, like most herbivores, require a regular supply of water. Those sites surrounding rivers, lakes, and ponds will receive a disproportionate amount of grazing due to the congregating herd of animals and concentrated travel corridors. Those sites farthest from water sources will receive the least amount of grazing (Soper 1941). Many researchers have also found that a recent burn site will attract bison (Frank et al. 1998, Bamforth 1987, and Biondini et al. 1999). The release of soil nutrients and the corresponding rapid new growth represents high-quality forage for several seasons following a fire event. Researchers today have noted that it is a relatively rare event in grasslands throughout the world for herbaceous re-growth to go un-grazed following a fire (Frank et al. 1998). There is also evidence that Native Americans purposely started fires to make grasslands more attractive to bison and to encourage the movement of bison to areas where they could be more easily hunted (White et al. 2001).

The historical fire and grazing disturbance regimes interacted to provide a mosaic of disturbance states across the Blackfoot watershed grass-shrub ecosystems. The amount of forage removed from a site and its distribution in the landscape determined the probability and intensity of the next fire event. Thus, the combination of fire and grazing produced the dynamic habitat mosaic and landscape heterogeneity to which the region's plant and animal species are well adapted (Hartnett et al. 1996).

Ecologists frequently characterize grassland ecosystems by the un-grazed height or stature of the dominant grass species (e.g., tallgrass, mixed-grass, and short-grass). The dominant grass species, and consequently grass height, is a function of both precipitation and grazing (Truett 2003). In general, the height and stature of dominant grasses within the Blackfoot watershed produce a mixed-grass stature that will decrease or increase in height with corresponding levels of precipitation, as well as drought cycles. The height and stature of dominant grasses will also decrease with increased grazing intensity.

At the ecosystem level, bison grazing influences the grassland community in many ways (Hartnett et al. 1996, Hartnett et al. 1997, and Knapp et al. 1999). Bison prefer grasses over forbs, with greater than 90% of the diet consisting of grasses. Their grazing patterns thereby increase the ratio of forbs in the community. Many of the more palatable bunchgrass species present in the Blackfoot watershed, such as rough fescue and bluebunch wheatgrass, decrease in amounts with increased grazing levels while many of the less palatable species, such as Idaho fescue, needleandthread, western wheatgrass, and Sandberg bluegrass, increase. The interaction of fire and grazing regimes on the species compositions and structures in a plant community represent the range of conditions or ecosystem diversity that can occur on a given site. Bison have also been shown to influence the survival of saplings and shrubs in or surrounding grassland areas (Coppedge and Shaw 1997). Horning and rubbing activity is frequently associated with the rut, shedding of winter pelage, and insect harassment. Horning and rubbing can cause significant damage to saplings and shrubs and may have, in addition to fire and drought influenced the distribution of woody vegetation in these ecosystems.

In addition to bison, other wild ungulates have and continue to use the grass-shrub ecosystems of the Blackfoot watershed to varying degrees including elk, deer, antelope, moose, and to a lesser extent, mountain sheep and mountain goats. The more common native bunchgrass species, rough fescue and bluebunch wheatgrass, are both highly preferred forage by wild ungulate species. While many ungulate species, such as deer and moose, are primarily browsers (i.e., prefer shrubs and trees), elk are generalists that rely heavily on grasses.

Another historical grazer that likely had intermittently profound influences on the grass-shrub ecosystems of the Blackfoot watershed was the Rocky Mountain grasshopper or locust. The locust periodically formed enormous swarms that moved between their breeding grounds in the lowlands of the Rocky Mountains to the prairies of the Mississippi and Missouri Valleys. Six major "plagues" were recorded between early 1800 and 1875 (Riley 1877) before the species went extinct. These plagues could cover thousands of acres where all vegetation in the swarm's path was consumed (Skinner 2000).

Framework and Methods for Describing Native Ecosystem Diversity

Terrestrial ecosystems of the Blackfoot watershed, as stated previously, are the combination of communities of living organisms with the physical environment in which they live. To characterize native ecosystem diversity, we used a combination of two primary drivers of ecosystem diversity; ecological sites and disturbance states. Ecological sites represent the physical environment component of an ecosystem and disturbance states represent the vegetation communities that can occur on an ecological site in response to historical disturbance regimes. The following sections provide a more detailed discussion of the importance of delineating ecological sites and identifying disturbance states to efforts at describing the native ecosystem diversity of a region as well as the methods used to describe and map ecological sites and disturbance states.

Ecological Sites

The term ecological site has been used in various capacities by different ecological disciplines for many years. For the purpose of the ecological framework described in this document, we are using ecological sites as defined and developed by the Natural Resource Conservation Service (NRCS 2006). NRCS ecological sites are a type of potential-based landscape classification system that identifies the different abiotic conditions (e.g., soils, aspect, elevation, temperature, moisture, etc.) that influence disturbance patterns and the potential plant communities that can occur on a site (USDA Natural Resources Conservation Service 1997, Bestelmeyer et al. 2009). They are based on the assumption that the differences in potential plant communities are influenced by these abiotic differences among sites (Bestelmeyer et al. 2006, Fuhlendorf and Smeins 1998).

Ecological sites may contain multiple soil types provided they exhibit similar properties that produce and support a characteristic plant community in response to similar disturbance processes. The soils characterizing an ecological site have developed over time through the interaction of parent material, climate, living organisms, and topography. This, in turn, influences the kind of plants that can occur and the combination of the plants and soils further influence the hydrology of a site, more specifically the amount of runoff and infiltration. The development of the soil, vegetation, and hydrology are therefore all interrelated and each influences and is influenced by the other. Each site responds similarly to drivers of ecosystem change such as climate, disturbance regimes, land-use practices, and management activities. For classification purposes, ecological sites are differentiated from each other based on several considerations including differences in plant species composition and productivity, differences in management response, and the processes of degradation and restoration (Bestelmeyer et al. 2009).

Plant communities change along environmental gradients. Ecological sites help delineate these gradients. Where changes in soil, geomorphic setting, or moisture conditions are abrupt, plant community boundaries can be distinct. Where boundaries are more gradual, plant community change will be less distinct and occur along wider environmental gradients of soils and topography.

Describing and Mapping Ecological Sites

The NRCS ecological site classification is correlated to existing NRCS soil maps (NRCS, Soil Survey Geographic Database (SSURGO)) and can therefore be displayed and mapped in a GIS. While the NRCS ecological site classification is suitable for the objectives of the ecosystem diversity framework described here, some limitations should be noted. A primary limitation is the fact that current soil mapping methodologies are often based on groupings of soils and may include minor inclusions of other soil types that may in fact represent another ecological site occurring within the larger soil type. As with most classification systems, the issue of mapping resolution is a common theme. While soil mapping is often finer resolution data than most existing vegetation classification systems, it is still likely to represent less diverse conditions than actually occur on the landscape.

To describe and map the ecological sites of the Blackfoot watershed, NRCS ecological site descriptions were obtained from the Montana NRCS. In 2009, the Montana NRCS initiated a new classification system as well as descriptions of ecological sites in Montana. We obtained the draft descriptions for use with this project. However, the Blackfoot watershed represents a transition zone between the Central Rocky Mountains and Central Rocky Mountain Valley Major Land Resources Area's (MLRA) and the Northern Rocky Mountain and Northern Rocky Mountain Valley MLRA's (USDA, NRCS 2006a and 2006b). Nearly all of the plot locations used to develop the existing ecological site descriptions were located outside the Blackfoot watershed. Ecological site descriptions were therefore reviewed for all MLRA's and for applicability to the Blackfoot watershed, and adjusted where better information was available. In addition, a reconnaissance level field survey was conducted in grass-shrub ecological sites to augment some of the native species information in the Blackfoot watershed. The methods and results of this field survey will be described in a following section.

For the purposes of this project, ecological site descriptions were sometimes grouped where similar dominant vegetation and disturbance responses were expected. NRCS ecological site descriptions have not been developed for forest ecological sites of the Blackfoot watershed. Forest ecological sites were developed using previously mapped soils data, as well as associated soils and site information available with the SSURGO dataset. SSURGO soils data were not available for the entire watershed, in particular the high elevation regions. Where SSURGO data was lacking, US Forest Service Land Systems Inventory data was correlated to SSURGO soils data, to fill these gaps. In addition, the relative effective annual precipitation data (MT Natural Resource Information Service 2009) were used. Digital Elevation Models were also used to develop information on site moisture. Forest habitat type information (Pfister et al. 1977) was used to help describe the forest ecological sites. Existing data-sets containing spatially-related habitat type classification points (US Forest Service and EMRI data) were used to evaluate assumptions and results of the forest ecological site mapping effort.

At the time of this project, Montana SSURGO data had not been updated to reflect the new grass-shrub ecological sites and was therefore not readily available for direct mapping. To facilitate the mapping of grass-shrub ecological sites, soils data were used in combination with the Montana ecological site key to classify the new ecological sites to the existing soil maps. In several instances the ecological site may have been grouped with similar ecological sites if the associated plant communities and vegetation structure was similar at the resolution needed for this project. The results of the ecological site mapping effort are displayed in Figure 5 for forested ecosystems and in Figure 6 for grass-shrub ecosystems.

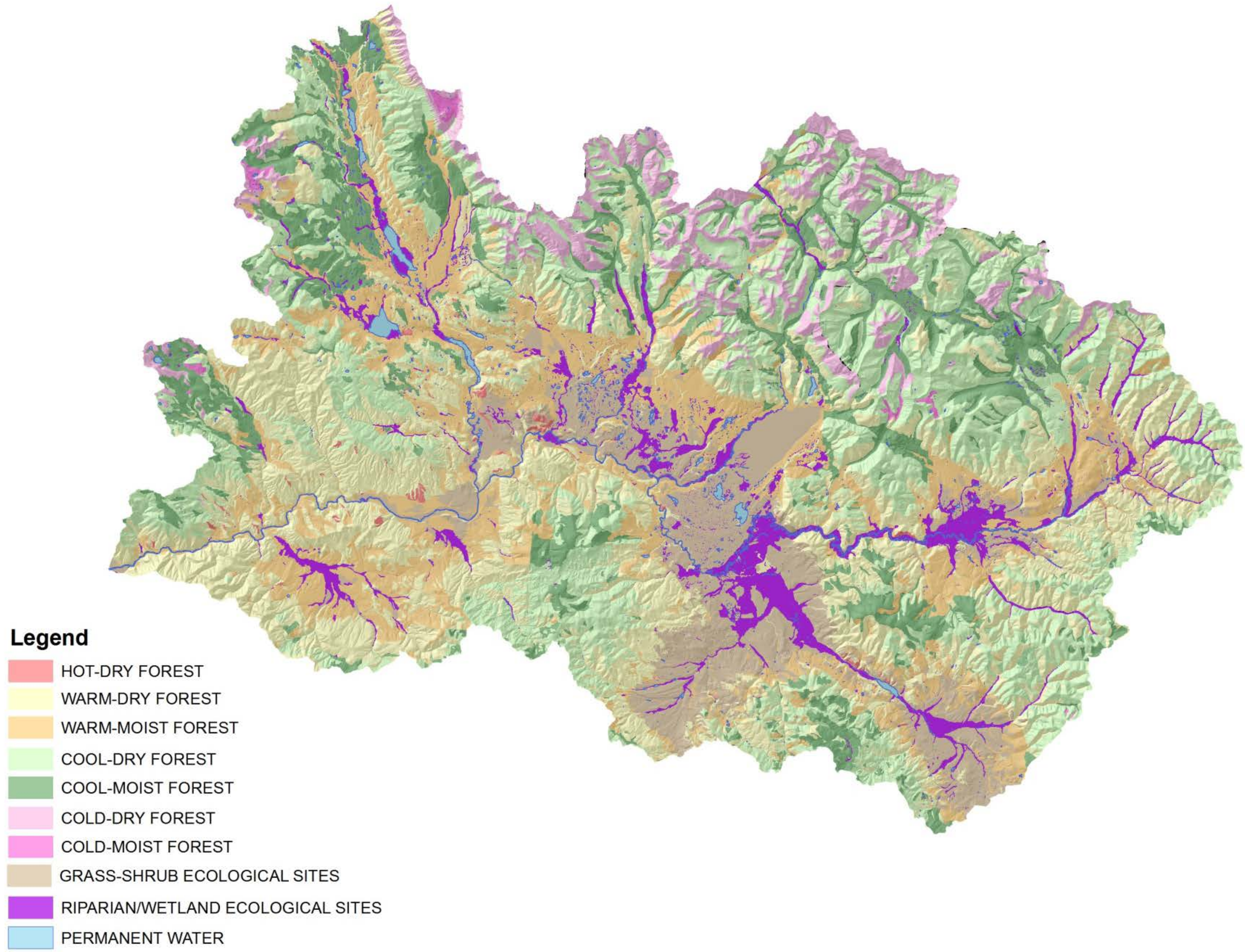


Figure 5. Map of the forest ecological sites for the Blackfoot Watershed subregion.

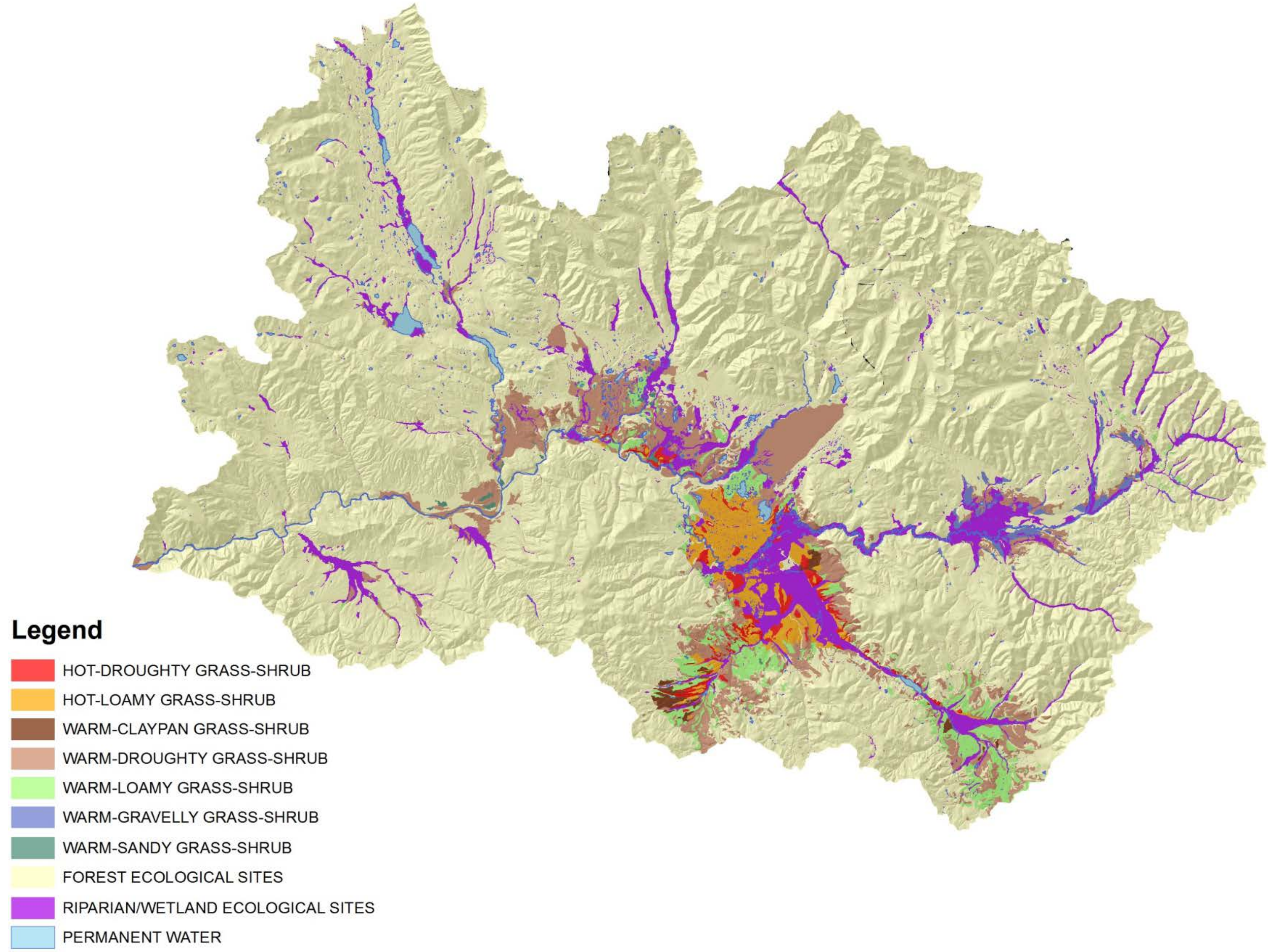


Figure 6. Map of the grass-shrub ecological sites for the Blackfoot Watershed subregion.

Table 2 identifies the number of acres for each of the 14 mapped terrestrial ecological sites identified for the Blackfoot watershed, plus the categories of wetland/riparian sites and permanent water.

Table 2. Number of acres for each of the 16 ecological sites and their percent representation within the Blackfoot watershed.

Ecological Site	Acres	% of watershed
Hot-Dry Forest	3,868	0.3
Warm-Dry Forest	381,723	25.8
Warm-Moist Forest	236,436	16.0
Cool-Dry Forest	356,888	24.1
Cool-Moist Forest	172,364	11.7
Cold-Dry Forest	85,397	5.8
Cold-Moist Forest	3,902	0.3
Hot-Droughty Grass-shrub	8,220	0.6
Hot-Loamy Grass-shrub	21,500	1.5
Warm- Droughty Grass-shrub	84,300	5.7
Warm-Loamy Grass-shrub	29,740	2.0
Warm-Sandy Grass-shrub	1,320	0.1
Warm-Gravelly Grass-shrub	4,770	0.3
Warm-Claypan Grass-shrub	2,950	0.2
Wetland/Riparian	74,088	5.0
Water	11,935	0.8
Total	1,479,401	

Available NRCS Ecological Site Descriptions (ESD) were obtained and used to help define historical plant communities and states as well as their primary drivers or transitions in terms of disturbance regimes. Descriptions were developed of the compositions and structures of each historical disturbance state as influenced by the historical disturbance regimes that affected each state. The descriptions of each state used information contained in the existing ESD's, the field survey (see following section), information on species responses to historical disturbances available from the NRCS PLANTS database (USDA, NRCS 2010), US Forest Service Fire Effects Information System (FEIS) (USDA, Forest Service 2010), as well as other sources and input from range ecologists. For each native ecosystem, the descriptions were developed as a historical reference condition for evaluating impacts and developing restoration objectives. These descriptions should be evaluated and updated on a regular basis, as new information becomes available.

- **Rapid Assessment Field Survey for Grass-shrub Ecosystems**

In August of 2010, a rapid assessment field survey was conducted to identify some of the native plant species occurring on grass/shrub ecological sites of the Blackfoot watershed. As mentioned previously, while draft ESD's for grass-shrub ecological sites were available for the region, the data used in the development of the ecological sites were generally obtained from areas outside the Blackfoot watershed. NRCS personnel (Walter Luhan, Missoula NRCS, personal communication) indicated that future plans call for refining the ecological site data with information obtained in the Blackfoot watershed, but these surveys have not been scheduled at this time.

The rapid assessment field survey was used to augment the interpretation of NRCS draft ESD's and their applicability to the Blackfoot watershed. Adjustments were made where necessary to reflect the species composition of the Blackfoot watershed as identified in the rapid-assessment field surveys. However, this information should be considered preliminary and future efforts to obtain more accurate information on ecological site delineation and species composition in the Blackfoot watershed should be considered a priority for conservation efforts in grass-shrub ecosystems of watershed.

Field surveys were conducted in 19 locations on grass-shrub ecosystems. Both private and public lands were surveyed. Survey locations were selected that had a high likelihood of being dominated by native vegetation. Survey methods consisted of navigating to a pre-determined GPS point and identifying all species encountered along a 100 foot transect. The four most dominant of the seven ecological sites were selected for the rapid assessment field survey; Hot-Droughty, hot loamy, warm droughty, and warm loamy. Visually estimated percent cover was obtained for all species identified. Table 3 summarizes the results of the rapid assessment field survey for visual estimates of cover by ecological site.

Some of the important results of the field surveys include the occurrence of three-tipped sagebrush on all four ecological sites but with a significantly greater amount occurring on the hot loamy ecological site. Wyoming big sagebrush was notably absent from the surveys, though the low number of survey plots does not support removing this species from the species list at this time. Mountain big sagebrush was found on all four ecological sites but was less common on the hot loamy ecological site where three-tipped sagebrush was more common. Most of the grass and forb species observed in the field surveys overlapped with those identified in the existing NRCS ecological site descriptions. The results of the rapid assessment field survey are provided in Table 3.

Table 3. Cover estimates of native plant species by ecological site for grass-shrub ecosystems.

COMMON NAME	SCIENTIFIC NAME	PLANTS CODE	HOT DROUGHTY *(n=4)*	HOT LOAMY *(n=3)*	WARM DROUGHTY *(n=6)*	WARM LOAMY *(n=6)*
western yarrow	*Achillea millefolium*	ACMI2	0.0	0.0	0.4	0.2
Columbia needlegrass	*Achnatherum nelsonii*	ACNE9	6.0	3.0	6.9	0.9
Richardson's needlegrass	*Achnatherum richardsonii*	ACRI8	0.0	0.0	0.8	0.0
pale agoseris	*Agoseris glauca*	AGGL	0.0	0.0	0.1	0.0
onion	*Allium spp.*	ALLIU	0.0	0.0	0.0	0.1
rosy pussytoes	*Antennaria rosea*	ANRO2	2.5	0.0	0.4	0.2
ballhead sandwort	*Arenaria congesta*	ARCO5	0.5	1.3	0.0	0.4
praire sagewort	*Artemisia frigida*	ARFR4	3.6	1.2	0.2	6.0
white sagebrush	*Artemisia ludoviciana*	ARLU	0.0	0.0	0.3	0.1
threetip sagebrush	*Artemisia tripartita spp. Tripartita*	ARTRT2	0.3	59.4	2.4	1.0
mountain big sagebrush	*Artemisia tridentata spp. Vaseyana*	ARTRV	18.0	0.0	9.4	43.2
astragalus	*Astragalus spp.*	ASTRA	0.5	0.0	0.0	0.0
arrowleaf balsamroot	*Balsamorhiza sagittata*	BASA3	0.0	0.0	0.1	0.0
threadleaf sedge	*Carex filifolia*	CAFI	1.2	1.5	6.9	4.8
yellow rabbitbrush	*Chrysothamnus viscidiflorus*	CHVI8	0.6	0.0	0.1	0.4
bastard toadflax	*Comandra umbellata*	COUM	0.5	0.0	0.0	0.1
timber oatgrass	*Danthonia intermedia*	DAIN	0.6	0.0	2.7	0.0
slender buckwheat	*Eriogonum heracleaoides*	ERHE2	0.0	0.0	0.3	0.1
rubber rabbitbrush	*Ericameria nauseosa*	ERNA10	0.0	0.9	0.0	0.3
rough fescue	*Festuca campestris*	FECA4	3.0	3.0	28.3	31.7
Idaho fescue	*Festuca idahoensis*	FEID	12.0	6.0	10.4	8.6
old man's whiskers	*Geum triflorum*	GETR	0.0	0.0	0.1	0.0
sticky purple geranium	*Geranium viscosissimum*	GEVI2	0.0	0.0	0.1	0.0
broom snakeweed	*Gutierrezia sarothrae*	GUSA2	0.3	0.0	0.0	5.5
needle and thread	*Hesperostipa comata*	HECO26	0.0	0.0	1.8	0.0
hairy false goldenaster	*Heterotheca villosa*	HEVI4	0.0	0.0	0.4	0.0
Rocky Mountain juniper	*Juniperus scopulorum*	JUSC2	1.2	0.0	0.0	0.0
prairie junegrass	*Koeleria macrantha*	KOMA	0.0	4.2	3.1	1.1
western stoneseed	*Lithospermum ruderale*	LIRU4	0.5	1.0	0.1	0.1
lupine	*Lupinus spp.*	LUPIN	0.5	1.3	6.6	0.5
creeping barberry	*Mahonia repens*	MARE11	0.0	0.0	0.1	0.0
thinleaved owl's-clover	*Orthocarpus tenuifolius*	ORTE2	0.0	0.0	0.2	1.1
western wheatgrass	*Pascopyrum smithii*	PASM	0.0	6.0	4.4	0.3
Hood's phlox	*Phlox hoodii*	PHHO	0.0	0.5	0.0	0.0
Sandberg bluegrass	*Poa secunda*	POSE	7.2	1.2	1.1	1.1
cinquefoil	*Potentilla spp.*	POTEN	0.0	0.0	0.3	0.0
chockecherry	*Prunus virginiana*	PRVI	0.3	0.0	0.0	0.0
bluebunch wheatgrass	*Pseudoroegneria spicata*	PSSP6	39.0	27.0	10.3	9.4
Wood's rose	*Rosa woodsii*	ROWO	0.3	0.3	0.2	0.0
lambstongue groundsel	*Senecio integerrimus*	SEIN2	0.0	0.0	0.1	0.0
goldenrod	*Solidago spp.*	SOLID	0.0	0.0	0.2	0.6
scarlet globemallow	*Sphaeralcea coccinea*	SPCO	0.0	0.0	0.0	0.1
spineless horsebrush	*Tetradymia canescens*	TECA2	1.3	0.0	0.1	0.5
deathcamas	*Zigadenus venenosus*	ZIVE	0.0	0.0	0.1	0.0

Disturbance States

Historical disturbance regimes are often responsible for maintaining the dynamic landscape processes that are important drivers of ecosystem integrity as well as the persistence of biodiversity. Disturbance regimes occur across a wide range of spatial and temporal scales. Any effort to identify and describe native ecosystem diversity must include an understanding of historical disturbances regimes and their influence on various ecosystem variables such as successional pathways, thresholds, transitions, etc. Often, with this understanding, recognizable patterns emerge that allow us to describe and predict a given plant communities response to the frequency or intensity of a disturbance type.

For the purposes of the ecological framework, we use the term disturbance state to refer to a specific plant community that could occur on a specific ecological site in response to disturbance processes. A disturbance state describes a potential plant community or ecosystem that may occur on an ecological site in response to historical disturbance regimes but, because it is a generalization, it may include a certain amount of variation both spatially and temporally. The transition between disturbance states is due to the interaction of disturbance with the abiotic characteristics of an ecological site, combined with climate influences. A disturbance state can be transient or relatively persistent on an ecological site. Although ecological sites provide valuable information on the interaction of the physical environment with vegetation, they are combined with a classification of disturbance states to identify the full range of vegetative conditions or ecosystem diversity possible on an ecological site, as influenced by historical disturbance events and processes. We use the term disturbance state to refer to all distinct plant communities that we identify. Others may include the terms plant community or plant community phase as subsets of disturbance states, but we chose to not identify such distinctions.

A state and transition model (STM) is a framework that is used to summarize and describe the range of disturbance states for an ecological site. STM's help to describe patterns and mechanisms of vegetation response to identified disturbance processes on an ecological site by identifying the triggers, drivers, and mechanisms of transition among states (Bestelmeyer et al. 2009). They provide a record of the knowledge of disturbance states to date while also allowing for future adjustment as new information becomes available. Typically, state and transition models have been implemented through simple printed flowcharts that identify the range of disturbance states that can occur on an ecological site and the disturbance processes that will influence the transition from one state to another. Transitions can occur rapidly such as in the event of a fire or more slowly such as in the event of changes to the grazing regime. Sometimes multiple disturbance changes must occur simultaneously to trigger a transition to a different state.

It should be noted that most STM's in use today have been developed by NRCS to provide a scientific framework to evaluate and describe today's conditions. In that context, NRCS STMs include additional information that is not being used in this project. Typically NRCS STM's include both historically native as well as today's impacted states in their STM's. In addition, they may include only one historically native reference state, referred to as the Historical Climax Plant Community (HCPC), that represents the historical range of variability. For this project, the goal for STM's is to identify the full range of native ecosystems that can occur on an ecological site in response to historical disturbance, where any one of these native ecosystem plant communities could be considered a reference condition. For this purpose, each native ecosystem plant community occurring on an ecological site is considered a historical disturbance state. So while existing NRCS STM's were used to inform the development of the STM's for this project, the framework, assumptions, and results may differ from NRCS descriptions due to these primary differences in objectives.

One of the limiting factors in the use of STM's relative to native ecosystem diversity is the lack of quantitative data available to evaluate their accuracy and refine their content. Their development should be based on the best information available on plant species and community response to historical disturbance, with recognition that this information can sometimes be subjective and based on expert opinion. Strategies are in place to strengthen the quantitative data available to support the development of STM's in the future (Bestelmeyer et al. 2009). However, it may be impossible to collect empirical data on many historical states that simply do not exist today because of changes to historical disturbance processes or conditions. These limitations however, should not detract from their immediate usefulness in efforts to describe native ecosystem diversity with recognition of the need to acquire additional data to support and strengthen their use. It provides planners and land managers with a visually effective tool to help educate decisions and direct strategies relative to maintaining or restoring native ecosystem diversity.

Describing Disturbance States and STM's

To describe the influences of historical disturbance on the vegetation of an ecological site in the Blackfoot watershed, fire and bison grazing and where appropriate, their interactions, were included as the primary mechanisms historically influencing the vegetation of the terrestrial ecosystems (Figure 2). While we recognize the diversity of types of herbivory that can occur in this region, we are primarily interested in the effects of bison grazing as they are considered a keystone species where they historically occurred. Climate cycles such as drought are also an important stochastic process that should be evaluated and considered in discussions of disturbance states and overall planning. In this effort, the influence of climate is more fully incorporated in the overall process through the development of the historical range of variability, discussed in a later section.

- **Forest Ecosystems**

Disturbance states for forest ecosystems were primarily developed using information on historical fire regimes for the region. As discussed previously, while bison and other grazing/browsing likely occurred in forest ecosystems, particularly adjacent to grass-shrub ecological sites, little information is available on the interaction of fire and grazing on the species composition and structure of forest ecosystems. For this reason, the primary disturbance emphasis will be on fire with the recognition that it may require revisiting this topic if more information becomes available in the future. The historical fire regime was described for this area using regionally obtained tree fire-scar data (Barrett 2002), information developed for the fire regime condition class Interagency Handbook Reference Conditions (Hahn 2003), as well as supplemental literature (Davis et al. 1980, Fischer and Bradley 1987, Arno et al. 1997, Arno et al. 1995, Arno et al. 1993, Arno et al. 1985).

In addition to the information on fire regimes, historical disturbance states were developed using information on forest seral stages and their dominant species composition resulting from the interaction of ecological site with fire (Pfister et al 1977, Davis et al. 1980, Cooper et al. 1991, Fischer and Bradley 1987, Arno et al. 1997, Arno et al. 1995, Arno et al. 1993, Arno et al. 1985, Green et al. 1992, Keeling et al. 2006). The criteria for defining disturbance states was based on the project objectives of identifying and describing native ecosystem diversity to support biological diversity. This means identifying the disturbance states that were different enough in terms of species compositions and structures to provide the range of habitat conditions that most native species were dependent upon. To accomplish this, six disturbance states were identified and described for each ecological site that include:

Disturbance State 1
Late seral fire maintained conditions resulting from primarily low severity fire; usually >180 years

Disturbance State 2
Grass/Forb/Shrub conditions resulting from recent high severity fire; usually <25 years post-fire, depending on ecological site

Disturbance State 3
Seedling/Sapling conditions as succession progresses post-high severity fire; usually 10 to 50 years post-fire, depending on ecological site

Disturbance State 4
Early-seral conditions as succession progresses post-high severity fire; usually 50 to 100 years post-fire

Disturbance State 5
Mid-seral conditions as succession progresses post-high severity fire; usually 100 to 180 years post fire

Disturbance State 6
Late-seral conditions as succession progresses post-high severity fire; usually >180 years

To help illustrate the influence of natural fire regimes on forest disturbance states, state and transition model's were developed for each ecological site. Figure 7 provides the framework used in the forest ecosystems STM's. The influence of the fire regime is captured in both the x-axis as the effects of low to high fire severity, and in the y-axis as the time since a high severity fire has occurred. The disturbance states were developed to identify native ecosystem diversity important to most biodiversity in the region, resulting from influence of fire on a particular ecological site.

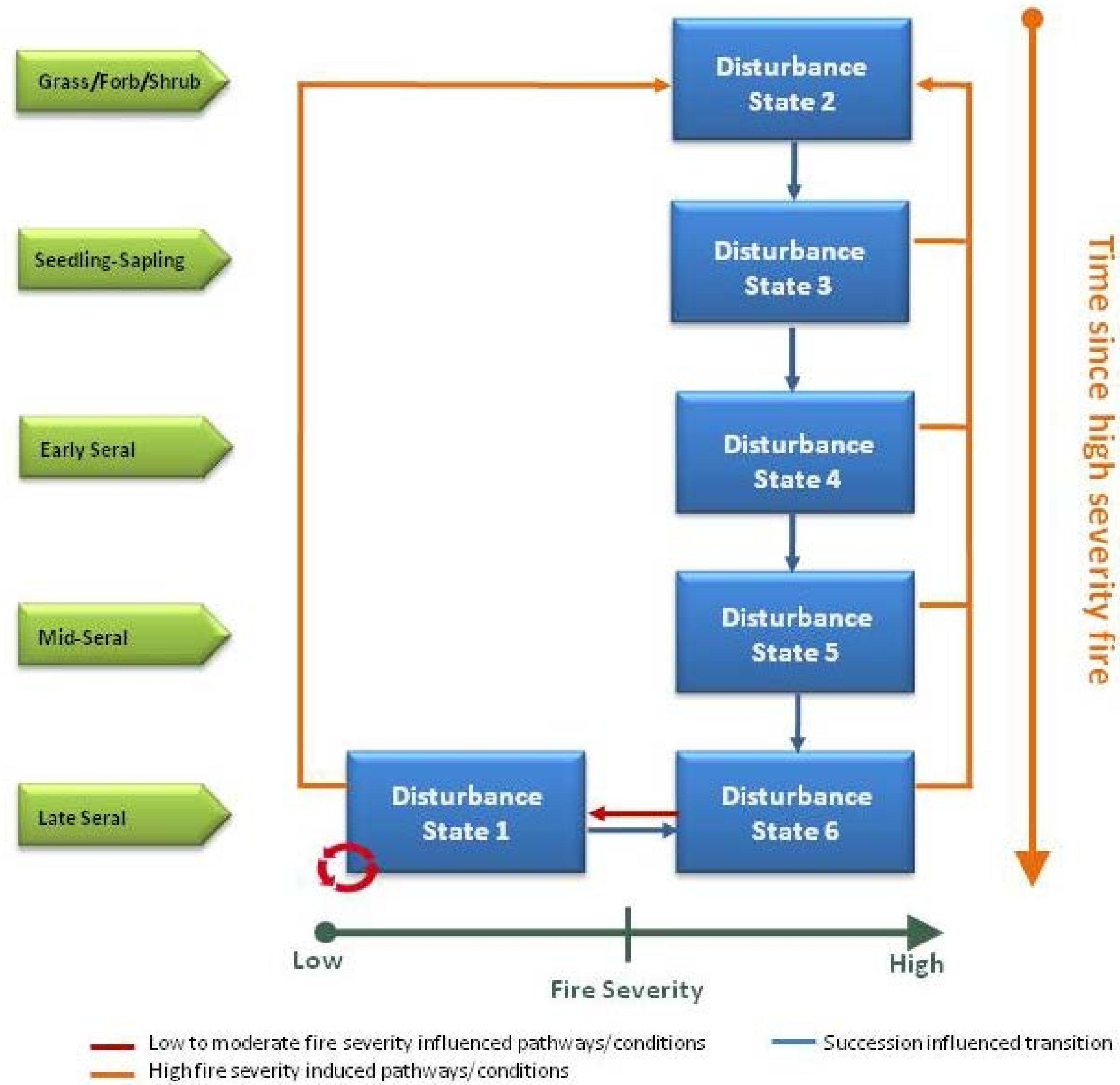


Figure 7. State and transition model framework to identify disturbance states for terrestrial forest ecosystems of the Blackfoot watershed, as influenced by the historical disturbance regime of fire.

- Grass-Shrub Ecosystems

Disturbance states were developed for grass-shrub ecosystems primarily using ESD's developed by Montana NRCS. Additional sources of information include Mueggler and Stewart (1980) and information obtained in the rapid assessment field surveys. Disturbance states are based on the combined influence of bison grazing, as defined along a gradient of lighter to heavier pressure, and fire, as defined along a gradient of more frequent to less frequent fire. Each of the 4 disturbance states are more specifically characterized relative to disturbance processes as follows:

Disturbance State 1 - "light" grazing x "frequent" fire (<25 year Mean Fire Return Interval (MFRI))
Disturbance State 2 - "moderate" grazing x "frequent" fire
Disturbance State 3 - "light" grazing x "infrequent" fire (>=25 MFRI)
Disturbance State 4 - "moderate" grazing x "infrequent" fire

To help illustrate the influence of historical fire regimes on grass-shrub disturbance states, State and transition models were developed for each ecological site. Figure 8 provides the framework used in the grass-shrub ecosystems STM's. These disturbance states were developed to identify native ecosystem diversity important to most biodiversity in the region, resulting from influence of grazing and fire on a particular ecological site.

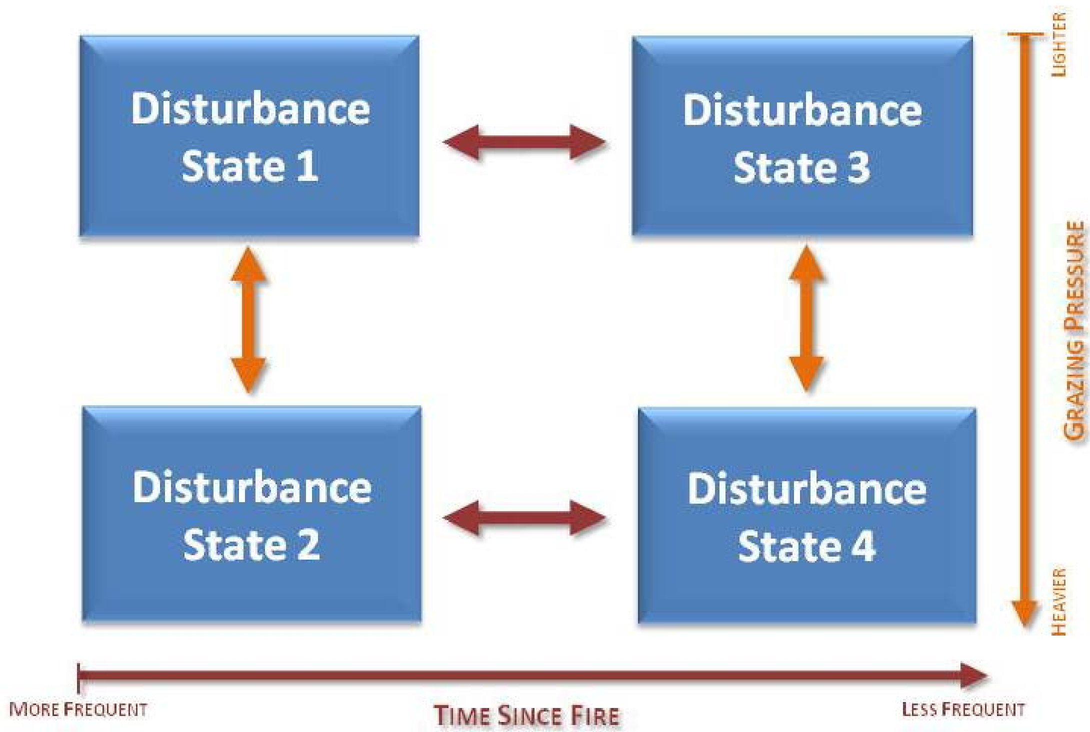


Figure 8. State and transition model framework to identify disturbance states for terrestrial grass-shrub ecosystems of the Blackfoot watershed, as influenced by the historical disturbance regimes of bison grazing and fire.

The following sections compile and synthesize the information developed for ecological sites and disturbance states of the Blackfoot watershed for both forest and grass-shrub ecosystems. This information is organized and discussed by ecological site. STM's are developed for each ecological site to identify the disturbance states that characterize the range of native ecosystem diversity for each ecological site.

Forest Ecological Sites

- ### Hot-Dry

Distribution: This ecological site represents the hot and dry extreme of forest environments and typically represents the lower timberline conditions where they transition to grass-shrub ecosystems. It is a relatively uncommon forest ecological site occurring on 3,868 acres or 0.3% of the watershed acres. These sites frequently occur at low elevations of the forest zone but may extend to mid-elevations on steep, dry, southerly aspects. Geology and terrain appear to be limiting factors only to the extent of retaining sufficient soil moisture, which is the controlling influence. Timber productivity on this ecological site is usually considered low.

Description: Primary tree species that can occur on this ecological site include ponderosa pine, Douglas-fir, and Rocky Mountain juniper. Historically, nearly all stands were dominated by ponderosa pine with savannah-like grass-dominated understories, as these sites were primarily influenced by a non-lethal fire regime. The mixed-severity A fire regime also occurred on more protected areas but was much less common in this ecological site. The mixed-severity B and lethal fire regimes almost never occurred. The influence of primarily low severity fires would maintain relatively open stands of large diameter ponderosa pine at very low stand densities. In addition, low fuel accumulations and few tree seedlings and small saplings would be present. At the moister range of conditions for this site, a few scattered Douglas-fir may have been associated with the ponderosa pine. The droughty conditions of the soils also limited the establishment of tree seedlings. The undergrowth vegetation was characterized by grasses and occasional small patches of shrubs on more protected areas. In contrast to the other six forest ecological sites, all members of the grass, shrub, and forb layers occur as components of the even drier and usually adjacent, grass-shrub ecological sites.

Since the early 1900s, attempts to exclude fire have lengthened fire return intervals. Tree seedlings, small saplings, and fire-sensitive shrub, have become more common and thereby have increased understory fuel loadings.

Native Ecosystem Diversity: The state and transition model for the Hot-Dry forest ecological site resulting from the natural fire regime is presented in Figure 9. For the purposes of describing native diversity relative to the state and transition model it is important to identify the scale of application. We are describing native diversity for all forest ecological sites at a stand level which we have quantified as roughly 50 acres (20 ha). The vegetation characteristics of both the low and high severity fire conditions of the Hot-Dry forest ecological site are provided in Table 4. For a more encompassing list of plant species that may be associated with this ecological site, please see Appendix A-1.

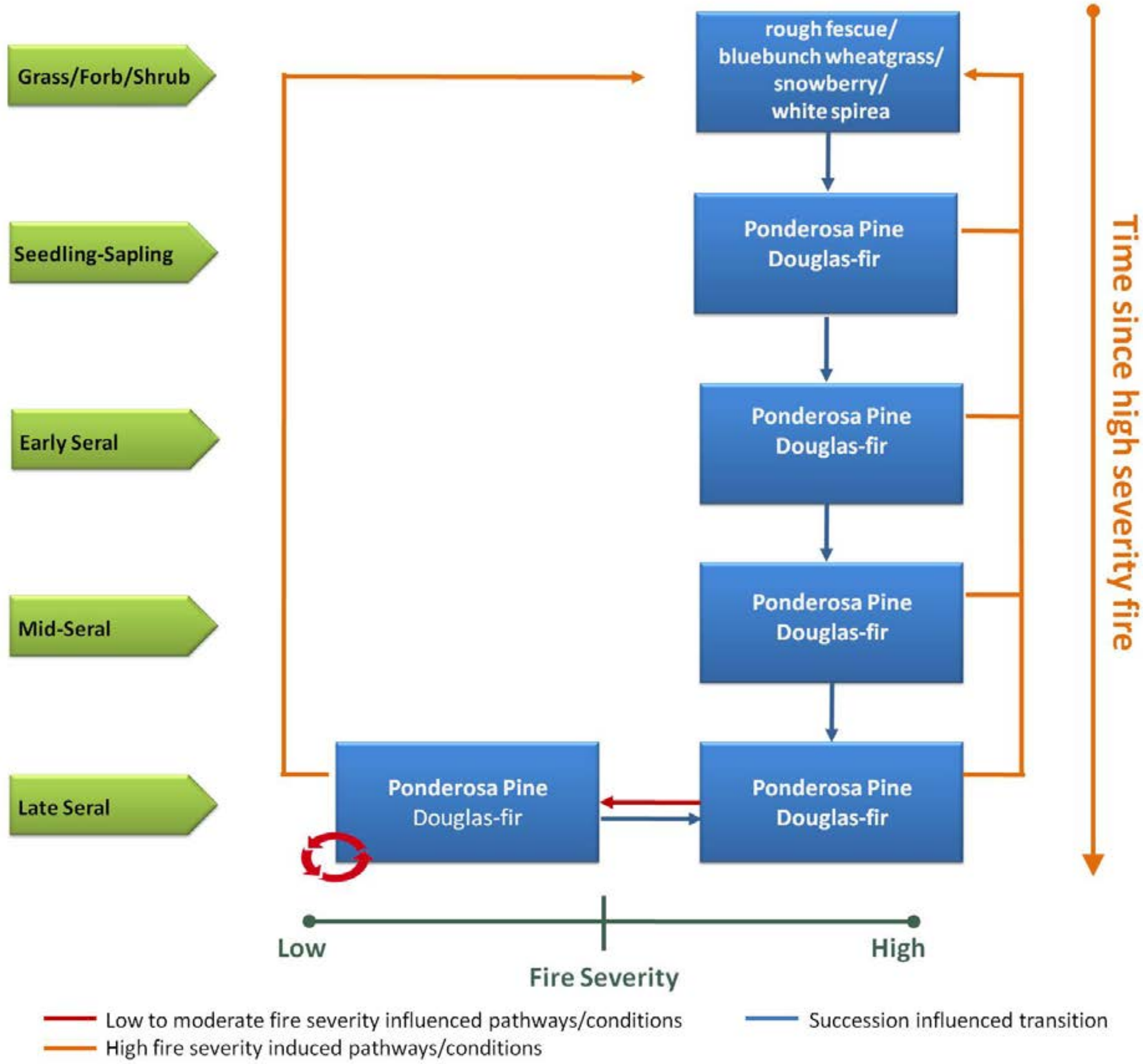


Figure 9. State and transition model that identifies the historical disturbance states or range of native ecosystem diversity for the Hot-Dry forest ecological site of the Blackfoot watershed.

Table 4. Vegetation characteristics resulting from the low and high severity fire conditions influencing the non-lethal and mixed-severity A fire regimes of the Hot-Dry forest ecological site.

Low Severity Fire Conditions	High Severity Fire Conditions
Overstory Structure	
• Low density, all aged conditions • Clear presence of large diameter trees • Fire adapted tree species, primarily ponderosa pine and occasional Douglas-fir • One to two story canopies • Mean basal area overstory = 50 to 100 sq. ft. per acre • 5 to 20 tpa > 18" dbh • Age of oldest cohort >180 years • Average canopy cover < 30% • Large persistent snags are important feature; occurring in a clumped manner not uniform throughout the stand	• Moderate to high density • Early seral states are primarily even-aged, one story canopies but becomes multi-aged, multi-storied in mid-seral states • Fire dependent and shade tolerant species dominate; primarily ponderosa pine and to a lesser extent, Douglas-fir • Mean basal area is variable depending on the seral state but varies between 0 to 250 sq. ft per acre • Age of oldest cohort likely <100 years • Average canopy cover of early to mid-seral states >50% • Between severe fires, snags are uniformly present in all age classes at low densities unless insects or disease kill higher percentage than average • After severe fire, snags are numerous and may persist for a number of years after fire; also a few scattered fire adapted species such as ponderosa pine and large Douglas-fir with thick bark may survive in the canopy
Understory Structure	
• open and park-like • dominated by grasses with occasional small trees and small patches/stringers of shrubs • coarse woody debris is large in size and occurs in clumped manner but is low at 5 to 9 tons per acre, small to medium diameter CWD is also less persistent due to the frequency of fire	• moderately dense to dense • dominated by small trees, shrubs, forbs, and grasses • coarse woody debris is variable in size depending on the age of the stand and is more uniformly distributed, it is also more persistent due to the greater time frame between fires

Cross-walk to habitat types

The Hot-Dry forest ecological site includes the following habitat types from Pfister et al. (1977):

130. Ponderosa pine/Bluebunch wheatgrass
140. Ponderosa pine/Idaho fescue
210. Douglas-fir/Bluebunch wheatgrass
220. Douglas-fir/Idaho fescue
230. Douglas-fir/Rough fescue

- **Warm-Dry**

Distribution: This ecological site represents the warm and dry forests of the Blackfoot watershed. It is the most common forest ecological site occurring on 381,723 acres and represents 25.8% of the area in the watershed. It occurs most commonly at low to mid-elevation sites. Timber productivity on this ecological site is usually considered moderate.

Description: Primary tree species that can occur on this ecological site include ponderosa pine, Douglas-fir, western larch, and lodgepole pine. Historically, the Warm-Dry forest ecological site was primarily influenced by the non-lethal fire regime that resulted in frequent low severity underburns that excluded most Douglas-fir and lodgepole pine, and killed many small seedlings and saplings. These fires burned extensively throughout the low- to mid-elevation forests, being extinguished only by fall rains or lack of fuel due to previous fires. Under the non-lethal fire regime, the stands remained open and park-like, consisting of ponderosa pine on most sites but with western larch also occurring on moister portions of this ecological site. Douglas-fir occurred as a minor component of the canopy. Stand densities were low and average tree diameters were large. Trees often occurred in clumps, with irregular shaped openings between the relatively low densities of trees. Mixed severity A fire regimes occurred less commonly on more protected areas. Mixed-severity B and lethal fire regimes rarely occurred. The potential for destructive wildfire, insect, or disease events was low. The frequent low severity fire would favor grass species and reduce the occurrence of shrubs in the understory to small, protected patches.

Since Euro-American settlement, fires have become less frequent and stand conditions have changed dramatically on this ecological site, particularly in unmanaged stands. Here, the historical condition of widely spaced ponderosa pine and to a lesser extent, western larch, is often still evident in the overstory as an older stand component but are now intermixed with many smaller ponderosa pine, Douglas-fir, lodgepole pine, and western larch ranging from sapling to mature trees. The undergrowth now supports mainly rhizomatous shrubs and grasses. Consequently, the risk of uncharacteristic high severity conditions and insect epidemics occurring in these forests is now high.

Native Ecosystem Diversity: The state and transition model resulting from the historical fire regime is presented in Figure 10. The vegetation characteristics of both the low and high severity fire conditions of the Warm-Dry forest ecological site are provided in Table 5. For a complete list of plant species that may be associated with this ecological site, please see Appendix A-2.

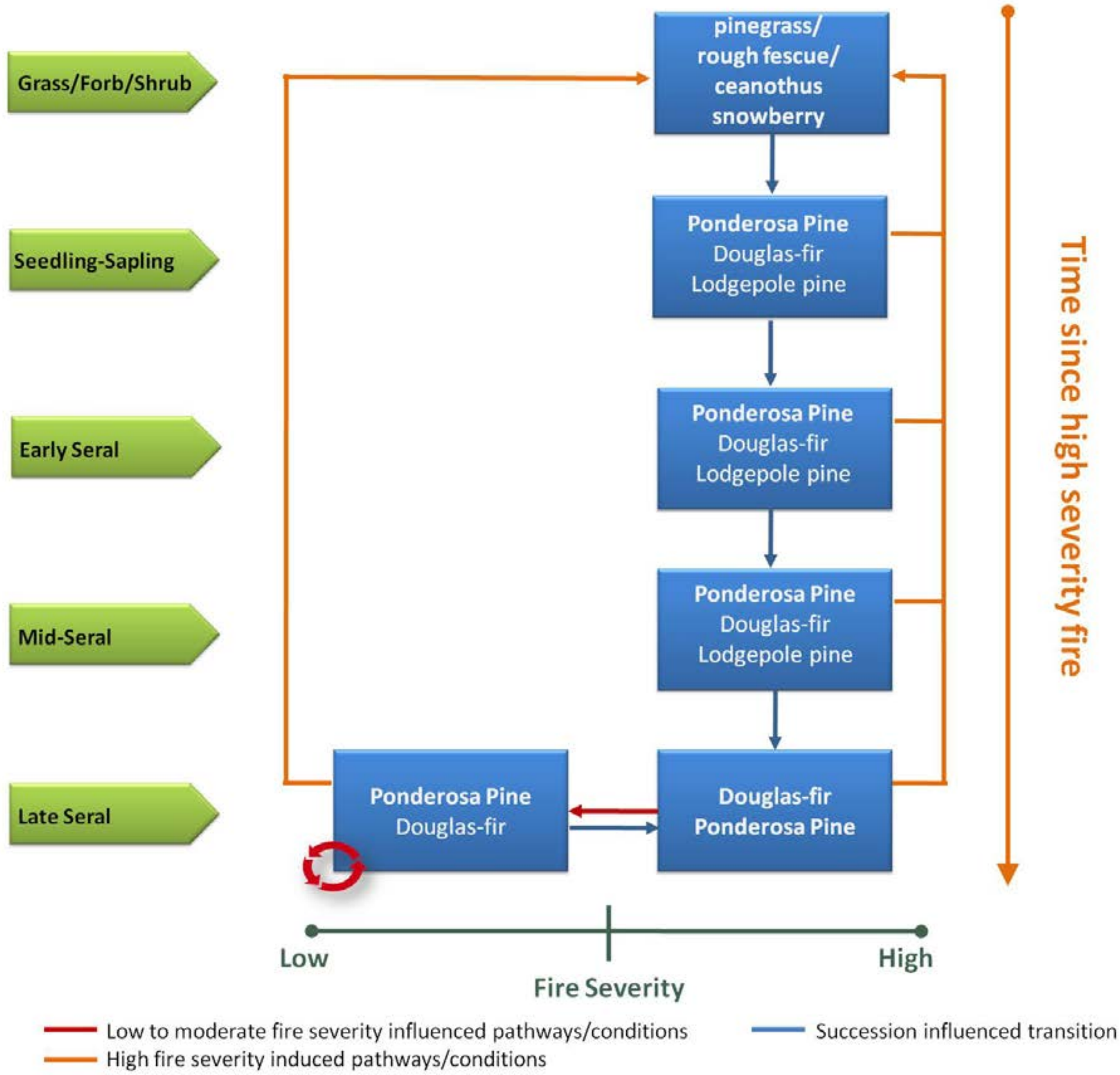


Figure 10. State and transition model that identifies the historical disturbance states or range of native ecosystem diversity for the Warm-Dry forest ecological site of the Blackfoot watershed.

Table 5. Vegetation characteristics resulting from the low and high severity fire conditions as influencing the non-lethal and mixed-severity A (MSA) fire regimes of the Warm-Dry forest ecological site.

LOW SEVERITY FIRE CONDITIONS	HIGH SEVERITY FIRE CONDITIONS
Overstory Structure	
• Low density, all aged conditions • Clear presence of large diameter trees • Fire adapted tree species, primarily ponderosa pine and minor amounts of Douglas-fir • One to two story canopies • Basal area range typically 60 to 120 sq. ft. per acre • 15 to 30 tpa > 18" dbh • Age of oldest cohort >180 years • Average canopy cover <50% • Large persistent snags are important feature; occurring in a clumped manner not uniform throughout the stand	• Moderate to high density • Early seral states are primarily even-aged, one story canopies but becomes multi-aged, multi-storied in mid-seral states • Fire dependent and shade tolerant species dominate; primarily ponderosa pine, Douglas-fir, and lodgepole pine • Basal area is variable depending on the seral state but ranges between 0 to 260 sq. ft per acre • Age of oldest cohort likely <100 years • Average canopy cover of early to mid-seral states >60% • Between severe fires, snags are uniformly present in all age classes at low densities unless insects or disease kill higher percentage than average • After severe fire, snags are numerous and may persist for a number of years after fire; also a few scattered fire adapted species such as ponderosa pine and large Douglas-fir with thick bark may survive in the canopy
Understory Structure	
• open and park-like • dominated by grasses with scattered small trees and small patches/stringers of shrubs • coarse woody debris is large in size and occurs in clumped manner but is low at 6 to 10 tons per acre, small to medium sized CWD is also less persistent due to the frequency of fire	• moderately dense to dense • dominated by small trees, shrubs, and grasses • coarse woody debris is variable in size depending on the age of the stand and is more uniformly distributed, it is also more persistent due to the greater time frame between fires

Cross-walk to habitat types

The Warm-Dry forest ecological site includes the following habitat types from Pfister et al. (1977):

262. Douglas-fir/ninebark_pinegrass
311. Douglas-fir/snowberry_bluebunch wheatgrass
320. Douglas-fir/pinegrass
330. Douglas-fir/elk sedge
340. Douglas-fir/white spiraea
350. Douglas-fir/kinnikinnick
360. Douglas-fir/common juniper

- **Warm-Moist**

Distribution: This ecological site represents the warm and moist forests of Blackfoot watershed and makes up 236,436 acres or 16.0% of the watershed. They are most common to the mid-elevation zone but may extend upwards in elevation on south and southwest exposures but may also occur at lower elevations in cold air drainages and frost pocket areas. At these lower elevations, nightly cold air patterns may be compensating for soil moisture. Timber productivity on this site is usually considered moderate.

Description: Primary tree species that can occur on this ecological site include ponderosa pine, western larch, Douglas-fir, and lodgepole pine. Historically, these sites were predominantly influenced by the non-lethal fire regime, with the mixed-severity A and B fire regimes occurring infrequently. The lethal fire regime rarely occurred on this ecological site. The non-lethal forest conditions are similar to the Warm-Dry ecological site but western larch occurs more extensively on this ecological site. Ponderosa pine may be less common on the cooler portions of this site. Douglas-fir increases as a component of the canopy but is still much less common than ponderosa pine or western larch. While grass species are still a dominant component of the understory due to the frequency of fires, shrubs patches are larger and may occur more frequently, due to the moister conditions of this ecological site. On the mixed severity influenced sites, small to moderate patches of high fire severity conditions promote early to mid-seral dense stands of Douglas-fir, lodgepole pine, western larch, and ponderosa pine.

With a century of fire suppression, forest conditions now vary from relatively open and large western larch and/or ponderosa pine, to nearly pure stands of single-age lodgepole pine, to mixtures of multi-age lodgepole, ponderosa pine, or western larch with Douglas-fir, to pure multi-age stands of Douglas-fir. Western larch, ponderosa pine, trembling aspen, and lodgepole pine, may dominate early to mid-seral stands. The undergrowth is characterized by both shade-intolerant and tolerant species depending on the fire history of the site. The probability of uncharacteristic high severity fire conditions occurring in these forests is high. Lack of fire has also increased the proportion of dense multistoried stands, making them more vulnerable to bark beetle attack and high severity fire. Severity of dwarf mistletoe infection has also increased.

Native Ecosystem Diversity: The state and transition model resulting from the historical fire regime is presented in Figure 11. The vegetation characteristics of both the low and high severity fire conditions of the Warm-Moist forest ecological site are provided in Table 6. For a complete list of plant species that may be associated with this ecological site, please see Appendix A-3.

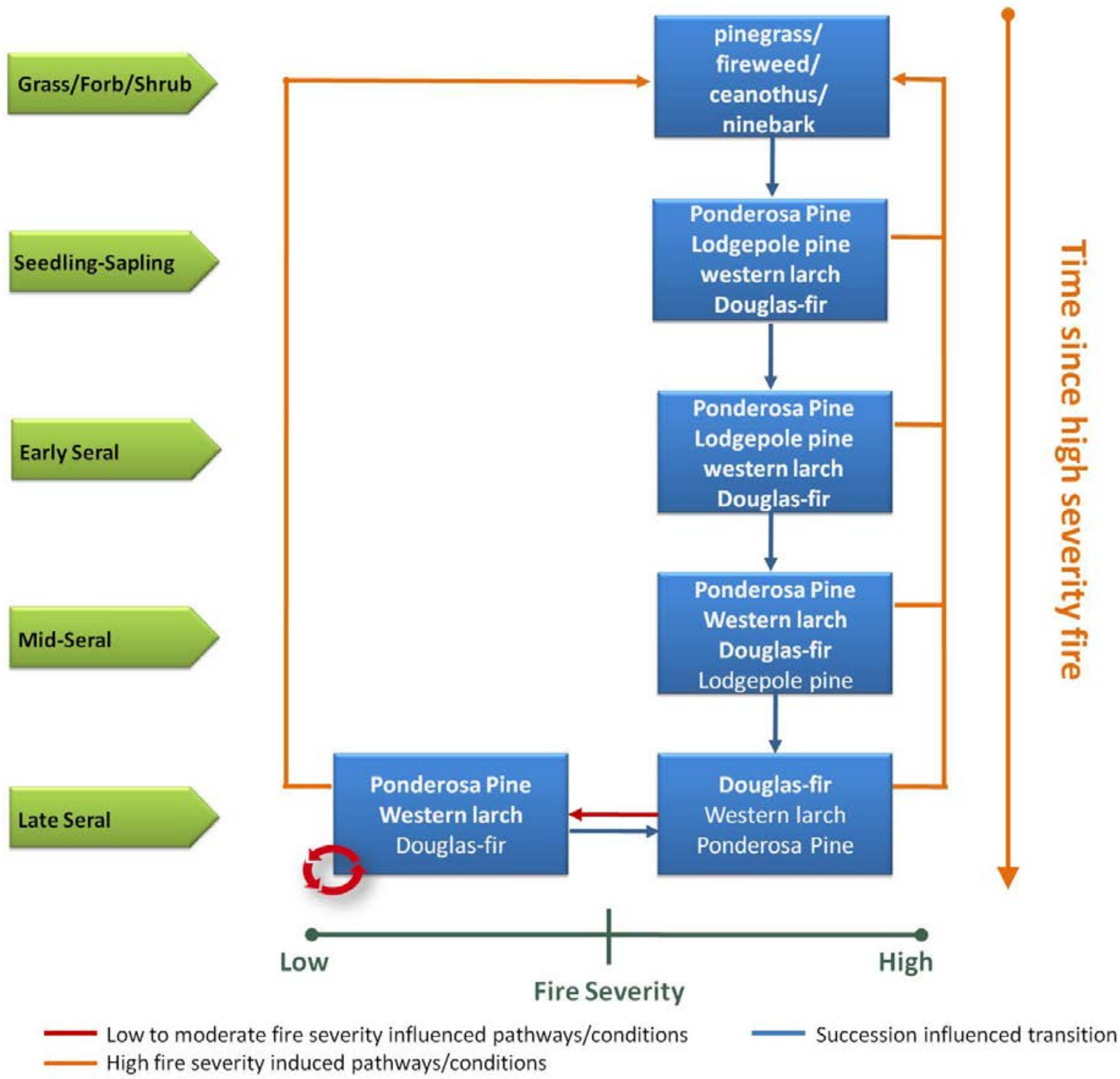


Figure 11. State and transition model to describe the historical disturbance states or range of native ecosystem diversity for the Warm-Moist forest ecological sites of the Blackfoot Watershed.

Table 6. Vegetation characteristics resulting from low and high severity fire conditions as influencing the non-lethal and mixed-severity A (MSA) and B (MSB) fire regimes of the Warm-Moist forest ecological site.

LOW SEVERITY FIRE CONDITIONS	HIGH SEVERITY FIRE CONDITIONS
Overstory Structure	
• Low density, all aged conditions • Clear presence of large diameter trees • Fire adapted tree species, primarily ponderosa pine, western larch, and smaller amounts of Douglas-fir • One to two story canopies • Basal area range typically 80 to 140 sq. ft. per acre • 15 to 35 tpa > 18” dbh • Age of oldest cohort >180 years • Average canopy cover <60% • Large persistent snags are important feature; occurring in a clumped manner not uniform throughout the stand	• Moderate to high density • Early seral states are primarily even-aged, one story canopies but becomes multi-aged, multi-storied in mid-to-late seral states • Fire dependent and shade tolerant species dominate; primarily ponderosa pine, Douglas-fir, and lodgepole pine • Basal area is variable depending on the seral state but ranges between 0 to 300 sq. ft per acre • Age of oldest cohort likely <100 years – MSA and <150 years - MSB • Average canopy cover of early to mid-seral states >65% • Between severe fires, snags are uniformly present in all age classes at low densities unless insects or disease kill higher percentage than average • After severe fire, snags are numerous and may persist for a number of years after fire; also a few scattered fire adapted species such as ponderosa pine, western larch, and large Douglas-fir with thick bark may survive in the canopy
Understory Structure	
• open and park-like • dominated by grasses with scattered small trees and small patches/stringers of shrubs • coarse woody debris is large in size and occurs in clumped manner but is low to moderate at 10 to 15 tons per acre, it is also less persistent due to the frequency of fire	• moderately dense to dense • dominated by small trees, shrubs, and grasses • coarse woody debris is variable in size depending on the age of the stand and is more uniformly distributed, it is also more persistent due to the greater time frame between fires

<u>Cross-walk to habitat types</u>

The Warm-Moist forest ecological site includes the following habitat types from Pfister et al. (1977):

250. Douglas-fir/dwarf huckleberry
261. Douglas-fir/ninebark_ninebark
280. Douglas-fir/blue huckleberry
290. Douglas-fir/twinflower
312. Douglas-fir/snowberry_pinegrass
313. Douglas-fir/snowberry_snowberry

- **Cool-Dry**

Distribution: This ecological site represents the cool and dry forests of Blackfoot watershed and encompasses 356,888 acres or 24.1% of the watershed. They are most common to the mid-elevation zone but at their lower limits may occur mainly on steep, northerly or easterly aspects but shift to southerly and westerly aspects at their upper limits. Sites at their lower limits are often influenced by cold air drainage and are heavily interfingered with the warm forest ecological sites. Timber productivity on this ecological site is usually considered moderate to high.

Description: Primary tree species that can occur on this ecological site include subalpine fir, Douglas-fir, western larch, lodgepole pine, Engelmann spruce, ponderosa pine, and possibly western white pine**. Historically, these sites were somewhat evenly influenced by the mixed-severity A, mixed-severity B, and lethal fire regimes. A mixture of low severity and high severity fire can create a diverse mosaic of seral stages and structures at both the stand and landscape level. Cyclic bark beetle and tussock moth attacks on dense patches of Douglas-fir, lodgepole pine, and Engelmann spruce can contribute further to this mosaic. Western larch, Douglas-fir, and lodgepole pine are the predominant seral trees, and small amounts of ponderosa pine may occur on warmer sites. Western larch and Douglas-fir are the more common trees on the low fire severity portions of the mixed-severity A and B influenced sites. At the cool extremes, lodgepole pine and Engelmann spruce may appear in varying amounts but seldom dominate. Tall and sometimes dense shrub layers are more common under mid-to-late seral conditions depending on the fire regime influences. Shrubs and grasses can develop high coverage on severely burned sites in early seral stages. Pinegrass can persist indefinitely on many of these sites, often dominating the herb layer.

(**The distribution and occurrence of western white pine in the Blackfoot watershed is not well documented. Several range maps indicate western white pine may have occurred in the Clearwater watershed subunit of the Blackfoot watershed (Little 1971, USDA Plants Database).)

Since Euro-American settlement interrupted the normal fire cycle, these sites are rapidly losing the influence of the mixed-severity fire regimes on forest conditions. They are losing the diverse mosaic patterns produced by the intermingling of low and high severity fire conditions and are becoming more uniform in structure. Unless managed to maintain fire regime diversity, these sites will increase their risk of extensive high severity fire and insect epidemics, providing less opportunities for a mosaic of conditions at the stand and landscape level. Also, western white pine has been eradicated from much of its former range by white pine blister rust, an introduced disease (Harvey et al. 2008).

Native Ecosystem Diversity: The state and transition model resulting from the historical fire regime is presented in Figure 12. The vegetation characteristics of both the low and high severity fire conditions of the Cool-Dry forest ecological site are provided in Table 7. For a complete list of plant species that may be associated with this ecological site, please see Appendix A-4.

landscape level.

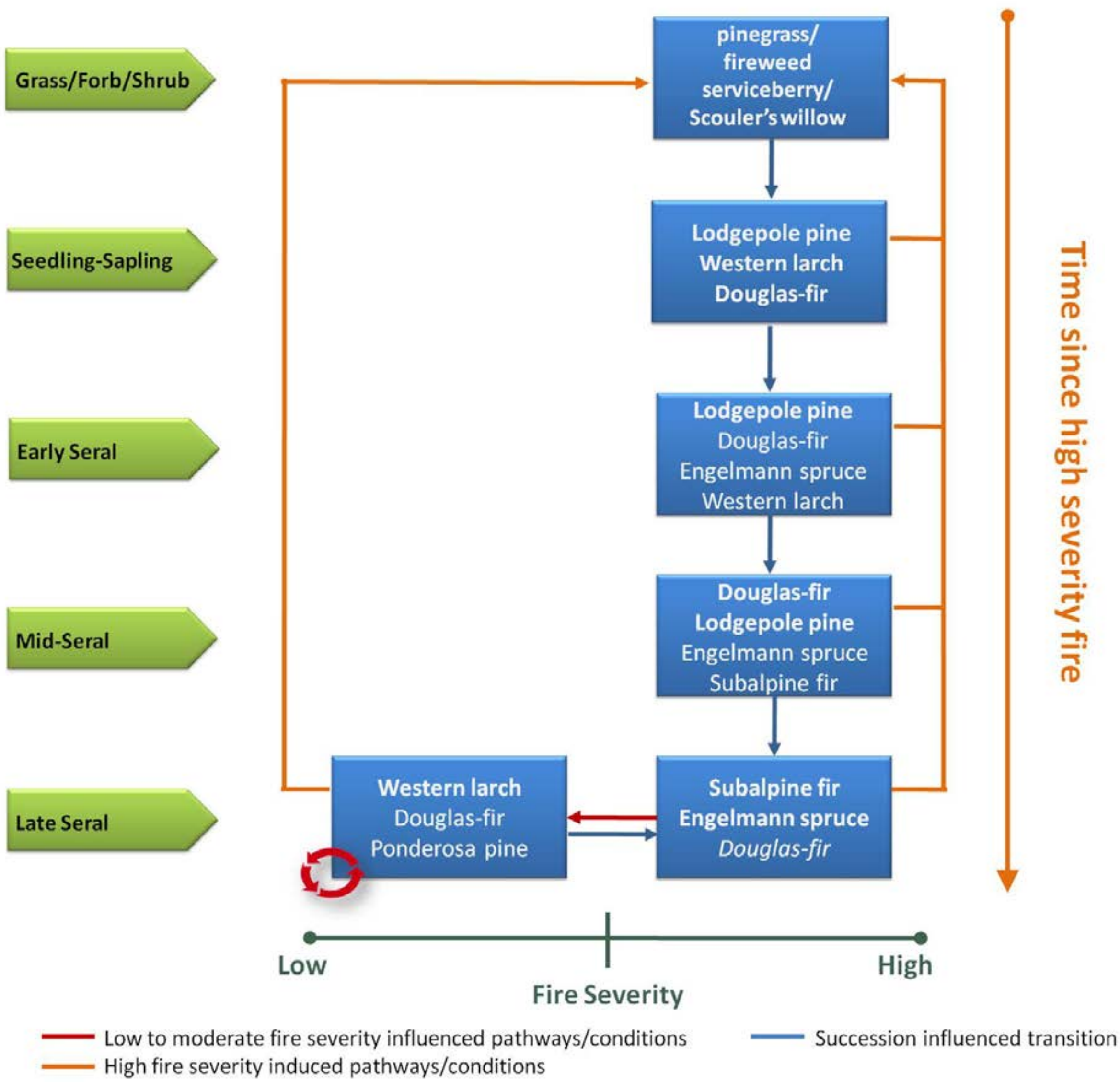


Figure 12. State and transition model to identify historical disturbance states or range of native ecosystem diversity for the Cool-Dry forest ecological site of the Blackfoot Watershed.

Table 7. Vegetation characteristics resulting from low and high severity fire conditions as influencing the mixed-severity A (MSA), mixed-severity B (MSB), and lethal fire regimes of the Cool-Dry forest ecological site.

Low Severity Fire Conditions	High Severity Fire Conditions
Overstory Structure	
• Low ot moderate density, all aged conditions • Clear presence of large diameter trees • Fire adapted tree species, primarily western larch, Douglas-fir, and ponderosa pine on some sites • One to two story canopies • Basal area range typically 100 to 160 sq. ft. per acre • 20 to 40 tpa > 18" dbh • Age of oldest cohort >180 years • Average canopy cover <70% • Large persistent snags are important feature; occurring in a clumped manner not uniform throughout the stand	• Moderate to high density • Early seral states are primarily even-aged, one story canopies but becomes multi-aged, multi-storied in mid-to-late seral states • Fire dependent and shade tolerant species dominate depending on the state; primarily western larch, Douglas-fir, lodgepole pine, Engelmann spruce, and subalpine fir • Basal area is variable depending on the seral state but ranges between 0 to 300 sq. ft per acre • Age of oldest cohort likely <100 years – MSA, <150 years – MSB, and lethal depends on seral state • Average canopy cover of early to late seral states >65% • Between severe fires, snags are uniformly present in all age classes at low densities unless insects or disease kill higher percentage than average • After severe fire, snags are numerous and may persist for a number of years after fire; also a few scattered fire adapted species such as ponderosa pine, western larch, and large Douglas-fir with thick bark may survive in the canopy
Understory Structure	
• open and park-like • dominated by grasses with scattered small trees and small patches/stringers of shrubs • coarse woody debris is large in size and occurs in clumped manner but is low to moderate at 10 to 20 tons per acre, it is also less persistent due to the frequency of fire	• moderately dense to dense • dominated by small trees, shrubs, and grasses • coarse woody debris is variable in size depending on the age of the stand and is more uniformly distributed, it is also more persistent due to the greater time frame between fires

Cross-walk to habitat types

The Cool-Dry forest ecological site includes the following habitat types from Pfister et al. (1977):

450. Engelmann spruce/dwarf huckleberry
640. Subalpine fir/dwarf huckleberry
660. Subalpine fir/twinflower
690. Subalpine fir/beargrass
731. Subalpine fir/grouse whortleberry
750. Subapline fir/pinegrass
792. Subalpine fir/elk grass
920. Lodgepole pine/dwarf huckleberry
925. Lodgepole pine/beargrass
940. Lodgepole pine/grouse whortleberry

- **Cool-Moist**

Distribution: This ecological site represents the cool and moist forests of the Blackfoot watershed and encompasses 172,364 acres or 11.7% of the watershed. They are commonly found at mid-to-high elevations. Timber productivity on this ecological site is usually considered moderate to high.

Description: Primary tree species occurring on this ecological site include subalpine fir, Douglas-fir, western larch, lodgepole pine, Engelmann spruce, and possibly western pine. Historically, these sites were predominantly influenced by the lethal fire regime, although mixed-severity A and B, were also common. Generally, ignitions occurred on adjacent drier site, frequently under drought conditions, and the fire was wind-driven onto these sites. On sites influenced by the high severity fire, various mixtures of lodgepole pine, western larch, Douglas-fir, and Engelmann spruce comprise the early to mid-seral tree layers and late seral conditions will be multi-storied with subalpine fir and Engelmann spruce becoming dominant in the canopy. Any one of these tree species may be dominant, depending on stand history and fire regime influences. Early to mid-seral shrub layers may be tall and dense. Late-seral shrub layers may be shorter in stature and more patchy. Western larch and Douglas-fir are the more common trees on the low fire severity portions of the mixed-severity A and B influenced sites. Further, these sites will be characterized by more open canopies of late-seral, multi-storied conditions and fewer shrubs in the understory.

Like the Cool-Dry ecological site, these sites are rapidly losing the influence of the mixed-severity fire regimes on forest conditions. They are losing the diverse mosaic patterns produced by the intermingling of low and high severity fire conditions and are becoming more uniform in structure. Unless managed to maintain fire regime diversity, these sites will increase their risk of extensive high severity fire and insect epidemics, providing less opportunities for a mosaic of conditions at the stand and landscape level. Western white pine has been eradicated from much of its former range by white pine blister rust, an introduced disease.

Native Ecosystem Diversity: The state and transition model resulting from the historical fire regime is presented in Figure 13. The vegetation characteristics of both the low and high severity fire conditions of the Cool-Moist forest ecological site are provided in Table 8. For a more detailed list of plant species that may be associated with this ecological site, please see Appendix A-5.

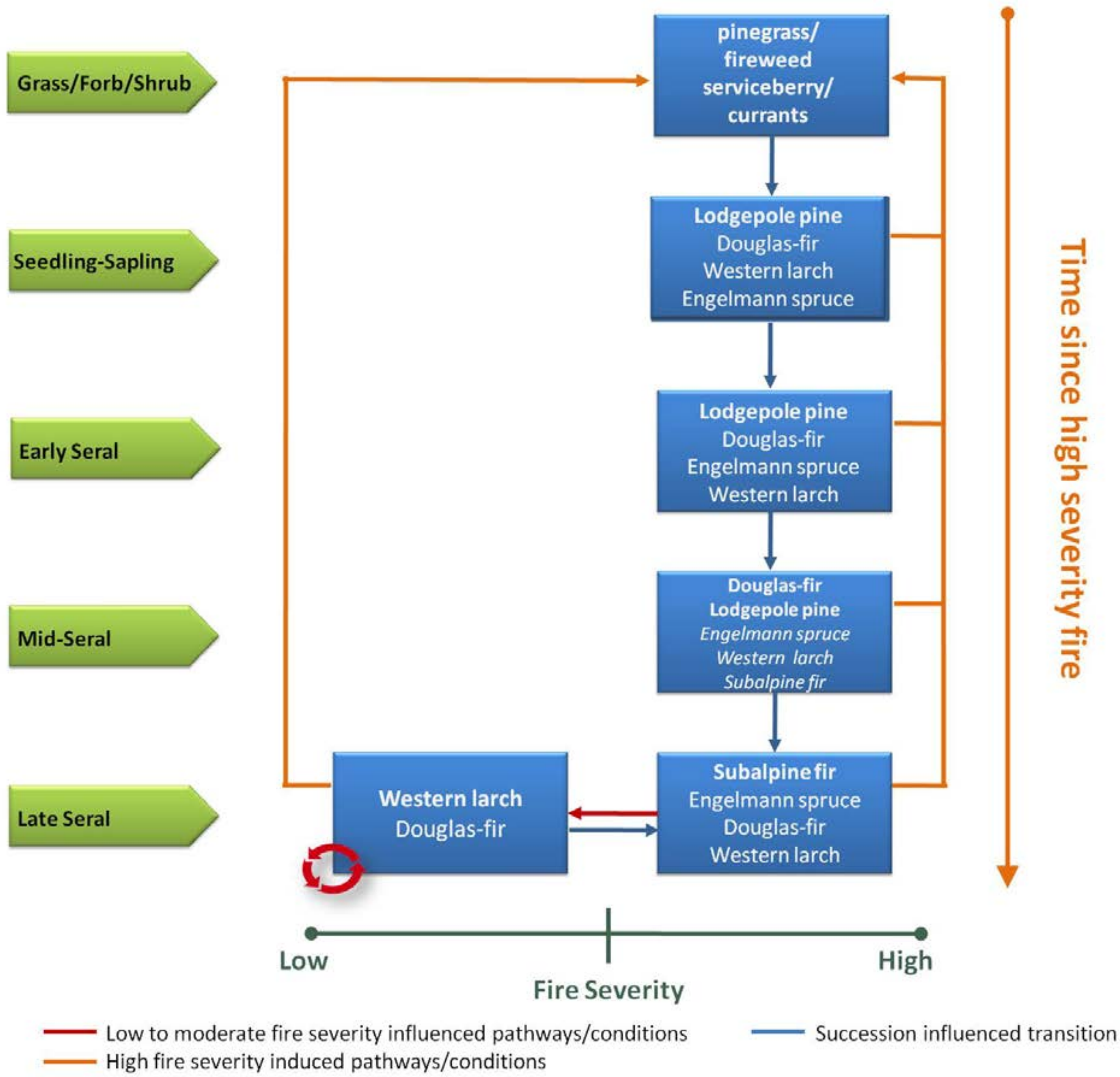


Figure 13. State and transition model identifying the historical disturbance states or range of native ecosystem diversity for the Cool-Moist forest ecological sites of the Blackfoot Watershed.

Table 8. Vegetation characteristics resulting from low and high severity fire conditions as influencing the mixed-severity A (MSA), mixed-severity B (MSB) and lethal fire regimes of the Cool-Moist forest ecological site.

LOW SEVERITY FIRE CONDITIONS	HIGH SEVERITY FIRE CONDITIONS
Overstory Structure	
• Low to moderate density, all aged conditions • Clear presence of large diameter trees • Fire adapted tree species, primarily western larch, Douglas-fir, and ponderosa pine on some sites • One to two story canopies • Basal area range typically 100 to 180 sq. ft. per acre • 25 to 40 tpa > 18" dbh • Age of oldest cohort >180 years • Average canopy cover <60% • Large persistent snags are important feature; occurring in a clumped manner not uniform throughout the stand	• Moderate to high density • Early seral states are primarily even-aged, one story canopies but becomes multi-aged, multi-storied in mid-to-late seral states • Fire dependent and shade tolerant species dominate depending on the state; primarily western larch, Douglas-fir, lodgepole pine, Engelmann spruce, and subalpine fir • Basal area is variable depending on the seral state but ranges between 0 to 300 sq. ft per acre • Age of oldest cohort likely <100 years – MSA, <150 years – MSB, and lethal depends on seral state • Average canopy cover of early to late seral states >70% • Between severe fires, snags are uniformly present in all age classes at low densities unless insects or disease kill higher percentage than average • After severe fire, snags are numerous and may persist for a number of years after fire; also a few scattered fire adapted species such as ponderosa pine, western larch, and large Douglas-fir with thick bark may survive in the canopy
Understory Structure	
• open and park-like • dominated by grasses with scattered small trees and small patches/stringers of shrubs • coarse woody debris is large in size and occurs in clumped manner but is low to moderate at 12 to 25 tons per acre, it is also less persistent due to the frequency of fire	• moderately dense to dense • dominated by small trees, shrubs, and grasses • coarse woody debris is variable in size depending on the age of the stand and is more uniformly distributed, it is also more persistent due to the greater time frame between fires

<u>Cross-walk to habitat types</u>

The Cool-Moist forest ecological site includes the following habitat types from Pfister el al. (1977):

620. Subalpine fir/queencup beedlily
670. Subalpine fir/menziesia
720. Subalpine fir/blue huckleberry
740. Subalpine fir/sitka alder
470. Engelmann spruce/twinflower
420. Engelmann spruce/queencup beedlily

- **Cold-Dry**

Distribution: This ecological site represents the more high elevation cold and dry environments of the Blackfoot watershed often occurring in the transition zone between the upper elevation forests and the alpine tundra. This site encompasses 85,397 acres or 5.8% of the watershed. The climate is characterized by a short growing season with early summer frosts. Precipitation comes primarily in the form of snow. Timber productivity on this ecological site is usually very low.

Description: Primary tree species that can occur on this ecological site include whitebark pine, subalpine fir, alpine larch, and Engelmann spruce. Historically, these sites were primarily influenced by the mixed-severity A fire regime. The mixed-severity B fire regime occurred occasionally and the lethal fire regime occurred more rarely. The non-lethal fire regime did not occur on this ecological site. Whitebark pine is usually a major component of the overstory and provides protection for Engelmann spruce and subalpine fir seedlings to become established in moister areas. Later seral stages will usually have more subalpine fir and Engelmann spruce occurring in the overstory. Alpine larch usually occurs on rockslides and talus. Shrub layers are usually sparse, reflecting the cool temperatures and short growing seasons inherent to these sites. The mixed-severity fire regimes are somewhat patchier even than on less extreme ecological sites, in that fires crept through these stands wherever fine fuels would carry a flame and then flared up wherever fuel concentrated in the denser patches of trees, usually those greater than eight inches in diameter. Beetle epidemics occurred similarly in the denser clumps of trees. When these trees were killed, the beetle population subsided until another group of trees grew into the vulnerable size class. After each beetle event, the dead trees soon fell and provided an opening for more regeneration or fuel for fires. In this manner, a mosaic of tree sizes and densities were maintained, which helped reduce stand uniformity and the widespread destruction from crown fires and bark beetle epidemics.

Today, white pine blister rust and insect epidemics has reduced much of whitebark pine occurring on this ecological site. Fire suppression efforts have also reduced the diverse structures and age classes. The risk of disease, insect epidemics, and fire are high.

Native Ecosystem Diversity: The state and transition model resulting from the historical fire regime is presented in Figure 14. The vegetation characteristics of both the low and high severity fire conditions of the Cold-Dry forest ecological site are provided in Table 9. For a complete list of plant species that may be associated with this ecological site, please see Appendix A-6.

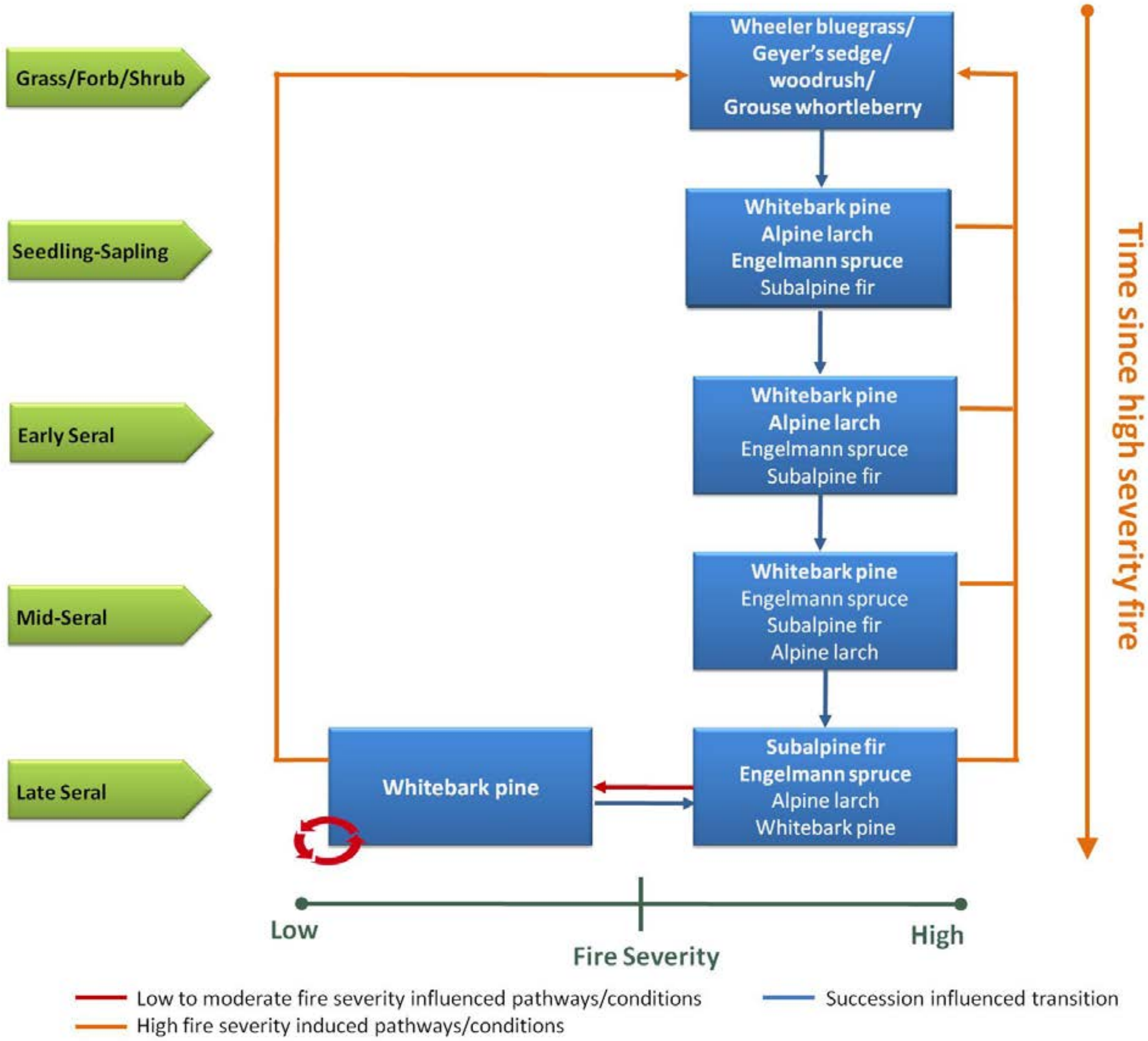


Figure 14. State and transition model identifying the historical disturbance states or range of native ecosystem diversity for the Cold-Dry forest ecological sites of the Blackfoot Watershed.

Table 9. Vegetation characteristics resulting from the low and high severity fire conditions as influencing the mixed-severity A (MSA), mixed-severity B (MSB), and lethal fire regimes of the Cold-Dry forest ecological site.

LOW SEVERITY FIRE CONDITIONS	HIGH SEVERITY FIRE CONDITIONS
Overstory Structure	
• Low to moderate density, all aged conditions • Clear presence of medium to large diameter trees • Fire adapted tree species, primarily whitebark pine • Trees tend to occur in clusters • On severe sites, trees heights and size can be stunted • Basal area range typically _ to _ sq. ft. per acre ** • _ to _ tpa > 12" dbh ** • Age of oldest cohort >180 years • Average canopy cover <50% • Medium to large persistent snags are important feature; occurring in a clumped manner not uniform throughout the stand	• Moderate density, even or uneven-aged conditions • Early seral states are primarily even-aged, one story canopies but becomes multi-aged, multi-storied in mid-to-late seral states • Fire dependent and shade tolerant species dominate depending on the state; primarily whitebark pine, Engelmann spruce, and subalpine fir • Basal area is variable depending on the seral state but ranges between _ to _ sq. ft per acre ** • Age of oldest cohort likely <100 years – MSA, <150 years – MSB, and lethal depends on seral state • Average canopy cover of early to late seral states >40% • Between severe fires, snags are uniformly present in all age classes at low densities unless insects or disease kill higher percentage than average • After severe fire, snags are numerous and may persist for a number of years after fire; also a few scattered fire adapted species such as ponderosa pine, western larch, and large Douglas-fir with thick bark may survive in the canopy
Understory Structure	
• open and park-like • dominated by grasses with scattered small trees and small patches/stringers of shrubs • coarse woody debris is large in size and occurs in clumped manner but is low to moderate at 7 to 15 tons per acre, it is also less persistent due to the frequency of fire	• moderately dense to dense • dominated by small trees, shrubs, and grasses • coarse woody debris is variable in size depending on the age of the stand and is more uniformly distributed, it is also more persistent due to the greater time frame between fires

** Historic stand structures in the Cold-Dry ecological site have not been well documented to date

Cross-walk to habitat types

The Cold-Dry forest ecological site includes the following habitat types from Pfister et al. (1977):

850. Whitebark pine - Subalpine fir
870. Whitebark pine

- **Cold-Moist**

Distribution: This ecological site represents the more high elevation cold and moist environments of the Blackfoot watershed often occurring in the transition zone between the upper elevation forests and the alpine tundra. This site encompasses 3,902 acres or 0.3% of the watersed. The climate is characterized by a short growing season with early summer frosts. Precipitation comes primarily in the form of snow. Timber productivity on this ecological site is usually low.

Description: Primary tree species that can occur on this ecological site include whitebark pine, subalpine fir, alpine larch, lodgepole pine, and Engelmann spruce. Historically, these sites were primarily influenced by the mixed-severity A fire regime. The mixed-severity B fire regime occurred occasionally and the lethal fire regime occurred more rarely. The non-lethal fire regime did not occur on this ecological site. Whitebark pine is usually a major component of the overstory and provides protection for Engelmann spruce and subalpine fir seedlings to become established in moister or more protected areas. Subalpine fir often struggles in this harsh, windblown environment, often becoming stunted and shrub-like when exposed. Alpine larch is usually found at the coolest extremes of this ecological site, together with the other species or in pure stands on more extreme sites. Shrub layers are usually sparse, reflecting the cool temperatures and short growing seasons inherent to this ecological site. The mixed-severity fire regimes are somewhat patchier even than on less extreme ecological sites, in that fires creep through these stands wherever fine fuels will carry a flame and then flare up wherever fuel is concentrated in the denser patches of trees, usually those greater than eight inches in diameter. Beetle epidemics occur similarly in the denser clumps of trees. As a patch of trees are killed, the beetle population subsides until another group of trees grow into the vulnerable size class. After each beetle event, the dead trees fall and provide an opening for more regeneration or fuel for fires. In this manner, a mosaic of tree sizes and densities are maintained, which help reduce stand uniformity and the widespread destruction from crown fires and bark beetle epidemics.

Today, white pine blister rust and insect epidemics has reduced much of whitebark pine occurring on this ecological site. Fire suppression efforts have also reduced the diverse structures and age classes. The risk of disease, insect epidemics, and fire are high.

Native Ecosystem Diversity: The state and transition model resulting from the historical fire regime is presented in Figure 15. The vegetation characteristics of both the low and high severity fire conditions of the Cold-Moist forest ecological site are provided in Table 10. For a more detailed list of plant species that may be associated with this ecological site, please see Appendix A-7.

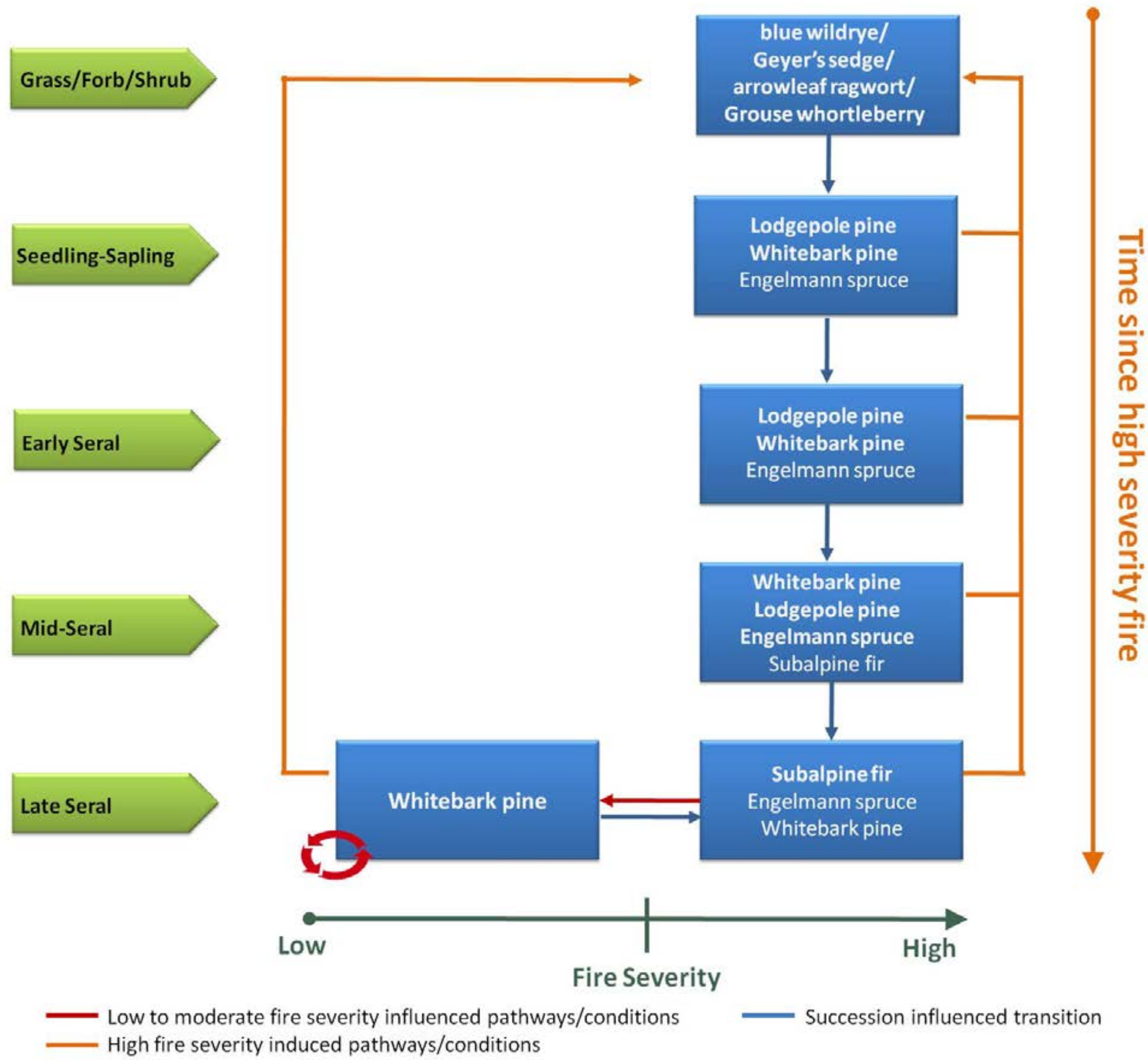


Figure 15. State and transition models identifying the historical disturbance states or range of native ecosystem diversity for the Cold-Moist forest ecological sites of the Blackfoot Watershed.

Table 10. Vegetation characteristics resulting from the low and high severity fire conditions as influencing the mixed-severity A (MSA), mixed-severity B (MSB), and lethal fire regimes of the Cold-Moist forest ecological site.

LOW SEVERITY FIRE CONDITIONS	HIGH SEVERITY FIRE CONDITIONS
Overstory Structure	
• Low to moderate density, all aged conditions • Clear presence of medium to large diameter trees • Fire adapted tree species, primarily whitebark pine • Trees tend to occur in clusters • On severe sites, trees heights and size can be stunted • Basal area range typically _ to _ sq. ft. per acre ** • _ to _ tpa > 12" dbh ** • Age of oldest cohort >180 years • Average canopy cover <50% • Medium to large persistent snags are important feature; occurring in a clumped manner not uniform throughout the stand	• Moderate density, even or uneven-aged conditions • Early seral states are primarily even-aged, one story canopies but becomes multi-aged, multi-storied in mid-to-late seral states • Fire dependent and shade tolerant species dominate depending on the state; primarily whitebark pine, lodgepole pine, Engelmann spruce, and subalpine fir • Basal area is variable depending on the seral state but ranges between _ to _ sq. ft per acre ** • Age of oldest cohort likely <100 years – MSA, <150 years – MSB, and lethal depends on seral state • Average canopy cover of early to late seral states >40% • Between severe fires, snags are uniformly present in all age classes at low densities unless insects or disease kill higher percentage than average • After severe fire, snags are numerous and may persist for a number of years after fire; also a few scattered fire adapted species such as ponderosa pine, western larch, and large Douglas-fir with thick bark may survive in the canopy
Understory Structure	
• relatively open stand conditions • dominated by grasses with scattered small trees and small patches/stringers of shrubs • coarse woody debris is medium to large in size and occurs in clumped manner but is low to moderate averaging 11 tons per acre, it is also less persistent due to the frequency of fire	• moderately dense • dominated by small trees, shrubs, and grasses • coarse woody debris is variable in size depending on the age of the stand and is more uniformly distributed, it is also more persistent due to the greater time frame between fires

** Historic stand structures in the Cold-Moist ecological site have not been well documented to date

<u>Cross-walk to habitat types</u>

The Cold-Moist forest ecological site includes the following habitat types from Pfister et al. (1977):

820. Subalpine fir/Whitebark pine_ grouse whortleberry
831. Subalpine fir/smooth wood rush_grouse whortleberry
925. Alpine larch-Subalpine fir

Grass-shrub Ecological Sites

As stated previously, the NRCS ecological site descriptions were used as the foundation to describe the ecological sites identified for the Blackfoot watershed and their associated native plant species composition. In addition, a rapid-assessment field survey was used to augment this information for 4 ecological sites that included Hot-Droughty, Hot-Loamy, Warm-Droughty, and Warm-Loamy. The remaining 3 ecological sites that include Warm-Claypan, Warm-Sandy, and Warm-Gravelly were not surveyed and consequently there is less confidence in the species composition information summarized in the following sections. In addition, there is repetition in the species composition of dominant species among the ecological sites that may suggest that additional grouping may be appropriate. However, we have chosen to keep these sites separate for now, until more information is obtained during future field surveys conducted in the Blackfoot watershed that may shed more light on important differences between these ecological sites.

- ### Hot-Droughty

Distribution: The Hot-Droughty grass-shrub ecological site occupies approximately 0.6% or 8,220 acres of the Blackfoot watershed. These sites receive the lowest average annual precipitation in the watershed at 9 to 14 inches and represent some of the hottest terrestrial sites in the watershed. The frost free period averages 105 days per year. Soils on these sites are very deep and well drained having formed in alluvium, colluvium, and till. The soil surface texture ranges from very fine sandy loam to silty clay loam while also exhibiting a skeletal structure – that is, containing 35% or more coarse fragments including gravels, stones, and rocks. This skeletal material decreases the water-holding capacity of the soils and overall productivity of this ecological site. These sites are usually associated with terraces, fans and steep south or west facing slopes. They also exhibit relatively low productivity in the watershed with an average annual range of 400 to 1400 lbs. per acre, depending on the current disturbance state and the amount of precipitation received during the year.

Description: Native ecosystem diversity on Hot-Droughty grass-shrub ecological sites was influenced by historical disturbance regimes of fire and herbivore grazing. The combined interaction of both disturbance types played an important role in shaping the species composition and vegetation structure on this ecological site. Primary grass species that respond as decreasers with increasing grazing pressure include bluebunch wheatgrass and Columbia needlegrass. Species such as Idaho fescue, Sandberg bluegrass, and threadleaf sedge usually respond as increasers at more moderate grazing levels but will often decrease with persistent, long-term heavy grazing. Historically, these sites were primarily influenced by the short-interval fire regime, consequently grass species were the dominant growth form and shrubs were a more minor component on these sites. On areas of this site influenced by the long-interval fire regime, shrubs species such as big sagebrush, chokecherry, and prairie sagewort would increase in cover and become dominant to or co-dominant with, grass species.

Native Ecosystem Diversity: Figure 16 demonstrates the Hot-Droughty ecological site state and transition model for different disturbance states within the Blackfoot watershed as influenced by historical disturbance regimes of fire and bison grazing. The combination of these 4 disturbance states represents the range of conditions or native ecosystem diversity that occurred historically on the Hot-

Droughty ecological site. The plant species identified in each disturbance state (boxes a. to d. in the figure) indicate the more common species that would increase or decrease in occurrence, depending on the influence of the historical disturbance regimes, as indicated by the direction of the arrows. These species are considered the primary indicators of a particular disturbance state based on their sensitivity to historical disturbance processes that includes the interaction of grazing intensity x fire frequency x Hot-Droughty ecological site characteristics. It is also important to note that each state represents a diverse ecological community of plant species that would function as habitat for associated animal species. Table 11 provides additional information on characteristic features of each disturbance state identified in Figure 16, as referenced to the letter code in the upper left corner of each box. For a more detailed list of the potential native species historically occurring on this site, please see Appendix B-1.

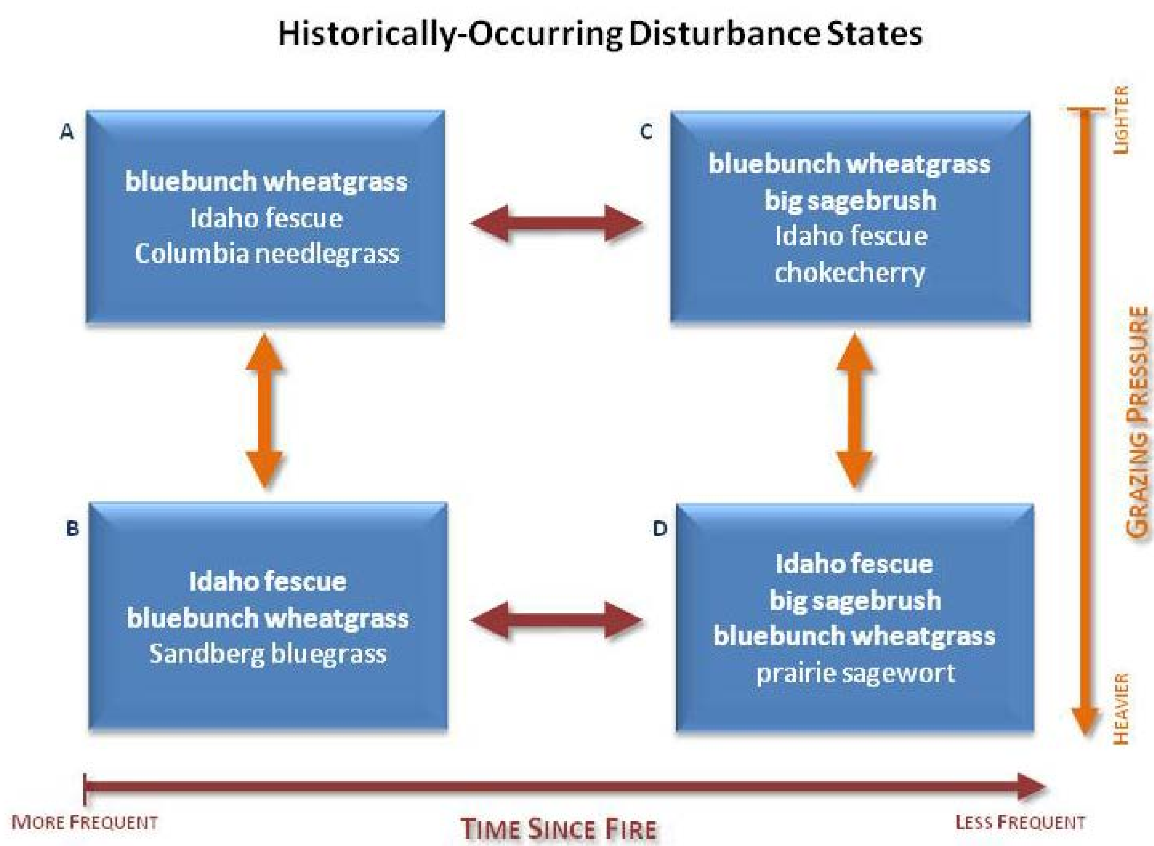


Figure 16. State and transition model identifying the historical disturbance states or range of native ecosystem diversity for Hot-Droughty grass-shrub ecological sites of the Blackfoot watershed.

Table 11. The vegetation characteristics resulting from fire and grazing regime influences on the 4 disturbance states historically occurring on the Hot-Droughty ecological site.

	Disturbance State A	Disturbance State B	Disturbance State C	Disturbance State D
Mean Fire Return Interval				
	SHORT < 25 years	**SHORT** < 25 years	**LONG** ≥ 25 years	**LONG** ≥ 25 years
Grazing Regime				
	LIGHT short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate	**LIGHT** short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate
Growth Form (% composition, relative cover)				
Grasses	>75%	>65%	<75%	<65%
Forbs	<15%	<25%	<15%	<25%
Shrubs	<10%	<10%	>10%	>10%
Dominant Structure				
	bunchgrasses; >8" avg. heights	bunchgrasses; <8" but >4" avg. heights	bunchgrasses; >8" avg. heights shrubs; >10" avg. heights	bunchgrasses; <8" but >4" avg. heights shrubs; >6" avg. heights
Historical Productivity Estimate (lbs/acre)				
	700 to 1300	400 to 1100	775 to 1400	450 to 1200
Primary Indicators-Disturbance Regimes (% relative cover)				
Fire Regime	sagebrush<10%	sagebrush<10%	sagebrush>10%	sagebrush>10%
Grazing Regime	bluebunch wheatgrass>50% and Idaho fescue<20%	bluebunch wheatgrass >10 to <50% and Idaho fescue>20%	bluebunch wheatgrass>40% and Idaho fescue<10%	bluebunch wheatgrass >10 to <40% and Idaho fescue>10%

- **Hot-Loamy**

Distribution: The Hot-Loamy grass-shrub ecological site occupies approximately 21,500 acres or 1.5% of the Blackfoot watershed. Along with the Hot-Droughty sites, the Hot-Loamy grass-shrub ecological sites receive the lowest average annual precipitation at 9 to 14", and are the hottest sites within the watershed. The frost free period also averages 105 days per year. Soils on these sites are very deep and well drained having formed in alluvial and glacial deposits. There are no significant soil or moisture limiting factors on this ecological site. These sites are usually found on terraces, benches, valley slopes, and fans. The Hot-Loamy grass-shrub ecological site exhibits relatively low to moderate productivity in the watershed with an average annual range of 500 to 1850 lbs. per acre.

Description: Native ecosystem diversity on Hot-Loamy grass-shrub ecological sites was influenced by historical disturbance regimes of fire and herbivore grazing. Primary grass species that respond as decreasers with increasing grazing pressure on these sites include bluebunch wheatgrass and Columbia needlegrass. Species such as Idaho fescue, western wheatgrass, Sandberg bluegrass, threadleaf sedge, and prairie junegrass usually respond as increasers at more moderate grazing levels but will often decrease with persistent, long-term heavy grazing levels. Historically, these sites were primarily influenced by the short-interval fire regime, consequently grass species were the dominant growth form and shrubs were a more minor component on these sites. On areas of this site influenced by the long-interval fire regime, shrubs species such as threetip big sagebrush, rubber rabbitbrush, big sagebrush, and prairie sagewort would increase in cover and become dominant to or co-dominant with grass species.

Native Ecosystem Diversity: Figure 17 demonstrates the Hot-Loamy ecological site state and transition model for different disturbance states within the Blackfoot watershed as influenced by historical disturbance regimes of fire and bison grazing. Table 12 provides additional information on characteristic features of each disturbance state identified in Figure 17, as referenced to the letter code in the upper left corner of each box. For a more detailed list of the potential native species historically occurring on this site, please see Appendix B-2.

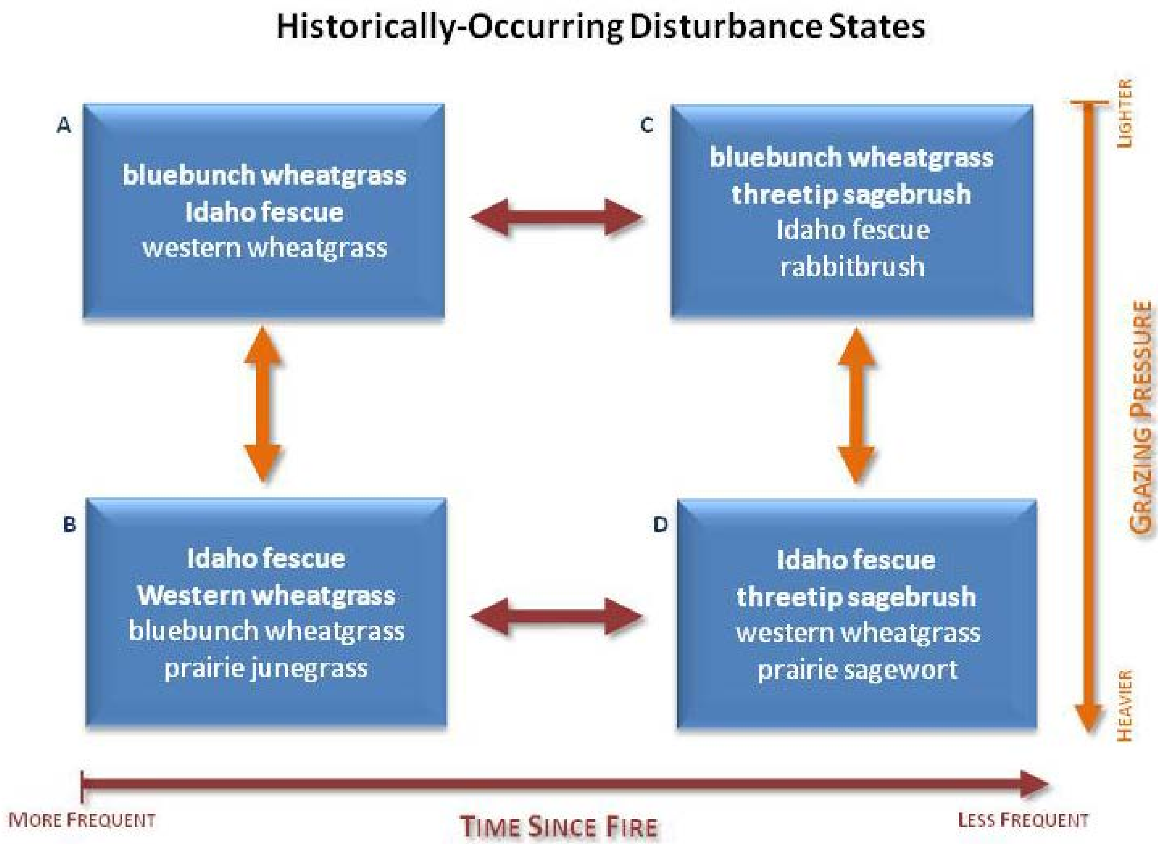


Figure 17. State and transition model identifying the historical disturbance states or range of native ecosystem diversity for Hot-Loamy grass-shrub ecological sites of the Blackfoot watershed.

Table 12. The vegetation characteristics resulting from fire and grazing regime influences on the 4 disturbance states historically occurring on the Hot-Loamy ecological site.

	Disturbance State A	Disturbance State B	Disturbance State C	Disturbance State D
Mean Fire Return Interval				
	SHORT < 25 years	**SHORT** < 25 years	**LONG** ≥ 25 years	**LONG** ≥ 25 years
Grazing Regime				
	LIGHT short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate	**LIGHT** short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate
Growth Form (% composition, relative cover)				
Grasses	>75%	>65%	<75%	<65%
Forbs	<15%	<25%	<15%	<25%
Shrubs	<10%	<10%	>10%	>10%
Dominant Structure				
	bunchgrasses; >8" avg. heights	bunchgrasses; <8" but >4" avg. heights	bunchgrasses; >8" avg. heights shrubs; >10" avg. heights	bunchgrasses; <8" but >4" avg. heights shrubs; >6" avg. heights
Historical Productivity Estimate (lbs/acre)				
	900 to 1700	500 to 1450	1000 to 1850	550 to 1575
Primary Indicators of Disturbance State (% relative cover)				
Fire Regime	sagebrush<10%	sagebrush<10%	sagebrush>10%	sagebrush>10%
Grazing Regime	bluebunch wheatgrass>50% and Idaho fescue<20%	bluebunch wheatgrass >10 to <50% and Idaho fescue>20%	bluebunch wheatgrass>40% and Idaho fescue<10%	bluebunch wheatgrass >10 to <40% and Idaho fescue>10%

- **Warm-Droughty**

Distribution: The Warm-Droughty grass-shrub ecological site occupies approximately 84,300 acres or 5.7% of the Blackfoot watershed and represents the largest extent of grass-shrub ecological sites in the watershed. These sites receive moderate levels of average annual effective precipitation at >14", and are relatively warm sites with the frost free period averaging 95 days per year. Soils are usually very deep and well-drained. The soil surface texture ranges from very fine sandy loam to silty clay loam while also exhibiting a skeletal structure. This skeletal material decreases the water-holding capacity of the soils and overall productivity of this ecological site. These sites are usually found on terraces, fans, and steep south and west facing slopes with large rock fragments. The Warm-Droughty grass-shrub ecological site exhibits relatively low to moderate productivity in the watershed with an average annual range of 450 to 2250 lbs. per acre.

Description: Native ecosystem diversity on warm droughty grass-shrub ecological sites was influenced by historical disturbance regimes of fire and herbivore grazing. Plant species that respond as decreasers with increasing grazing pressure include rough fescue and bluebunch wheatgrass. Species like Idaho fescue, needleandthread, Sandberg bluegrass, western/thickspike wheatgrass, and prairie junegrass usually respond as increasers to more moderate to heavy grazing levels. Historically, these sites were primarily influenced by the short-interval fire regime, consequently grass species were the dominant growth form and shrubs were a more minor component on these sites. On more protected areas of these sites influenced by the long-interval fire regime, shrubs species such as Wyoming big sagebrush, skunkbush sumac, and rubber rabbitbrush would increase in cover and become dominant to or co-dominant with grass species

Native Ecosystem Diversity: Figure 18 demonstrates the warm droughty grass-shrub ecological site state and transition model for different disturbance states within the Blackfoot watershed as influenced by historical disturbance regimes of fire and bison grazing. Table 13 provides additional information on characteristic features of each disturbance state identified in Figure 18, as referenced to the letter code in the upper left corner of each box. For a more detailed list of the potential native species historically occurring on this site, please see Appendix B-3.

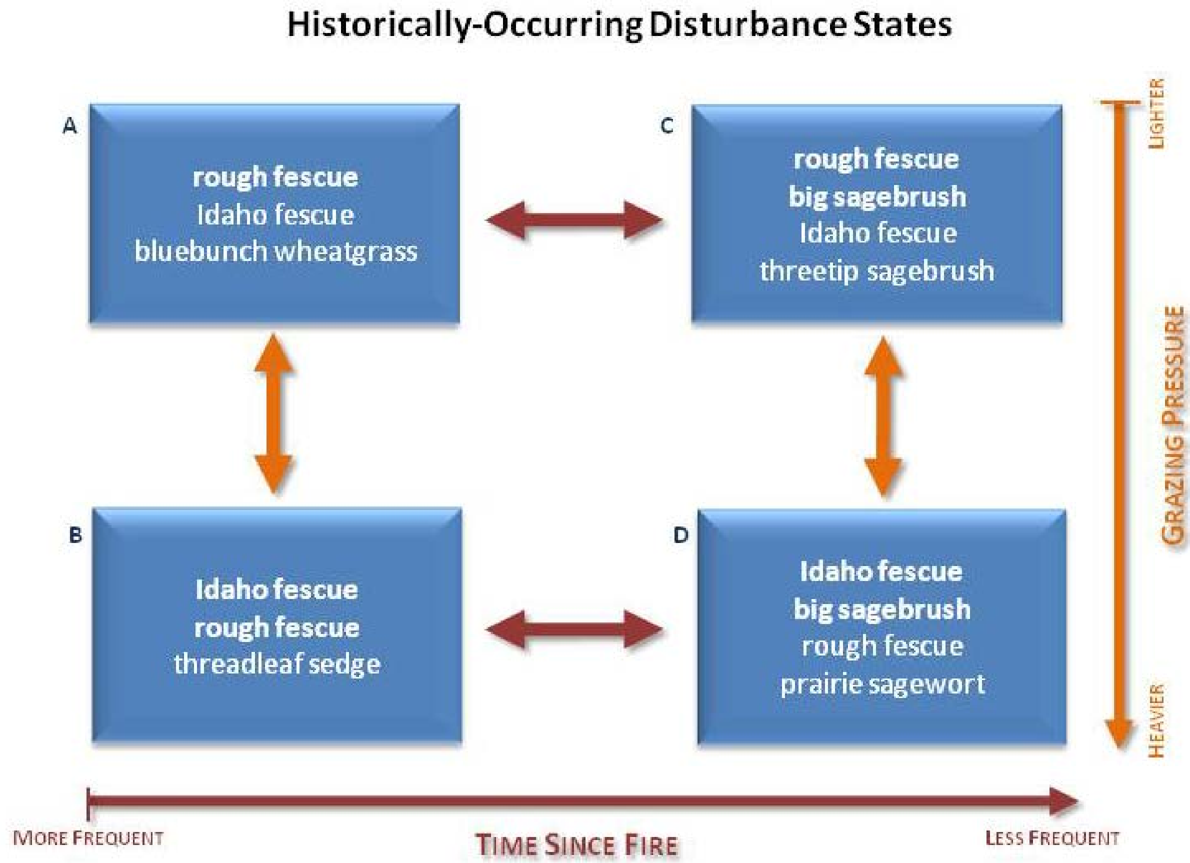


Figure 18. State and transition model identifying the historical disturbance states or range of native ecosystem diversity for Warm-Droughty grass-shrub ecological sites of the Blackfoot watershed.

Table 13. The vegetation characteristics resulting from fire and grazing regime influences on the 4 disturbance states historically occurring on the Warm-Droughty ecological site.

	Disturbance State A	Disturbance State B	Disturbance State C	Disturbance State D
Mean Fire Return Interval				
	SHORT < 25 years	**SHORT** < 25 years	**LONG** ≥ 25 years	**LONG** ≥ 25 years
Grazing Regime				
	LIGHT short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate	**LIGHT** short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate
Growth Form (% composition, relative cover)				
Grasses	>75%	>65%	<75%	<65%
Forbs	<15%	<25%	<15%	<25%
Shrubs	<10%	<10%	>10%	>10%
Dominant Structure				
	bunchgrasses; >8" avg. heights	bunchgrasses; <8" but >4" avg. heights	bunchgrasses; >8" avg. heights shrubs; >10" avg. heights	bunchgrasses; <8" but >4" avg. heights shrubs; >6" avg. heights
Historical Productivity Estimate (lbs/acre)				
	800 to 2100	450 to 1800	875 to 2250	500 to 1900
Primary Indicators of Disturbance State (% relatve cover)				
Fire Regime	sagebrush<10%	sagebrush<10%	sagebrush>10%	sagebrush>10%
Grazing Regime	rough fescue>50% and Idaho fescue<20%	rough fescue>10 to <50% and Idaho fescue>20%	rough fescue>40% and Idaho fescue<10%	rough fescue>10 to <40% and Idaho fescue>10%

- **Warm-Loamy**

Distribution: The Warm-Loamy ecological site occupies approximately 29,740 acres or 2.0% of the Blackfoot watershed. These sites receive moderate average annual effective precipitation at >14", and are relatively warm sites with the frost free period averaging 95 days per year. Soils on these sites are very deep and well drained having formed in alluvial and glacial deposits. There is no significant soil or moisture limiting factors to plant growth. The soil surface texture ranges from very fine sandy loam to clay loam. Predominant landforms often include alluvial fans, stream terraces, moraines, and hills. The Warm-Loamy grass-shrub ecological site is moderately productive in the watershed with an average annual productivity range of 650 to 3250 lbs. per acre, depending on the current disturbance state and the amount of precipitation received during the year.

Description: Native ecosystem diversity on Warm-Loamy grass-shrub ecological sites was influenced by historical disturbance regimes of fire and herbivore grazing. Primary plant species that respond as decreasers with increasing grazing pressure include rough fescue and bluebunch wheatgrass. Species such as Idaho fescue, needleandthread, Sandberg bluegrass, western/thickspike wheatgrass, and prairie junegrass usually respond as increasers at more moderate to heavy grazing levels. Historically, these sites were primarily influenced by the short-interval fire regimes, consequently grass species were the dominant growth form and shrubs were a more minor component on these sites. On more protected areas of these sites influenced by the long-interval fire regime, shrubs species such as mountain big sagebrush, Wyoming big sagebrush, broom snakeweed, and rubber rabbitbrush would increase in cover and become dominant to or co-dominant with grass species.

Native Ecosystem Diversity: Figure 19 demonstrates the Warm-Loamy grass-shrub ecological site state and transition model for different disturbance states within the Blackfoot watershed as influenced by historical disturbance regimes of fire and bison grazing. Table 14 provides additional information on characteristic features of each disturbance state identified in Figure 19, as referenced to the letter code in the upper left corner of each box. For a more detailed list of the potential native species historically occurring on this site, please see Appendix B-4.

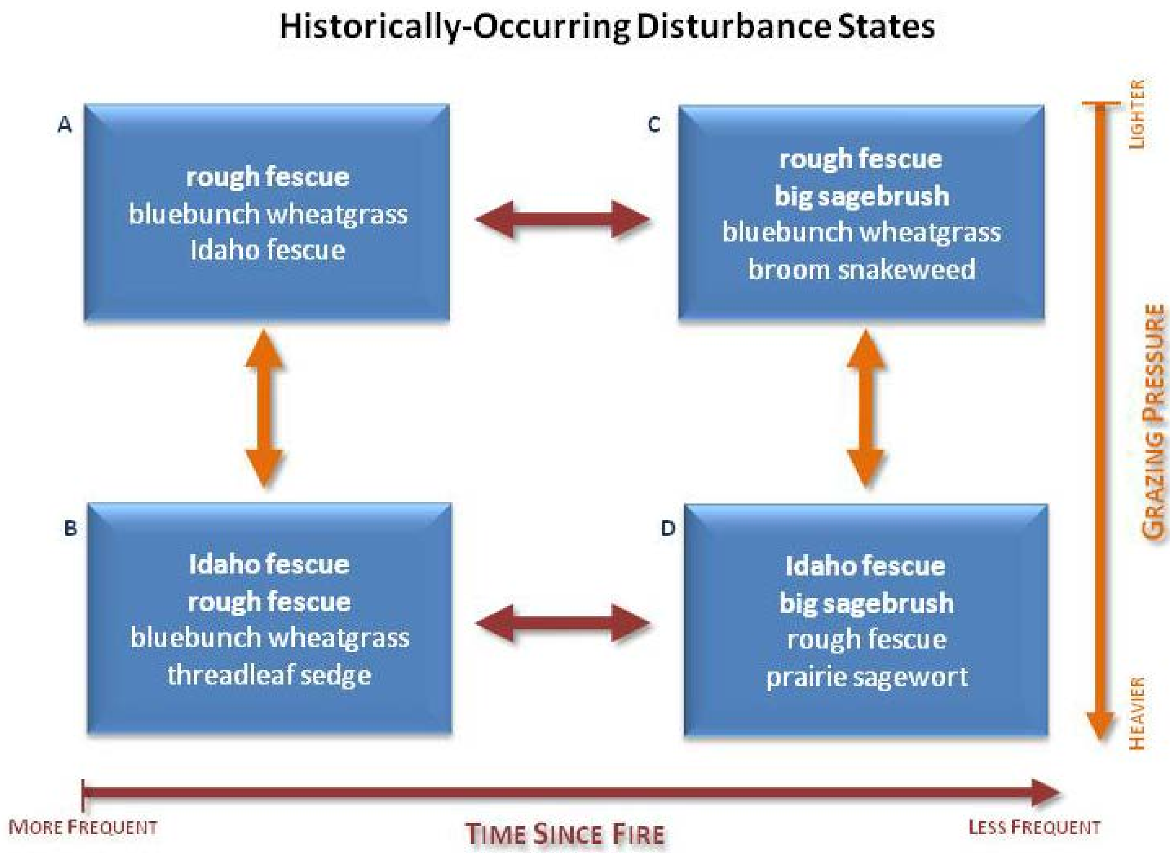


Figure 19. State and transition model identifying in the historical disturbance states or range of native ecosystem diversity for Warm-Loamy grass-shrub ecological sites of the Blackfoot watershed.

Table 14. The vegetation characteristics resulting from fire and grazing regime influences on the 4 disturbance states historically occurring on the Warm-Loamy ecological site.

	Disturbance State A	**Disturbance State B**	**Disturbance State C**	**Disturbance State D**
Mean Fire Return Interval				
	SHORT < 25 years	**SHORT** < 25 years	**LONG** ≥ 25 years	**LONG** ≥ 25 years
Grazing Regime				
	LIGHT short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate	**LIGHT** short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate
Growth Form (% composition, relative cover)				
Grasses	>75%	>65%	<75%	<65%
Forbs	<15%	<25%	<15%	<25%
Shrubs	<10%	<10%	>10%	>10%
Dominant Structure				
	bunchgrasses; >8" avg. heights	bunchgrasses; <8" but >4" avg. heights	bunchgrasses; >8" avg. heights shrubs; >10" avg. heights	bunchgrasses; <8" but >4" avg. heights shrubs; >6" avg. heights
Historical Productivity Estimate (lbs/acre)				
	1200 to 3000	650 to 2250	1300 to 3250	725 to 2750
Primary Indicators of Disturbance State (% relative cover)				
Fire Regime	sagebrush<10%	sagebrush<10%	sagebrush>10%	sagebrush>10%
Grazing Regime	rough fescue>30% and Idaho fescue<20%	rough fescue>10 to <30% and Idaho fescue>20%	rough fescue>20% and Idaho fescue<10%	rough fescue>10 to <20% and Idaho fescue>20%

- **Warm-Sandy**

Distribution: The Warm-Sandy grass-shrub ecological site occupies approximately 1,320 acres or 0.1% of the Blackfoot watershed. These sites receive moderate average annual effective precipitation at >14”, and are relatively warm sites with the frost free period averaging 95 days per year. Soils on these sites are very deep and well drained having formed in alluvium and eolian deposits. Soil permeability is moderately slow to moderately rapid. The soil surface texture ranges from coarse to fine sandy loams. Predominant landforms often include alluvial fans, stream terraces, and dunes. The Warm-Sandy grass-shrub ecological site is moderately productive in the watershed with an average annual productivity range of 800 to 2200 lbs. per acre.

Description: Native ecosystem diversity on Warm-Sandy grass-shrub ecological sites was influenced by historical disturbance regimes of fire and herbivore grazing. Plant species that respond as decreasers with increasing grazing pressure include rough fescue, bluebunch wheatgrass, and Indian ricegrass. Species like Idaho fescue, needleandthread, Sandberg bluegrass, western/thickspike wheatgrass, and prairie junegrass usually respond as increasers at more moderate to heavy grazing levels. Historically, these sites were primarily influenced by the short-interval fire regime, consequently grass species were the dominant growth form and shrubs were a more minor component on these sites. On more protected areas of these sites influenced by the long-interval fire regime, shrubs species such as big sagebrush and Wood’s rose would increase in cover and become dominant to or co-dominant with grass species.

Native Ecosystem Diversity: Figure 20 demonstrates the sandy grass-shrub ecological site state and transition model for different disturbance states within the Blackfoot watershed as influenced by historical disturbance regimes of fire and bison grazing. Table 15 provides additional information on characteristic features of each disturbance state identified in Figure 20, as referenced to the letter code in the upper left corner of each box. For a more detailed list of the potential native species historically occurring on this site, please see Appendix B-5.

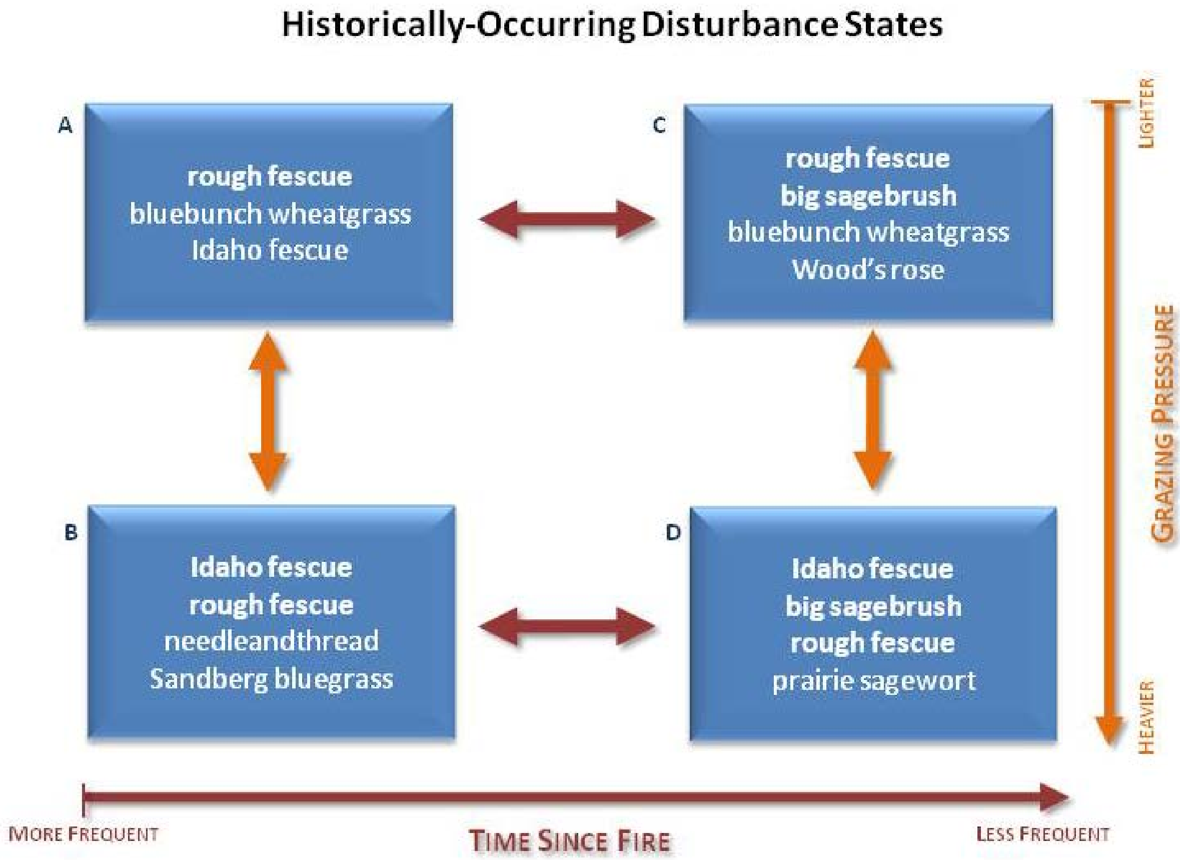


Figure 20. State and transition model identifying the historical disturbance states or range of native ecosystem diversity for Warm-Sandy grass-shrub ecological sites of the Blackfoot watershed.

Table 15. The vegetation characteristics resulting from fire and grazing regime influences on the 4 disturbance states historically occurring on the Warm-Sandy ecological site.

	Disturbance State A	Disturbance State B	Disturbance State C	Disturbance State D
Mean Fire Return Interval				
	SHORT < 25 years	**SHORT** < 25 years	**LONG** ≥ 25 years	**LONG** ≥ 25 years
Grazing Regime				
	LIGHT short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate	**LIGHT** short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate
Growth Form (% composition, relative cover)				
Grasses	>75%	>65%	<75%	<65%
Forbs	<15%	<25%	<15%	<25%
Shrubs	<10%	<10%	>10%	>10%
Dominant Structure				
	bunchgrasses; >8" avg. heights	bunchgrasses; <8" but >4" avg. heights	bunchgrasses; >8" avg. heights shrubs; >10" avg. heights	bunchgrasses; <8" but >4" avg. heights shrubs; >6" avg. heights
Historical Productivity Estimate (lbs/acre)				
	1100 to 2200	600 to 1875	1200 to 2375	650 to 2000
Primary Indicators of Disturbance State (% relative cover)				
Fire Regime	sagebrush<10%	sagebrush<10%	sagebrush>10%	sagebrush>10%
Grazing Regime	rough fescue>30% and Idaho fescue<20%	rough fescue>10 to <30% and Idaho fescue>20%	rough fescue>30% and Idaho fescue<20%	rough fescue>10 to <30% and Idaho fescue>20%

- **Warm-Gravelly**

Distribution: The Warm-Gravelly grass-shrub ecological site occupies approximately 4,770 acres or 0.3% of the Blackfoot watershed. These sites receive moderate average annual effective precipitation at >14", and are relatively warm sites with the frost free period averaging 95 days per year. Soils on these sites are very deep and well drained having formed in alluvium and outwash deposits. Soil permeability is moderate to moderately rapid. The soil surface texture ranges from loamy sand to loam while also exhibiting a skeletal structure. This skeletal material decreases the water-holding capacity of the soils and overall productivity of this ecological site. Predominant landforms often include outwash plains, alluvial fans, and stream terraces. The Warm-Gravelly grass-shrub ecological site exhibits relatively low productivity in the watershed with an average annual productivity range of 700 to 1700 lbs. per acre, depending on the current disturbance state and the amount of precipitation received during the year.

Description: Native ecosystem diversity on Warm-Gravelly grass-shrub ecological sites was influenced by historical disturbance regimes of fire and herbivore grazing. Primary plant species that respond as decreasers with increasing grazing pressure include rough fescue and bluebunch wheatgrass. Species such as Idaho fescue, needleandthread, Sandberg bluegrass, western/thickspike wheatgrass, and prairie junegrass usually respond as increasers at more moderate to heavy grazing levels. Where this ecological site was influenced by the short-interval fire regime, grass species were the dominant growth form and shrubs were a more minor component. Whereas, on areas more commonly influenced by the long-interval fire regime, shrub species such as big sagebrush, Wood's rose, and skunkbush sumac were dominant or co-dominant with the grasses.

Native Ecosystem Diversity: Figure 21 demonstrates the Warm-Gravelly grass-shrub ecological site state and transition model for different disturbance states within the Blackfoot watershed as influenced by historical disturbance regimes of fire and bison grazing. Table 16 provides additional information on characteristic features of each disturbance state identified in Figure 21, as referenced to the letter code in the upper left corner of each box. For a more detailed list of the potential native species historically occurring on this site, please see Appendix B-6.

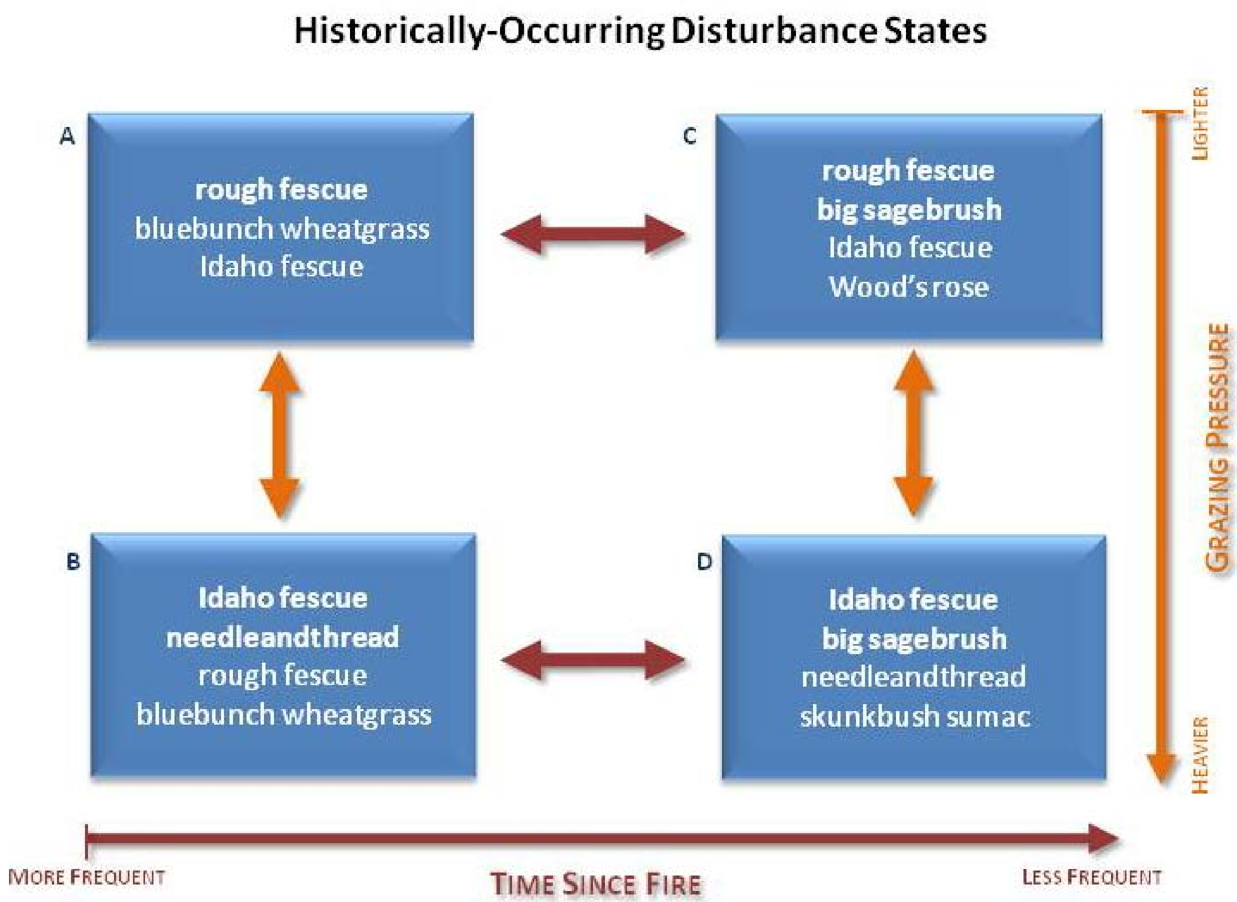


Figure 21 . State and transition model identifying the historical disturbance states or range of native ecosystem diversity for Warm-Gravelly ecological sites of the Blackfoot watershed.

Table 16. The vegetation characteristics resulting from fire and grazing regime influences on the 4 disturbance states historically occurring on the Warm-Gravelly ecological site.

	Disturbance State A	Disturbance State B	Disturbance State C	Disturbance State D
Mean Fire Return Interval				
	SHORT < 25 years	**SHORT** < 25 years	**LONG** ≥ 25 years	**LONG** ≥ 25 years
Grazing Regime				
	LIGHT short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate	**LIGHT** short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate
Growth Form (% composition, relative cover)				
Grasses	>75%	>65%	<75%	<65%
Forbs	<15%	<25%	<15%	<25%
Shrubs	<10%	<10%	>10%	>10%
Dominant Structure				
	bunchgrasses; >8" avg. heights	bunchgrasses; <8" but >4" avg. heights	bunchgrasses; >8" avg. heights shrubs; >10" avg. heights	bunchgrasses; <8" but >4" avg. heights shrubs; >6" avg. heights
Historical Productivity Estimate (lbs/acre)				
	1000 to 1700	550 to 1450	1100 to 1850	600 to 1575
Primary Indicators of Disturbance State (% relative cover)				
Fire Regime	sagebrush<10%	sagebrush<10%	sagebrush>10%	sagebrush>10%
Grazing Regime	rough fescue>50% and Idaho fescue<20%	rough fescue>10 to <50% and Idaho fescue>20%	rough fescue>50% and Idaho fescue<20%	rough fescue>10 to <50% and Idaho fescue>20%

- **Warm-Claypan**

Distribution: The Warm-Claypan ecological site occupies approximately 2,950 acres or 0.2% of the ecological sites in the Blackfoot watershed. These sites receive moderate average annual effective precipitation at >14”, and are relatively warm sites with the frost free period averaging 95 days per year. Soils on these sites have loamy surfaces generally 4 to 8 inches thick over dense clayey subsoils. Drainage and permeability are slow. These sites are typically characterized as nearly level to moderately sloping on benches and terraces, where slopes can range from 0 to 15%. Warm-Claypan ecological sites are low to moderately productive in the watershed with an average annual productivity range of 350 to 2900 lbs. per acre, depending on the current disturbance state and the amount of precipitation received during the year.

Description: Native ecosystem diversity on Warm-Claypan grass-shrub ecological sites was influenced by historical disturbance regimes of fire and herbivore grazing. Primary plant species that respond as decreasers with increasing grazing pressure include rough fescue and bluebunch wheatgrass. Species such as Idaho fescue, Columbia needlegrass, threadleaf sedge, Sandberg bluegrass, and western wheatgrass usually respond as increasers at more moderate to heavy grazing levels. Shrubs that might occur in small amounts on sites receiving frequent fires include big sagebrush and horsebrush. Historically, these sites were primarily influenced by the short-interval fire regime, consequently grass species were the dominant growth form and shrubs were a more minor component on these sites. On more protected areas of these sites influenced by the long-interval fire regime, shrubs species such as big sagebrush, horsebrush, and other shrubs would increase in cover and become dominant to or co-dominant with grass species.

Native Ecosystem Diversity: Figure 22 demonstrates the Warm-Claypan grass-shrub ecological site state and transition model for different disturbance states within the Blackfoot watershed as influenced by historical disturbance regimes of fire and bison grazing. Table 17 provides additional information on characteristic features of each disturbance state identified in Figure 22, as referenced to the letter code in the upper left corner of each box. For a more detailed list of the potential native species historically occurring on this site, please see Appendix B-7.

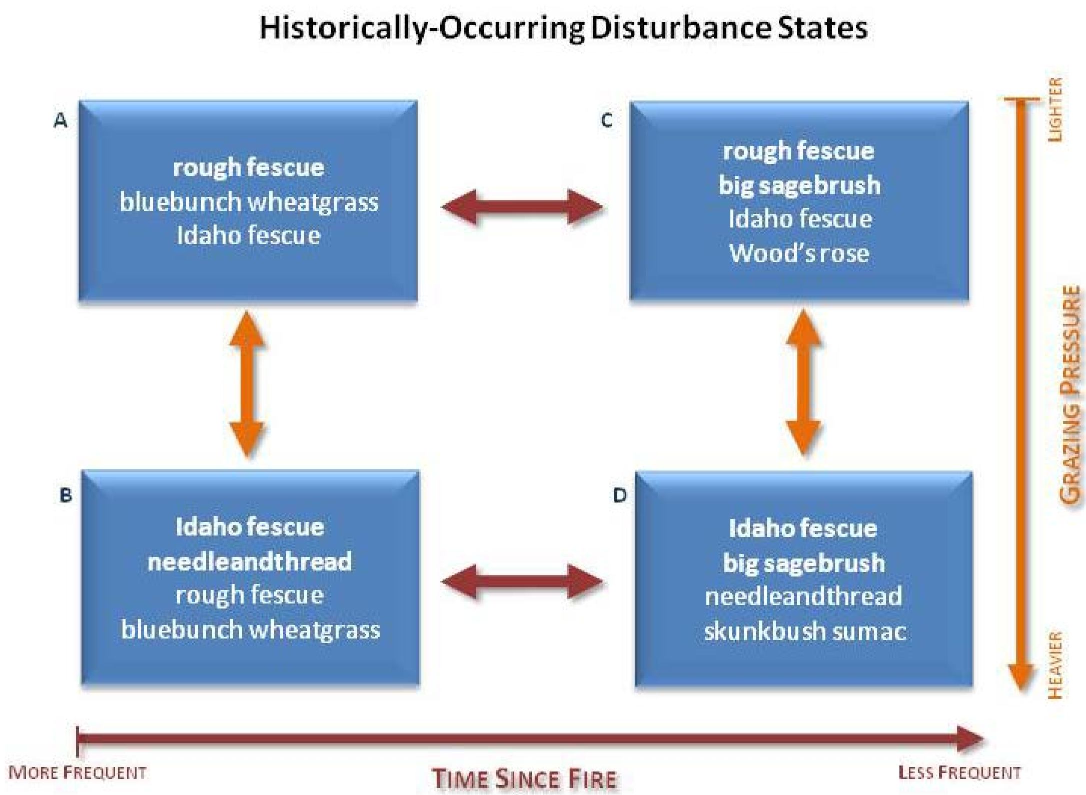


Figure 22. State and transition model identifying the historical disturbance states or range of native ecosystem diversity for Warm-Claypan grass-shrub ecological sites of the Blackfoot watershed.

Table 17. The vegetation characteristics resulting from fire and grazing regime influences on the 4 disturbance states historically occurring on the Warm-Claypan ecological site.

	Disturbance State A	**Disturbance State B**	**Disturbance State C**	**Disturbance State D**
Mean Fire Return Interval				
	SHORT < 25 years	**SHORT** < 25 years	**LONG** ≥ 25 years	**LONG** ≥ 25 years
Grazing Regime				
	LIGHT short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate	**LIGHT** short-term or sporadic periods of moderate to heavy grazing	**MODERATE** variable but occurring most years as moderate
Growth Form (% composition, relative cover)				
Grasses	>75%	>65%	<75%	<65%
Forbs	<15%	<25%	<15%	<25%
Shrubs	<10%	<10%	>10%	>10%
Dominant Structure				
	bunchgrasses; >8" avg. heights	bunchgrasses; <8" but >4" avg. heights	bunchgrasses; >8" avg. heights shrubs; >10" avg. heights	bunchgrasses; <8" but >4" avg. heights shrubs; >6" avg. heights
Historical Productivity Estimate (lbs/acre)				
	800 to 1500	500 to 1200	900 to 1650	600 to 1350
Primary Indicators of Disturbance State (% relative cover)				
Fire Regime	sagebrush<10%	sagebrush<10%	sagebrush>10%	sagebrush>10%
Grazing Regime	rough fescue>30% and Idaho fescue<20%	rough fescue>10 to <30% and Idaho fescue>20%	rough fescue>30% and Idaho fescue<20%	rough fescue>10 to <30% and Idaho fescue>20%

Historical Range of Variability

Describing and quantifying the historical reference conditions and Historical Range of Variability (HRV) requires information on temporal changes in disturbance states in a spatially explicit format. Various sources of information, including early explorers, fur trappers, and settlers accounts, historical photographs and paintings, natural resource expeditions, and pre-settlement land survey records have been used to describe the native vegetation of the United States before settlement impacts occurred (Egan and Howell 2001). However, this information typically only captures one point in time and is frequently non-spatial. Consequently, one of the most common methods used to quantify HRV is computer simulation. Both non-spatial and spatial models have been developed for this purpose (Keane et al. 2004). While simulation models are recognized to have limitations, they can produce reasonable estimates of HRV (Keane et al. 2009). To meet the objectives of this project, a spatially explicit simulation model was used to quantify HRV by simulating the interaction of historical disturbance regimes and vegetation dynamics over a 1000 year period prior to Euro-American settlement of the Blackfoot watershed. The results of the simulation model were then compared to non-spatial, point in time data such as land survey records, historical photographs, etc., to verify that the model results were consistent with these other sources of historical information.

Historical range of variability was modeled for terrestrial ecosystems of the Blackfoot watershed using the spatially explicit landscape model SIMPPLLE (SIMulating Patterns and Processes at Landscape scales)(Chew et al. 2004). SIMPPLLE was used to simulate plant community dynamics as a result of historical disturbance events (e.g., fire and bison grazing), climate, and landscape elements (e.g., ecological site, fire breaks, proximity to water, and elevation). SIMPPLLE uses process probabilities in a stochastic manner and disturbance response parameters that are specified to annually assign disturbance patterns. The probability of a disturbance process originating or spreading from a specific unit on the landscape is determined not just by the plant community's attributes, but also by what exists around it, what processes are occurring around it and what processes have occurred in the past. Although SIMPPLLE has a variety of potential applications, it was specifically used in this project to derive the historical range of variability (HRV) for each terrestrial ecosystem. HRV was described using the average, minimum, and maximum number and percent of acres that each terrestrial ecosystem occupied in multiple simulations.

At the time of this assessment, SIMPPLLE had several modules that could be applied to the Blackfoot watershed. For forest ecosystems, the "Region 1" module was manually configured to obtain information on HRV relative to the objectives of this project. The Region 1 module was developed primarily for forest systems and incorporates the disturbance processes of fire and climate. For grass-shrub ecosystems, the "Great Plains Steppe" module was manually configured to obtain information on HRV relative to the objectives of this project. The Great Plains Steppe module was developed for grass-shrub ecosystems and incorporates the disturbance processes of fire, bison grazing, and climate. The following sections outline the model parameters and model assumptions used in the SIMPPLLE simulations of the Blackfoot watershed.

Model Attributes and Assumptions

Landscape

A model landscape was created for the Blackfoot watershed in ArcGIS. Each of the two SIMPPLLE models was run on this landscape to target either forest ecosystems or grass-shrub ecosystems, as previously discussed. The landscape was delineated into 10 acre cells and each cell was identified as a specific vegetation unit based on its ecological site and by a pre-selected disturbance state. Ecological sites were considered static landscape features in each simulated area. While a starting point for a disturbance state was arbitrarily selected, the model was run for 1000 years prior to recording the results to ensure that the starting vegetation condition was not inappropriately influencing the results. The outputs of these runs were then used to simulate historical ecosystem dynamics. Five simulations, each representing 500 years, were performed in SIMPPLLE for each of the two subregions (forest or grass-shrub) of the Blackfoot watershed. In each of the simulations, the weather patterns were varied but within the range of weather patterns recorded for the Blackfoot watershed in recent history (70+ years). Fire starts were also stochastic, resulting in variations designed to simulate historical variations over time. Following the simulations, the data were summarized using the ecological site x disturbance state framework described previously.

Ecological sites were mapped for model input using the NRCS ecological site classification applied to soils data and combined with National Wetlands Inventory to further refine the wetland and riparian characteristics that could be influencing fire spread and grazing patterns. Digital elevation models were used to map elevation within the watershed.

Plant Dynamics

The response of key plant species to weather patterns (i.e., precipitation and temperature) and disturbance (i.e., fire only for the forest model, and fire and grazing for the grass-shrub model) were tracked annually for each 10 acre cell within SIMPPLLE. Historical climate information was obtained from available climate data for the watershed and described based on the model parameters of dry-normal-wet for moisture patterns and warm-normal-cool for temperature patterns. Within a given year, plant species within each cell were subject to change based on the interaction of weather, grazing in grass-shrub ecosystems only (e.g., light, moderate, or heavy grazing), and the occurrence of fire. Subsequently each 10 acre cell was given a classification (terrestrial ecosystems only) that placed it into a disturbance state within each ecological site based on its plant species composition. That is, classification rules were developed that used species cover within a cell to identify what historical disturbance state it belonged to, and over time, climate and disturbance induced changes in plant species composition caused shifts among disturbance states. Plant species response to weather patterns and disturbance, as well as transition periods among disturbance states, were developed from expert opinion and scientific literature.

- **Fire**

Fire starts were caused by lightning strikes in this model and were stochastically selected, resulting in variations designed to simulate historical variations in lightning-caused fires over time. While Native American fire starts were not specifically included in the SIMPPLLE model, the fire return intervals used to inform the model results did incorporate their influence, so the model results should provide similar historical conditions. While Native Americans likely targeted specific locations for burning, whereas the SIMPPLLE model used random fire starts, it was the vegetation patterns that had the greatest influence on resulting fire occurrences, so the SIMPPLLE model should produce reasonable estimates of the historical fire effects.

The number of lightning strikes was adjusted in the model to cause increases or decreases in the number of fire starts, but the overall influence of fire was more dependent on the burn patterns than on the number of fire starts. Once a fire started in a given cell it had the opportunity to spread to adjacent cells until it encountered cells that reduced the ability of fire to spread (see below), or encountered a stochastic weather ending event. The probability of fire occurrence was influenced by the weather pattern (precipitation and temperature) in a given year and for the Great Plains module, on the grazing history of individual units (e.g., a moderately grazed unit in a given year had a lower probability of burning, whereas a lightly grazed unit had a higher probability of burning). Fire spread probabilities were also influenced by landscape features that acted as natural fire breaks such as permanent water sources (11,935 acres). Intermittent water sources (74,088 acres) that might remain moist during wet precipitation cycles could also influence fire spread probabilities under the right conditions.

Model results were evaluated and model parameters adjusted based on the frequency and severity of fire being applied in the model relative to known mean fire return intervals and fire severity data developed by S. Barrett (2006) using regional fire scar analysis by habitat type/ecological site.

- **Grazing**

Bison grazing only applied to the Great Plains Steppe module. Grazing intensity was dependent on the proximity of the 10 acre vegetation units to water and the fire history of the vegetation units within the areas simulated. For instance, based on current knowledge of bison grazing behavior it was assumed that the closer the 10 acre vegetation units were to water and the more recently burned the vegetation units were, the heavier bison would graze. Vegetation units located between 0 to 5,000 feet away from water had a higher probability of receiving heavy bison grazing, whereas vegetation units located between 5,000 to 15,840 and 15,841 or greater feet away from water had increasingly higher probabilities of receiving moderate or light grazing, respectively. However, grass-shrub ecosystems in the Blackfoot watershed are rarely greater than 5,000 feet from water so this variable is expected to have less influence than time since fire on the overall results. Likewise, the probability of heavy grazing on 10 acre vegetation units 1 to 2 years after a fire was higher, whereas 3 to 5 years and 6 or more years after fire the vegetation units had a higher probability of moderate and light grazing, respectively.

Model Results

Results of the SIMPPLLE model simulations of the historical range of variability are summarized in the following sections by forest and grass-shrub ecosystems.

Forest Ecosystems

Tables 18 and Table 19 provide summaries of the results of the SIMPPLLE model simulations relative to the percent of the Blackfoot watershed with forest ecosystem conditions characterized by the non-lethal, mixed-severity A, mixed-severity B, and lethal fire regimes for both the watershed as a whole and by forest ecological sites, respectively.

Table 18. Results of SIMPPLLE model simulations identifying the percent of forest ecosystems of the Blackfoot watershed historically characteristic of the non-lethal, mixed severity A, mixed severity B, or lethal fire regimes.

Mean Fire Return Interval			
Non-lethal <25 yrs	Mixed Severity A ≥25 and <50 yrs	Mixed Severity B ≥ 50 years and <100 yrs	Lethal ≥ 100 yrs
---------% of landscape---------			
44.9	21.4	13.1	20.5

Table 19. Results of SIMPPLLE model simulations identifying the percent of forest ecosystems of the Blackfoot watershed historically characteristic of the non-lethal, mixed severity A, mixed severity B, or lethal fire regimes by forest ecological site.

FIRE REGIME	HRV	Hot-Dry	Warm-Dry	Warm-Moist	Cool-Dry	Cool-Moist	Cold-Dry	Cold-Moist
NL	mean	91.1%	89.5%	89.7%				
	range	78-97%	82-93%	84-94%				
MS-A	mean	8.9%	10.5%	8.3%	26.4%	24.0%	79.0%	70.1%
	range	3-22%	7-18%	5-15%	9-33%	67-31%	74-85%	49-83%
MS-B	mean			2.0%	28.0%	25.1%	16.6%	22.9%
	range			1-3%	16-54%	12-56%	10-22%	14-57%
L	mean				45.6%	50.9%	4.4%	7.0%
	range				33-57%	29-65%	3-6%	2-13%
TOTAL ACRES		**3,868**	**381,723**	**236,436**	**356,888**	**172,364**	**85,397**	**3,902**

NL = Non-lethal Fire Regime (mfri<25 yrs.)
MS-A = Mixed-severity A Fire Regime (mfri≥25 and <50 yrs.)
MS-B = Mixed-severity B Fire Regime (mfri ≥50 and <100 yrs.)
L = Lethal Fire Regime (mfri ≥ 100 yrs.)

The historical range of variability is summarized in Table 20 for forest ecosystems. The results are presented by ecological site and disturbance state (i.e., seral stage and fire severity). These results are presented as the average, minimum, and maximum percent of total acres for a forest ecological site occurring in the Blackfoot watershed. Similarly, Table 21 presents these same results by the average, minimum, and maximum number of acres occupied by each forest ecosystem.

Table 20. Results of SIMPPLLE model simulations to estimate the historical range of variability (HRV) for forest ecosystems of the Blackfoot watershed, as summarized by ecological site and disturbance state (i.e., seral stage and fire severity). The numbers represent the average and the minimum to maximum percent of the overall acres for each ecological site.

		Hot-Dry		Warm-Dry		Warm-Moist		Cool-Dry		Cool-Moist		Cold-Dry		Cold-Moist	
Seral Stage	**HRV (%)**	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity
GRASS/ FORB/ SHRUB	mean		0.6%		0.8%		0.35%		1.9%		1.3%		0.2%		0.4%
	min-max		(0.5-0.8)		(0.7-1.0)		(0.3-0.4)		(1.8-2.1)		(1.2-1.5)		(0.2-0.3)		(0.3-0.4)
SEEDLING/ SAPLING	mean		1.3%		1.8%		2.4%		13.1%		9.4%		1.4%		2.4%
	min-max		(1.0-1.9)		(1.6-2.2)		(2.2-2.7)		(12.4-14.3)		(8.7-10.3)		(1.3-1.5)		(2.1-2.7)
EARLY SERAL	mean		1.3%		1.8%		1.8%		9.8%		7.3%		1.1%		1.8%
	min-max		(1.0-1.9)		(1.6-2.2)		(1.6-2)		(9.3-10.7)		(6.8-8)		(1-1.2)		(1.6-2)
MID-SERAL	mean		1.8%		2.5%		1.6%		9.0%		7.3%		1.0%		1.7%
	min-max		(1.4-2.6)		(2.3-3)		(1.5-1.9)		(8.6-9.9)		(6.8-8)		(0.9-1)		(1.5-1.9)
LATE SERAL	mean	92.8%	2.2%	89.9%	3.2%	86.8%	7.0%	27.9%	38.3%	25.6%	49.1%	57.6%	38.7%	54.3%	39.5%
	min-max	(89.6-94.3)	(1.8-3.2)	(88-90.9)	(2.8-3.7)	(85.2-88.1)	(6.3-7.9)	(21-31.3)	(36.5-42)	(18.6-30.8)	(45.6-53.7)	(55.7-59.3)	(37.2-40.5)	(48.5-58.7)	(35.7-44.5)
TOTAL ACRES		**3,880**		**381,580**		**235,770**		**356,010**		**172,200**		**85,390**		**3,970**	

Table 21. Results of SIMPPLLE model simulations to estimate the historical range of variability for forest ecosystems of the Blackfoot watershed, as summarized by ecological site and disturbance state (i.e., seral stage and fire severity). The numbers represent the average and the minimum to maximum acres for each ecological site.

		Hot-Dry		Warm-Dry		Warm-Moist		Cool-Dry		Cool-Moist		Cold-Dry		Cold-Moist	
Seral Stage	**HRV (acres)**	**Low Fire Severity**	**High Fire Severity**	**Low Fire Severity**	**High Fire Severity**	**Low Fire Severity**	**High Fire Severity**	**Low Fire Severity**	**High Fire Severity**	**Low Fire Severity**	**High Fire Severity**	**Low Fire Severity**	**High Fire Severity**	**Low Fire Severity**	**High Fire Severity**
GRASS/ FORB/ SHRUB	mean		23		3053		825		6764		2239		171		17
	min-max		(19-31)		(2671-3816)		(707-943)		(6408-7120)		(2066-2583)		(128-214)		(12-20)
SEEDLING/ SAPLING	mean		50		6868		5659		46637		16187		120		95
	min-max		(39-74)		(6105-8395)		(5187-6366)		(44145-50909)		(14981-17737		(111-128)		(83-107)
EARLY SERAL	mean		50		6868		4244		34889		12571		939		72
	min-max		(39-74)		(6105-8395)		(3772-4715)		(33109-38093)		(11710-13776)		(854-1025)		(64-79)
MID-SERAL	mean		70		9540		4244		32041		12571		854		68
	min-max		(54-101)		(8776-11447)		(3772-4715)		(30617-35245)		(11710-13776)		(769-1281)		(60-75)
LATE SERAL	mean	3601	85	343040	12211	204648	16504	99327	136352	44083	84550	49185	33046	2156	1568
	min-max	(3477-3659)	(70-124)	(335791-346856)	(10684-14119)	(200876-207713)	(14854-18626)	(74762-111431)	(129944-149524)	(32029-53038)	(78523-92471)	(47562-50636)	(31765-34586)	(1926-2330)	(1417-1767)
TOTAL ACRES		**3,880**		**381,580**		**235,770**		**356,010**		**172,200**		**85,390**		**3,970**	

Grass-Shrub Ecosystems

Table 22 provides a summary of the results of the SIMPPLLE model simulations relative to the percent of the Blackfoot watershed with grass-shrub ecosystem conditions characterized by the short (<25 years) and long (≥25 years) interval fire regimes.

Table 22. Results of SIMPPLLE model simulations describing the percent of grass-shrub ecosystems of the Blackfoot watershed historically characteristic of the combination of short (<25 year) or long (≥25 year) fire return intervals with light and moderate grazing regimes.

Grazing Regime	Mean Fire Return Interval	
	< 25 years	≥ 25 years
	---------% of landscape---------	
Light	15.6	20.5
Moderate	61.9	2.0
Total	77.5	22.5

The historical range of variability is summarized in Table 23 for grass-shrub ecosystems. The results are presented by ecological site and short or long fire interval combined with light or moderate grazing. These results are presented as the average, minimum, and maximum percent of total acres for a grass-shrub ecological site occurring in the Blackfoot watershed. Similarly, Table 24 presents these same results by the average, minimum, and maximum number of acres occupied by each grass-shrub ecosystem.

Table 23. Results of the SIMPPLLE modeling effort to estimate the historical range of variability (HRV) for grass-shrub terrestrial ecosystems of the Blackfoot watershed. The numbers represent the average and the minimum to maximum percent of the overall acres for each ecological site.

	HRV %	Hot-Droughty	Hot-Loamy	Warm-Droughty	Warm-Loamy	Warm-Sandy	Warm-Gravelly	Warm-Claypan
MFRI <25 years	**HRV %**							
Light Grazing	mean	**13.8**	**6**	**14.1**	**22.5**	**12.1**	**26.4**	**50.3**
	min-max	(2.3 - 25.7)	(1.6 - 11.1)	(6.3 - 20.7)	(8.2 - 35.8)	(0 - 16.7)	(3.4 - 46.1)	(5.8 - 80.7)
Moderate Grazing	mean	**55.5**	**79.8**	**65**	**50.7**	**77.4**	**26.7**	**22.5**
	min-max	(50.7 - 62.0)	(70.2 - 82.6)	(49.2 - 70.4)	(34.8 - 64.1)	(59.1 - 87.1)	(5.7 - 49.3)	(0.7 - 67.8)
MFRI ≥ 25 years	**HRV %**							
Light Grazing	mean	**30.5**	**13.9**	**18.5**	**24.4**	**9.9**	**43.6**	**24.4**
	min-max	(18.5 - 40.5)	(10.0 - 18.1)	(12.9 - 27.4)	(11.6 - 41.0)	(6.1 - 22.0)	(26.4 - 71.3)	(5.1 - 73.9)
Moderate Grazing	mean	**0.2**	**0.3**	**2.3**	**2.5**	**0.6**	**3.3**	**2.9**
	min-max	(0 - 3.8)	(0 - 8.8)	(0 - 17.8)	(0 - 16.7)	(0 - 18.2)	(0 - 24.3)	(0 - 25.4)
	Total Acres	**8,220**	**21,560**	**84,330**	**29,740**	**1,320**	**4,770**	**2,950**

Table 24. Results of the SIMPPLLE modeling effort to estimate the historical range of variability (HRV) for grass-shrub terrestrial ecosystems of the Blackfoot watershed. The numbers represent the average and the minimum to maximum acres for each disturbance state x ecological site.

	Acres	Dry-Droughty	Dry-Loamy	Moist-Droughty	Moist-Loamy	Moist-Sandy	Moist-Gravelly	Moist-Claypan
MFRI <25 years								
Light Grazing	mean	**1134**	**1294**	**11886**	**6692**	**160**	**1259**	**1482**
	min-max	(189-2112)	(345-2393)	(5311-17450)	(2439-10647)	(0-220)	(162-2199)	(171-1359)
Moderate Grazing	mean	**4563**	**17205**	**54879**	**15047**	**1022**	**1274**	**662**
	min-max	(4168-5096)	(15135-17809)	(41476-59347)	(10350-19063)	(780-1150)	(272-2352)	(21-2000)
MFRI ≥ 25 years								
Light Grazing	mean	**2507**	**2996**	**15596**	**7257**	**130**	**2080**	**720**
	min-max	(1521-3329)	(2156-3902)	(10875-23098)	(3450-12193)	(80-290)	(1259-3401)	(151-2103)
Moderate Grazing	mean	**16**	**65**	**1939**	**744**	**8**	**157**	**86**
	min-max	(0-312)	(0 - 1897)	(0 - 15005)	(0 - 4967)	(0 - 240)	(0 - 1159)	(0 - 749)
	Total Acres	**8,220**	**21,560**	**84,330**	**29,740**	**1,320**	**4,770**	**2,950**

TODAY'S ECOSYSTEM DIVERSITY AND CUMULATIVE CHANGES

Native ecosystems and habitats of the Blackfoot watershed have and continue to be directly and indirectly altered by human actions. Although Native Americans interacted and influenced this landscape for thousands of years, those influences are incorporated in the historical reference. It is the extent of human influence over the last 100 years that is of primary interest when considering the cumulative impacts to native ecosystem diversity and biodiversity of the Blackfoot watershed. Land conversion to cropland, domestic pasture, urban uses, and roads are the most obvious changes. However, there are also less obvious changes as well. The implications of a century of alterations to and interruptions of historical disturbance regimes on native ecosystem diversity have only begun to be assessed and much is still unknown. Studies have shown that the suppression, alteration, or cessation of historical disturbance has gradually changed ecosystem processes and the species composition, structure, and function of both forest and grass-shrub ecosystems (Arno et al. 1997, Arno et al. 1995, Arno et al. 1993, Arno et al. 1985, Keeling et al. 2006, Fuhlendorf and Engle 2001, Knight 1994, Perryman and Laycock 2000, Haufler et al. 2008).

More specifically, two primary types of ecosystem conversion or alteration have occurred within the Blackfoot watershed and have contributed to the cumulative changes to native terrestrial ecosystem diversity observed in the landscape today. These are: 1) the direct conversion of native ecosystems to some other land type or use, and 2) the indirect alteration of native ecosystems through the suppression of historical disturbance processes or alteration of species compositions, structures, or functions resulting from human activities and spread of non-native species. In the Blackfoot watershed, the primary causes of direct conversion of native terrestrial ecosystems include agriculture, roads, residential and urban development (including gravel pits, golf courses, airports, etc.), and rural farm development (i.e., residences/out-building sites/high density animal holding sites). The primary causes of indirect alteration of ecosystems include timber harvests, fire suppression, altered grazing regimes, as well as accidental or intentional introduction of non-native species that degrade the quality and function of native species habitats and native ecosystems.

Both direct conversion and indirect alteration of native ecosystems can result in habitat loss to associated native species. Habitat loss and its effects on biological diversity can be viewed as having four aspects associated with it:

1. the actual loss or conversion of habitat from conditions that support a species to new land uses that support unfavorable conditions that do not support a species,
2. changes in ecosystem structure, function, or composition (Noss et al. 1995, Franklin et al. 1981) that severely reduces the habitat quality of an ecosystem for a particular species,
3. the reduction in the size of the remaining patches that may not provide enough area in one patch to support a species, and
4. habitat changes that slowly or quickly cause a single population within the landscape to become a metapopulation, consisting of many independent populations that only interact with occasional dispersal of individuals; metapopulations may then be further influenced by

continued habitat loss to the point that interruption of demographic or genetic support to the metapopulation occurs (Hanski and Gilpin 1997), resulting in the subsequent loss of the entire population.

Developing a better understanding of the terrestrial ecosystem conditions present in the Blackfoot watershed today is an important step toward identifying and quantifying cumulative changes to native terrestrial ecosystem diversity and its corresponding influence on the habitat conditions of native wildlife species. To facilitate this understanding, an assessment of terrestrial ecosystem conditions was undertaken in the Blackfoot watershed. The assessment utilized a combination of remotely sensed data and reconnaissance-level vegetation field surveys to help describe and quantify today's ecosystem conditions. The following sections provide a summary of the methods used and the results obtained from this assessment.

TODAY'S CONDITIONS

Quantification of today's ecosystem diversity requires two essential layers of mapped information maintained in a geographic information system (GIS): 1) the ecological site layer and 2) the disturbance state layer. By overlaying the ecological site layer with the vegetation disturbance state layer, the resulting union of the mapped polygons provides the ability to quantify today's ecosystem diversity. The following provides a discussion of the methods used for describing and quantifying today's conditions relative to forest and grass-shrub ecosystems.

Forest Ecosystems

To develop the forest ecosystems disturbance state, GIS layer for current conditions, forest stand inventory data referenced to available GIS data were used where available. Decision rules were developed to characterize a stand's structure and species composition relative to the disturbance states and ecological sites previously described for native forest ecosystems. Where stand inventory data were not available, classified VMAP satellite imagery data were used, however, the accuracy and resolution of these data is believed to be reduced relative to the forest inventory data.

Figure 23 describes the decision rules used to identify a disturbance state according to the 5 seral stages (grass/forb/shrub, seedling/sapling, early seral, mid-seral, and late-seral). Forest stand inventory data or VMAP stand characteristics data were evaluated against these decision rules to determine the appropriate seral stage. As discussed previously, forest conditions influenced by low severity fire differ from forest conditions influenced by high severity fire. Using information obtained from recent studies on historical stand structures and species composition resulting from different levels of fire severity, a set of decision rules (Table 25) were developed to determine whether each of today's stands roughly represent the historical fire-maintained conditions as influenced by low fire severity and high fire severity. Inventory data and VMAP stand characteristics data were again evaluated against these rules to determine the most likely fire severity level influencing a site. Forest conditions that still represent native conditions but do not represent historical conditions (e.g., managed stands that left

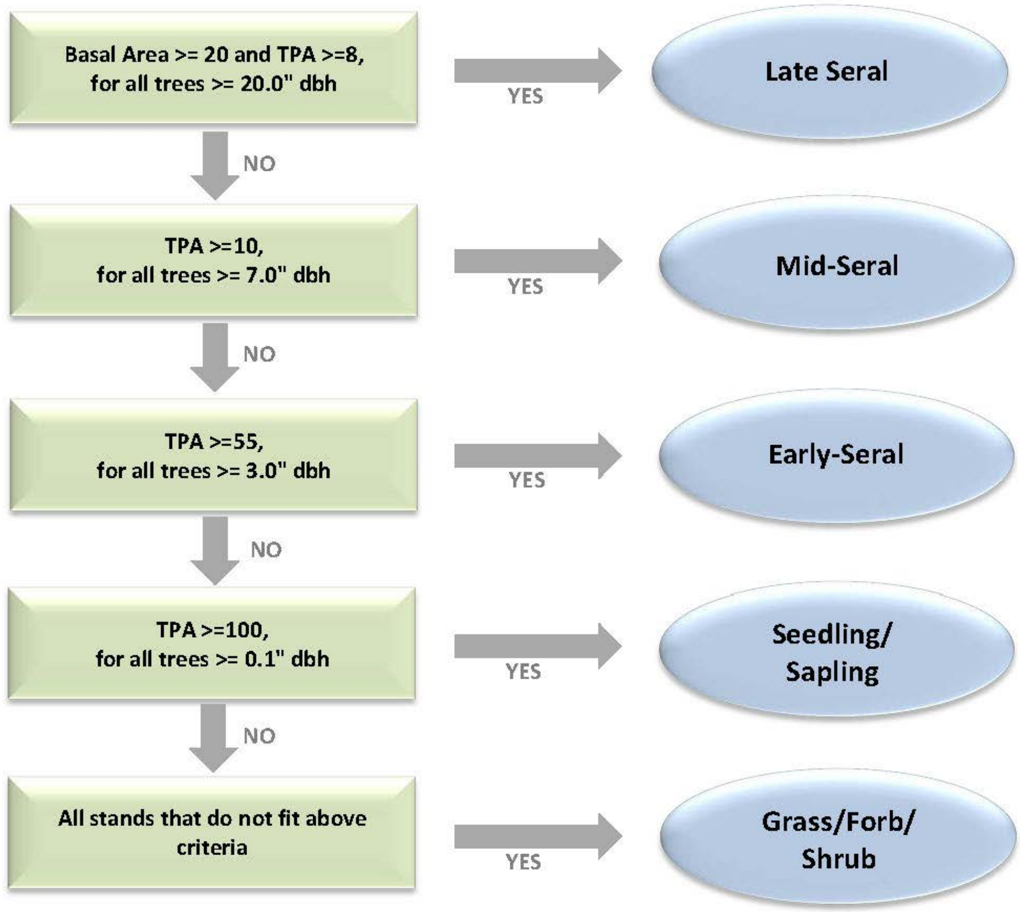


Figure 23. Decision rules used to classify forest stand inventory data and VMAP stand characteristics data for the 5 seral stages identified in the forest ecosystem disturbance states for the Blackfoot watershed.

low densities of fire intolerant species as seed trees) were classified as "other" conditions for purposes of this assessment. In addition, converted conditions were identified from VMAP satellite imagery data for urban and developed categories. A primary road layer was also added that assumed a surface impact of 4 meters and lots with residences were assigned a 4 acre impacted circle in the center of the lot. The converted conditions layer was combined with the forest disturbance states to produce a GIS layer of existing conditions for forest ecosystems of the Blackfoot watershed. Figure 24 represents a map identifying the forest ecosystem disturbance states and converted conditions occurring on the landscape today, as developed using the best available classified satellite imagery data.

As previously discussed, the forest ecological site GIS layer was developed from existing publicly available soils and other data for the watershed and mapped in a GIS to meet the objectives of this project. The GIS layer of forest ecosystem disturbance states was then combined with the GIS layer of

FORESTED ECOLOGICAL SITE	FIRE SEVERITY		OTHER CONDITIONS
	LOW	HIGH	
Hot-Dry	>=10 and <=30 overstory TPA and species composition dominated by historically dominant seral species	>30 overstory TPA	forest conditions that did not occur historically
Warm-Dry	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA	
Warm-Moist	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA	
Cool-Dry	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA	
Cool-Moist	>=10 and <=60 overstory TPA and species composition dominated by historically dominant seral species	>60 overstory TPA	
Cold-Dry	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA	
Cold-Moist	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA	

Table 25. Decision rules used to identify forest conditions by ecological site as influenced by low and high fire severity. "Other" conditions identify today's forest conditions that do not represent historical stand structures and/or species compositions.

ecological sites, and the resulting layer provided the ability to calculate the number of acres representing today's forest ecosystem diversity. These results were then compared to the mean HRV developed through the SIMPPLLE modeling effort, to describe cumulative changes in forest native ecosystem diversity. See the following section on cumulative changes for a summary of these results.

Today's fire regimes were also evaluated using the combined results of the ecological site and disturbance state data. A moving window assessment was conducted across the landscape to identify patterns of historical fire regimes. This additional GIS analysis was conducted using a moving window of 50 acre size resolution to search for combinations of low and high fire severity forest conditions that met the patch size criteria for non-lethal, mixed-severity A or B, and lethal fire regimes described in previous sections. The results of this assessment were then compared to the mean values of HRV developed through the SIMPPLLE modeling effort to describe cumulative changes in historical fire regimes for the watershed. See the following section on cumulative changes for a summary of these results.

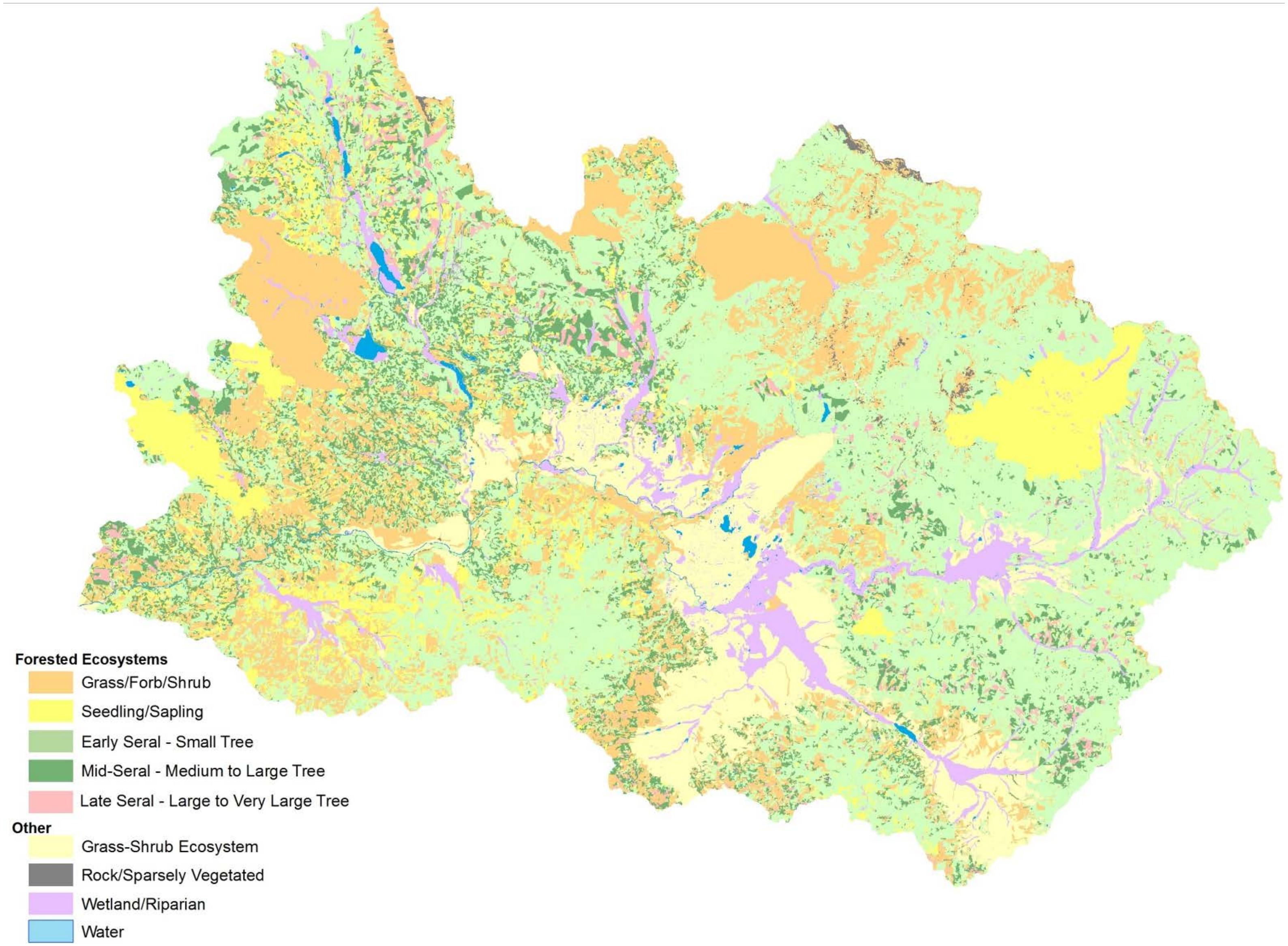


Figure 24. Today's disturbance states identified for the forest ecosystems of the Blackfoot watershed using best available information.

Grass-Shrub Ecosystems

To develop the disturbance state GIS layer for current grass-shrub ecosystem conditions, LANDFIRE GIS and associated data, specifically the SAF_SRM vegetation covertype classification were used. VMAP data were not available for non-forested areas of the watershed. It is important to note that existing information was not available on the level of grazing influencing today's native grass-shrub ecosystems. This will limit the ability of this assessment to adequately quantify all impacts to native ecosystem diversity in grass-shrub ecosystems. The implications of this will be discussed in a later section. Short and long fire return influences were determined based on the classification of covertypes labeled as grass dominated (i.e., rough fescue-Idaho fescue) versus shrub dominated (i.e., mountain big sagebrush-rough fescue). Grass dominated covertypes were assumed to exhibit conditions similar to those historically influenced by short interval fire regimes and shrub dominated covertypes were assumed to exhibit conditions similar to those exhibited by long interval fire regimes. Covertypes that still represent native vegetation but did not represent historical conditions (e.g., conifer encroachment on grass-shrub ecological sites) were classified as “other” conditions for purposes of this assessment. Converted conditions were then identified from LANDFIRE data for urban and developed categories and converted cropland and domestic pasture polygons were digitized from 2009 NAIP imagery. In addition, further conversion was identified using a primary road layer that assumed a 4 meter wide surface impact and lots with residences were assigned a 4 acre impacted circle in the center of the lot. Rural farmsteads were assigned a 6 acre impacted circle to account for the added footprint of outbuildings and animal holding facilities. Residences and rural farmstead approximate locations were identified from CADASTRAL GIS layers and associated data. The GIS layer of existing vegetation conditions and converted conditions represents the grass-shrub disturbance states for the Blackfoot watershed. Figure 25 represents a map identifying the grass-shrub ecosystem disturbance states occurring on the landscape today, as developed using the best available classified satellite imagery data.

As previously discussed, the grass-shrub ecological site layer was developed from existing publicly available soils data for the watershed and mapped in a GIS. The disturbance state layer was combined with the ecological site layer to allow for the quantification of today's grass-shrub native ecosystem diversity. These results were then compared to the mean HRV developed through the SIMPPLLE modeling effort, to describe cumulative changes in grass-shrub native ecosystem diversity. See the following section on cumulative changes for a summary of these results.

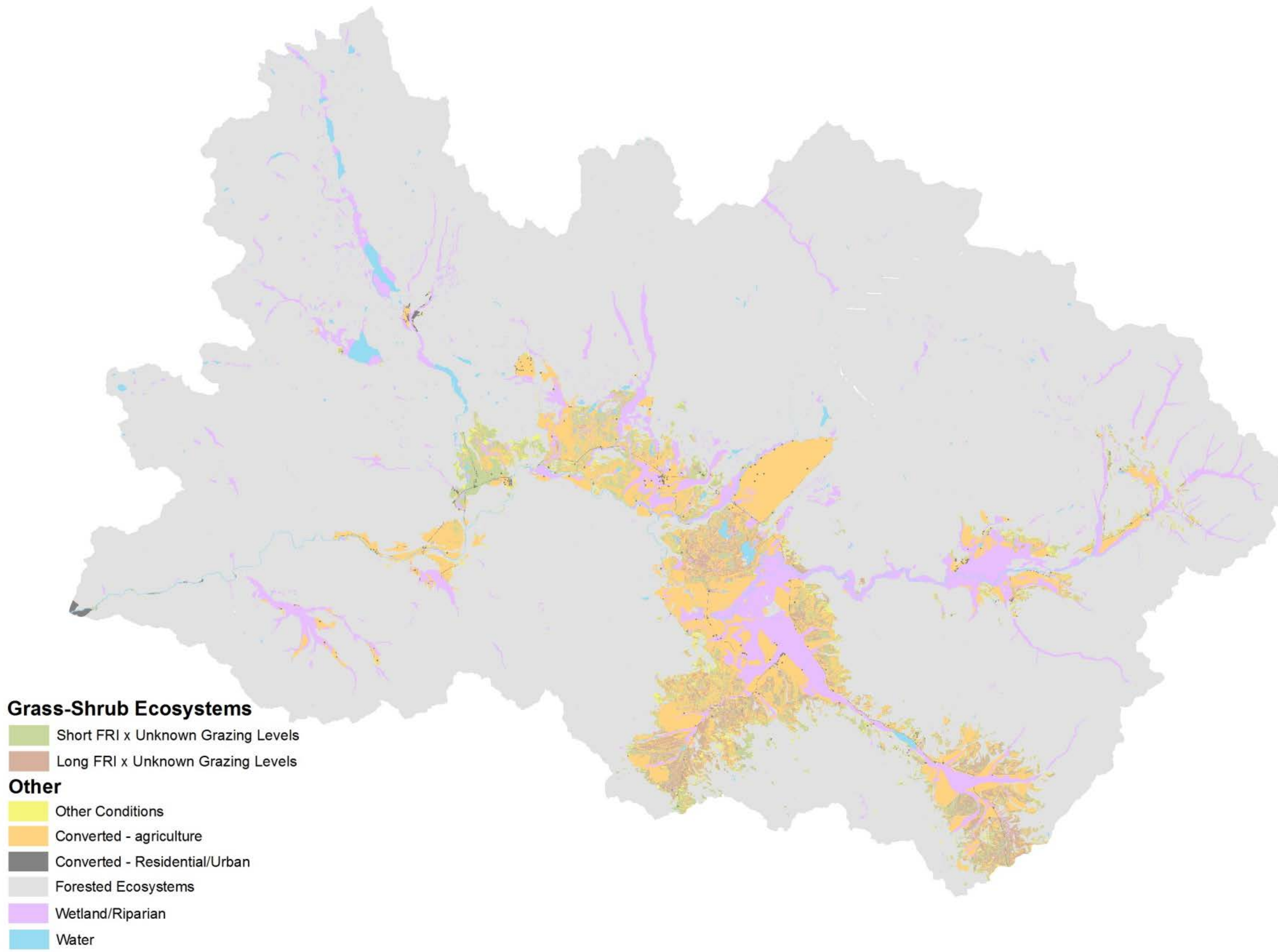


Figure 25. Today's disturbance states identified for grass-shrub ecosystems of the Blackfoot watershed using best available information.

Cumulative Changes

Direct Conversion of Native Ecosystems

Overall direct land conversion that can be estimated using the methods previously described for terrestrial ecological sites of the Blackfoot watershed is relatively low at 102,490 acres or 7.4% of the total terrestrial acres in the watershed. On forest ecological sites, only 1.5% of the total acres have been converted to new land uses. Proportionally, grass-shrub ecological sites have received the highest percentage of overall direct conversion at 56.7% of the total grass-shrub acres. The majority of the acres converted in the watershed have resulted from agricultural conversion in the form of cropland and non-native pastures at 96.8% of the grass-shrub acres converted, followed distantly by residential/urban development at 1.5%, roads at 1.0%, and rural farm development at 0.7%.

Table 26 and 27 provide a more detailed breakdown of the type of conversion occurring on both forest and grass-shrub ecological sites. Conversion types are characterized by four categories that include cropland/non-native pasture, residential/urban development, rural farm development and roads. The Warm-Dry forest ecological site has received the highest rate of conversion at 5.3% with cropland/non-native pasture and town/residential development representing 44.8% and 40.2% of the converted acres on this ecological site, respectively. Six of the seven grass-shrub ecological sites in the Blackfoot watershed have experienced direct conversion of greater than 50% of their acres. Most of this conversion has occurred as agricultural uses.

Table 26. Number of acres and overall percent of each forest ecological site converted to other non-native uses in the Blackfoot watershed, relative to 4 primary conversion type categories.

Conversion Type	Hot-Dry	Warm-Dry	Warm-Moist	Cool-Dry	Cool-Moist	Cold-Dry	Cold-Moist
Cropland/Non-native Pasture	37	1,004	5,592	4	53	0	0
Town/Residential Development	10	823	5,010	196	144	0	0
Rural Farm Development	1	326	1,032	76	75	0	0
Roads	10	296	841	58	65	0	0
Total acres converted	**58**	**2,449**	**12,475**	**334**	**337**	**0**	**0**
% of ecological site converted	**1.5%**	**0.6%**	**5.3%**	**0.1%**	**0.2%**	**0%**	**0%**

Table 27. Number of acres and overall percent of each grass-shrub ecological site converted to other non-native uses in the Blackfoot watershed, by 4 primary conversion type categories.

Conversion Type	Hot-Droughty	Hot-Loamy	Warm-Droughty	Warm-Loamy	Warm-Sandy	Warm-Claypan	Warm-Gravelly
Cropland/Non-native Pasture	5,353	14,680	44,796	13,031	1,054	1,563	3,591
Town/Residential Development	14	51	1,006	31	32	0	61
Rural Farm Development	75	69	393	93	9	3	35
Roads	114	105	452	142	33	2	49
Total acres converted	**5,556**	**14,905**	**46,647**	**13,297**	**1,128**	**1,568**	**3,736**
% of ecological site converted	**68.2%**	**69.7%**	**54.9%**	**45.0%**	**76.0%**	**54.6%**	**78.7%**

Indirect Alteration of Native Ecosystems

Forest Ecosystems

While the overall direct conversion of forest ecosystem conditions is relatively low at 1.5%, the number of acres present today that represent historically common native forest ecosystem conditions in terms of species composition and structure is of great concern. While many lands within the watershed still provide intact forest conditions and continue to be used by wildlife, in many cases they exhibit different plant species compositions and structures when compared to conditions that would have been more common historically and as influenced by historical disturbance regimes. Currently, forest ecosystems are, for the most part, no longer influenced by the non-lethal fire regime and the extent and distribution of mixed-severity A and B fire regimes have been reduced. To evaluate the cumulative impacts of Euro-American settlement, today's conditions were assessed relative to structural and species compositions that most closely resemble native ecosystem conditions as influenced by historical disturbance processes. Ecosystems present today that are relatively similar in structure and species compositions to those present historically, are assumed for the purposes of this assessment to provide similar ecosystem functions and habitat benefits to the wildlife species they historically supported.

Indirect alteration of forest ecosystems in the Blackfoot watershed, have resulted from three primary human-influences: 1) the suppression of fire in the landscape, 2) past timber management activities, and 3) the introduction of exotic disease. Some sources indicate that Western white pine may have been a component of the moist, fertile ecological sites of the northwestern Blackfoot watershed (GIS layer citation). Where western white pine occurs, it has been reported with varying overstory composition ranging from 15 to 80 percent of the forest canopy (Harvey et al. 2008). Over the past century, white pine blister rust, an introduced disease, has had a devastating effect on the occurrence of western white pine throughout its former range in North America. This disease has also had profound influence on whitebark pine within the high elevation forests. Recent population increases in the western pine beetle have further added to the losses incurred by the blister rust and many whitebark pine communities are currently endangered or at risk throughout the region.

In addition to white pine blister rust, much of the indirect alteration of forest ecosystems has occurred as a result of the reduction of fire in the landscape which has produced profound effects on today's conditions relative to historical conditions. In some instances, timber management objectives have also altered species compositions and structures to no longer resemble native ecosystems. Several examples of this would be the use of shelterwood cuts where mature late successional species may be left in low densities to re-seed a stand or clearcuts on sites historically influenced by the non-lethal or mixed-severity A fire regimes.

Cumulative changes to the forests of the Blackfoot watershed are summarized in Tables 28 and 29. Table 28 provides an estimate of the percentage of each disturbance state occurring today as compared to the mean historical range of variability where low and high fire severity interacted with ecological site to influence forest conditions. These results summarize the changes that have occurred on each ecological site, where the vegetation present today is still similar to native ecosystem conditions (i.e., has similar structure and species compositions). Table 28 also identifies the percentage of an ecological site that has been altered, termed "other" condition, in that while forested, it no longer represents historically occurring conditions. An example of this in the Blackfoot watershed is the use of a shelterwood cut that leaves a small number of fire intolerant species to reseed the site. The observed species composition would likely not have occurred under this type of structure on this ecological site, especially as influenced by historical fire regimes. It also identifies the percentage of an ecological site that has been directly converted to non-forested uses. The direct conversion of an ecological site was discussed in the previous section and summarized in Table 26.

Relative to forest disturbance states, the most concerning changes in the Blackfoot watershed identified in Table 28 have occurred in the 'Late Seral' disturbance state, where historically it comprised a total of 83.2% of the landscape. Today it has been reduced to only 1.9% of the landscape. It should be noted that VMAP estimates of existing conditions could be reporting a number of stands as being mid-seral stands, but that still have the late-seral tree component and could be restored to this condition. Thus, the estimates of existing conditions reported here may overestimate mid-seral conditions and underestimate late-seral conditions due to the inability of satellite imagery to classify residual large tree conditions when masked by larger numbers of smaller diameter trees. However, the reduction in late-seral conditions is believed to be substantial, even if some errors in mapping of current conditions have occurred. The results indicate that the amounts of the Late Seral disturbance state has declined across all ecological sites but has been particularly impacted on the lower elevation, drier ecological sites. Grass/Forb/Shrub, Seedling/Sapling, Early Seral and Mid-seral disturbance states all show moderate to high increases over historical amounts.

Table 28 also identifies that nearly 12.2% of the overall landscape no longer exhibits conditions that are expected to have occurred historically, with 10.9% of this amount representing "other" conditions and 1.3% representing converted conditions. The "other" conditions are relatively consistent across ecological sites but converted conditions have primarily occurred at lower elevation ecological sites.

Table 28 also illustrates the significant reduction in low severity fire influenced vegetation conditions across all ecological sites. Table 29 further illustrates this point using the percent mean HRV compared to today's conditions for each of the four fire regimes. Similar patterns are observed with a significant loss of vegetation conditions that are indicative of the non-lethal fire regime. Vegetation conditions indicative of the mixed-severity A and B fire regimes have also been greatly reduced. Conditions indicative of the lethal fire regime have correspondingly increased significantly but the size and patterns of these potential fires have changed. Of particular concern relative to forest ecological sites is the change from fire regimes that historically occurred to fire regimes that did not historically occur. This is particularly evident on the low elevation and drier ecological sites where nonlethal and mixed-severity A were the normal fire regimes but which have now been replaced by conditions indicative of mixed-severity B and lethal.

Table 28. The percentage of each forest ecosystem disturbance state occurring today in the Blackfoot watershed as compared to the mean historical range of variability (HRV), where low and high fire severity interacted with ecological site to influence forest conditions. These results summarize the changes that have occurred on each ecological site, where the vegetation present today is still similar to native ecosystem conditions. The percent of conditions present today that did not occur historically, or "other" and converted conditions, are also summarized by ecological site.

		Hot-Dry		Warm-Dry		Warm-Moist		Cool-Dry		Cool-Moist		Cold-Dry		Cold-Moist		
Seral Stage	%	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	% TOTAL
GRASS/ FORB/ SHRUB	Mean HRV		0.6		0.8		0.35		1.9		1.3		0.2		0.4	1.1%
	Today		63.3		25.5		23.3		19.3		18.0		42.3		12.7	23.2%
SEEDLING/ SAPLING	Mean HRV		1.3		1.8		2.4		13.1		9.4		1.4		2.4	6.2%
	Today		3.6		10.8		10.0		10.3		17.2		3.8		15.5	10.9%
EARLY SERAL	Mean HRV		1.3		1.8		1.8		9.8		7.3		1.1		1.8	4.8%
	Today		2.6		16.1		16.3		20.5		19.1		10.9		19.8	17.5%
MID-SERAL	Mean HRV		1.8		2.5		1.6		9.0		7.3		1.0		1.7	4.8%
	Today	10.5	7.5	9.1	23.8	10.7	21.8	4.8	32.8	3.0	32.7	4.1	24.3	1.5	36.1	34.3%
LATE SERAL	Mean HRV	92.8	2.2	89.9	3.2	86.8	7.0	27.9	38.3	25.6	49.1	57.6	38.7	54.3	39.5	83.2%
	Today	0.0	0.2	0.1	2.0	0.10	1.4	0.1	2.1	0.1	2.2	0.0	0.5	0.0	2.9	1.9%
Conditions that did not occur historically																
Other	Today	10.8		12.1		11.2		10.1		7.5		14.1		11.5		10.9%
Converted	Today	1.5		0.5		5.2		0		0.2		0.0		0.0		1.3%
TOTAL ACRES		3,880		381,580		235,770		356,010		172,200		85,390		3,970		

Table 29. The percent mean historical range of variability (HRV) for forest ecosystems as compared to today's conditions for each of the four fire regimes historically influencing the Blackfoot watershed.

	Hot-Dry		Warm-Dry		Warm-Moist		Cool-Dry		Cool, Moist		Cold-Dry		Cold-Moist		TOTAL	
FIRE REGIME	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today
NL*	91.1%	0.8%	89.5%	0.8%	89.7%	0.4%	0	0	0	0	0	0	0	0	44.9%	0.3%
MS-A	8.9%	0.7%	10.5%	0.6%	8.3%	1.1%	26.4%	0.3%	24.0%	0.3%	79.0%	0.3%	70.2%	0.3%	21.4%	0.6%
MS-B	0	30.9%	0	12.4%	2.0%	13.4%	28.0%	3.6%	25.1%	3.4%	16.6%	2.7%	22.9%	1.3%	13.1%	8.0%
L	0	55.6%	0	73.4%	0	68.5%	45.6%	86.1%	50.9%	88.4%	4.4%	86.5%	7.0%	94.2%	20.5%	78.9%
Other	0	10.5%	0	12.2%	0	11.3%	0	9.9%	0	7.7%	0	10.5%	0	4.2%	0	10.9%
Converted	0	1.5%	0	0.6%	0	5.3%	0	0.1%	0	0.2%	0	0.0%	0	0.0%	0	1.3%
TOTAL ACRES	**3,880**		**381,580**		**235,770**		**356,010**		**172,200**		**85,390**		**3,970**		**1,234,920**	

*NL = Non-lethal Fire Regime (mfri<25 yrs.); MS-A = Mixed-severity A Fire Regime (mfri>25 and <50 yrs.); MS-B = Mixed-severity B Fire Regime (mfri >50 and <100 yrs.); and L = Lethal Fire Regime (mfri ≥ 100 yrs.)

The native ecosystem representation goal identified in the Blackfoot Subbasin Plan was 50% of the historical range of variability for forest ecosystems of the watershed. Table 30 identifies the number of acres representing 50% of the mean historical range of variability (HRV) for forest ecosystems of the Blackfoot watershed compared to the number of acres present today. Table 31 identifies the number of acres representing 50% of the mean historical range of variability (HRV) compared to the number of acres present today, relative to disturbance states and ecological sites. Those disturbance states that represent less than 50% of the mean HRV are identified and are therefore underrepresented in this watershed.

- **Goals for Forest Ecosystem Restoration**

The native ecosystem representation goal identified in the Blackfoot Subbasin Plan was 50% of the historical range of variability for forest ecosystems of the watershed. For the purposes of quantifying this goal, we have interpreted this to represent 50% of the mean historical range of variability. The results of the cumulative change assessment indicate the number of acres that would require restoration to achieve that goal is 456,703 acres across the watershed. As discussed previously, the primary disturbance state that is underrepresented in the watershed today is the late-seral forest condition. Table 32 identifies the late-seral forest ecosystems by ecological site and the restoration acres required to achieve the 50% goal. To achieve the appropriate spatial distribution of these restoration acres requires an equally important consideration of restoring historical fire regimes by ecological site. Table 33 identifies the number of acres by ecological site and historical fire regime that would require restoration to achieve the 50% goal.

Previous sections of this document describe forest ecological sites and identify historical state and transition models for each of these ecological sites occurring within the Blackfoot watershed. These descriptions and models describe the influences of historical disturbance processes and their interactions and can be used in disturbance-based forest management programs to identify appropriate objectives and priorities for conserving ecosystem and biological diversity within the Blackfoot watershed. This strategy focuses on providing sufficient amounts of functionally similar ecosystems to what occurred historically across the landscape in order to maintain and benefit all native species. The number of acres needed to meet the Blackfoot Subbasin Plan's goal of 50% representation of native forest ecosystems of the Blackfoot watershed are presented by ecological site and disturbance state in Table 32. Table 33 identifies the number of acres of each of the four historical fire regimes that would be required to reach the goal of 50% representation across the watershed, by ecological site.

The combined information on historical forest conditions and estimates of acres needed to meet restoration objectives provide the foundation for implementing an effective restoration strategy for native forest ecosystems of the Blackfoot watershed.

Table 30. The number of acres representing 50% of the mean historical range of variability (HRV) for forest ecosystems of the Blackfoot watershed compared to the number of acres present today, relative to disturbance states and ecological sites. Those cells highlighted in red indicate today's conditions that represent less than 50% of the mean HRV and are therefore underrepresented in this watershed.

		Hot-Dry		Warm-Dry		Warm-Moist		Cool-Dry		Cool-Moist		Cold-Dry		Cold-Moist	
Seral Stage	Acres	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity
GRASS/ FORB/ SHRUB	50% Mean HRV		12		1527		472		3382		1120		86		8
	Today		2454		93834		54922		68639		30964		36144		504
SEEDLING/ SAPLING	50% Mean HRV		25		3434		2829		23319		8094		598		48
	Today		138		41754		23559		36580		29529		3243		616
EARLY SERAL	50% Mean HRV		25		3434		2122		17445		6286		470		36
	Today		100		61987		38401		72809		32890		9262		787
MID-SERAL	50% Mean HRV		35		4770		1886		16021		6285		427		34
	Today	409	292	34985	91593	25269	51307	16950	117187	5103	56293	3525	20826	60	1433
LATE SERAL	50% Mean HRV	1800	44	171520	6106	102324	8253	49664	68176	22042	42275	24592	16523	1076	784
	Today		9	170	8091	88	3336	145	7471	84	3734		385		113

Conditions that did not occur historically

		Hot-Dry	Warm-Dry	Warm-Moist	Cool-Dry	Cool-Moist	Cold-Dry	Cold-Moist
Other	Today	420	46687	26413	35895	13266	12005	457
Converted	Today	58	2449	12475	334	337		

Table 31. The number of acres representing 50% of the mean historical range of variability (HRV) for forest ecosystems of the Blackfoot watershed compared to the number of acres present today, relative to the 4 historical fire regimes and ecological site. Those cells highlighted in red indicate today's conditions that represent less than 50% of the mean HRV and are therefore underrepresented in this watershed.

FIRE REGIME	Hot-Dry		Warm-Dry		Warm-Moist		Cool-Dry		Cool-Moist		Cold-Dry		Cold-Moist	
	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today
NL*	1768	31	170757	3053	105743	943	0	0	0	0	0	0	0	0
MS-A	173	27	20033	2290	9784	2593	46993	1068	20664	517	33729	256	1394	12
MS-B	0	1199	0	47316	236	31593	49841	12816	21611	5855	7087	2305	455	52
L	0	2157	0	280080	0	161502	81170	306525	43825	152225	1879	73862	139	3740
Other	0	407	0	46553	0	26642	0	35245	0	13259	0	8967	0	167
Converted	0	58	0	2290	0	12496	0	356	0	344	0	0	0	0
TOTAL ACRES	**3,880**		**381,580**		**235,770**		**356,010**		**172,200**		**85,390**		**3,970**	

*NL = Non-lethal Fire Regime (mfri<25 yrs.); MS-A = Mixed-severity A Fire Regime (mfri>25 and <50 yrs.); MS-B = Mixed-severity B Fire Regime (mfri >50 and <100 yrs.); and L = Lethal Fire Regime (mfri ≥ 100 yrs.)

Table 32. The number of acres required to restore 50% of the mean historical range of variability for forest ecosystems in the Blackfoot watershed by late-seral disturbance state and ecological site.

	Hot-Dry		Warm-Dry		Warm-Moist		Cool-Dry		Cool-Moist		Cold-Dry		Cold-Moist		
Seral Stage	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	Low Fire Severity	High Fire Severity	TOTAL
LATE SERAL	1,800	35	171,350	0	102,236	4,917	49,519	60,705	21,958	3,541	24,592	16,138	1,076	671	456,703

Table 33. The number of acres required to restore 50% of the mean historical range of variability for forest ecosystems in the Blackfoot watershed by historical fire regime and ecological site.

FIRE REGIME	Hot-Dry	Warm-Dry	Warm-Moist	Cool-Dry	Cool-Moist	Cold-Dry	Cold-Moist	Total
NL*	1737	167704	104800					274241
MS-A	146	17743	7191	45925	20147	33473	1382	126007
MS-B				37025	15756	4782	403	57966
L								0
TOTAL ACRES	1,883	185,447	111,991	82,950	35,903	38,255	1,785	458,214

*NL = Non-lethal Fire Regime (mfri<25 yrs.); MS-A = Mixed-severity A Fire Regime (mfri>25 and <50 yrs.); MS-B = Mixed-severity B Fire Regime (mfri >50 and <100 yrs.); and L = Lethal Fire Regime (mfri ≥ 100 yrs.)

Grass-shrub Ecosystems

As stated previously, the amount of direct conversion of native grass-shrub ecosystems in the Blackfoot watershed is cause for great concern. Of equal concern, however, are the indirect changes to native grass-shrub ecosystems present today in terms of species composition and structures, when compared to conditions that would have been more common historically and as influenced by historical disturbance regimes. To evaluate the cumulative impacts of Euro-American settlement, today's grass-shrub ecosystem conditions were assessed relative to structural and species compositions that most closely resemble native ecosystem conditions as influenced by historical disturbance processes. Ecosystems present today that are relatively similar in structure and species compositions to those present historically, are assumed for the purposes of this assessment to provide similar ecosystem functions and habitat benefits to the wildlife species they historically supported.

Indirect alteration of grass-shrub ecosystems in the Blackfoot watershed have resulted from three primary human-influences: 1) the suppression of fire in the landscape, 2) past and present grazing management programs, and 3) the introduction of non-native species. The short fire return interval, most common historically, has been significantly reduced throughout the watershed due to fire suppression programs and land use changes. The result has been changes to the species composition and structures (i.e., more shrubs occur today) of these historically grass dominated systems. In some instances, particularly along the inter-grade with forest ecosystems, the loss of frequent fires has allowed trees to spread onto grass-shrub ecological sites, where they were rare or non-existent historically.

Grazing today is primarily by cattle, horse, and sheep. Grazing practices in the late 1800's and early 1900's were highly variable throughout the western United States, with many areas receiving relatively high levels of grazing. More recently, range management recommendations have focused on producing relatively uniform and consistent grazing levels applied across their pastures. Many ranchers today try to manage their grasslands to maintain long-term productivity. To accomplish this, ranchers will often try to moderate grazing patterns and intensity through better distribution of water sources and monitoring numbers of animals using each pasture. These grazing practices differ from the historical grazing regimes by native herbivores. In some areas, elk and other native herbivores are still an influence on grass-shrub ecosystems, but the lack of bison and the reduction in grazing variability across the landscape has reduced grass-shrub ecosystem diversity.

Finally, the spread of invasive non-native plant species, as well as aggressive introduced non-native forage species, threaten the future integrity and function of remaining native grass-shrub ecosystems in the Blackfoot watershed (Mack et al. 2000, Mack 1981, DiTomaso 2000). While a specific level of non-native species composition that would disqualify a site from being representative of native ecosystem conditions has not been quantified by research, a level greater than 10% relative cover of non-native species might be suggested as cause for concern by landowners and managers. It is our experience that when a site goes beyond the 10% threshold, the ability of the natives species to resist additional spread by non-natives, declines rapidly.

Cumulative changes to the grass-shrub ecosystems of the Blackfoot watershed are summarized in Table 34. This table provides an estimate of the percentage of each disturbance state occurring today as compared to the mean historical range of variability. These results summarize the changes that have occurred on each ecological site, where the vegetation present today is still similar to native ecosystem conditions (i.e., has similar structure and species compositions). As previously discussed, it was not possible to identify different levels of grazing from the existing data available to this assessment. Consequently, any cumulative changes to grazing regimes cannot be quantified at this time. The cumulative changes should only be interpreted relative to changes in historical fire regimes in grass-shrub ecosystems. Relative to this, the greatest changes have occurred in the loss of conditions representing the influence of the short interval fire regime. Grass-shrub conditions resulting from the influence of the long interval fire regime are well represented in the landscape, except on the Warm-Gravelly ecological site.

As previously discussed, grazing trends on private land in the western United States, in general, have been toward moderate levels. While grazing levels in the Blackfoot watershed have not been quantified, it is believed that grazing is more commonly represented by moderate levels on private lands, though some light and heavy grazing also occur. Light grazing levels may be underrepresented on private lands in the watershed, but these grazing levels may be more commonly encountered on public lands that include wildlife management areas. However, assessing the distribution of today's grazing levels relative to ecological sites and compared to historical amounts is critical information that is required to fully understand the cumulative changes to grass-shrub ecosystems in the Blackfoot watershed. Efforts to obtain this information should be considered a high priority for future research and study.

Table 34 also identifies the percentage of an ecological site that has been altered, termed "other" condition, in that while it still has native vegetation, it no longer represents historically occurring conditions. An example of this in the grass-shrub ecosystems of the Blackfoot watershed is the spread of forest conditions into grass-shrub ecological sites, due to fire suppression efforts. The observed species composition and structure would likely not have occurred on this ecological site, especially as influenced by historical fire regimes. It also identifies the percentage of an ecological site that has been directly converted to other uses. The direct conversion of a grass-shrub ecological site was discussed more detail in the previous section and summarized in Table 27.

The native ecosystem representation goal identified in the Blackfoot Subbasin Plan was 50% of the historical range of variability for grass-shrub ecosystems of the watershed, which was estimated to total 76,303 acres across the 7 terrestrial ecological sites. Table 35 identifies the number of acres representing 50% of the mean historical range of variability (HRV) for grass-shrub ecosystems of the Blackfoot watershed compared to the number of acres present today. Those disturbance states that represent less than 50% of the mean HRV and are therefore underrepresented in this watershed are identified. Results of the cumulative change assessment suggest that 49,892 acres or 65% of remaining native grass-shrub ecosystems represent historical conditions for the short and long fire return intervals under today's conditions. Due to reasons previously discussed it is still unknown how many acres represent light and moderate grazing levels today relative to historical amounts.

Table 34. The percentage of each grass-shrub ecosystem occurring today in the Blackfoot watershed as compared to the mean historical range of variability (HRV), relative to fire regime and ecological site. These results summarize the changes that have occurred on each ecological site, where the vegetation present today is still similar to native ecosystem conditions. The percent of conditions present today that did not occur historically, or "other" and converted conditions, are also summarized by ecological site.

Disturbance Regime	Hot-Droughty		Hot-Loamy		Warm-Droughty		Warm-Loamy		Warm-Sandy		Warm-Claypan		Warm-Gravelly	
	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today	Mean HRV	Today
Short Fire Return Interval (<25 yrs) X Unknown Grazing Levels	69.3%	14.0%	85.8%	11.3%	79.1%	25.1%	73.2%	26.0%	89.5%	11.0%	72.8%	18.4%	30.7%	12.1%
Long Fire Return Interval (≥25 yrs) X Unknown Grazing Levels	30.7%	16.4%	14.2%	18.4%	20.9%	12.8%	26.8%	25.3%	10.5%	7.4%	27.2%	25.4%	69.3%	4.6%
Conditions that did not occur historically														
Other		1.4%		0.6%		7.2%		3.7%		5.7%		1.6%		4.6%
Converted		68.2%		69.7%		54.9%		45.0%		76.0%		54.6%		78.7%
TOTAL ACRES	**8,220**		**21,560**		**84,300**		**29,740**		**1,320**		**2,950**		**4,770**	

Table 35. The number of acres representing 50% of the mean historical range of variability (HRV) for grass-shrub ecosystems of the Blackfoot watershed compared to the number of acres present today. Those cells highlighted in red indicate today's conditions that represent less than 50% of the mean HRV and are therefore underrepresented in this watershed.

Disturbance Regime	Hot-Droughty		Hot-Loamy		Warm-Droughty		Warm-Loamy		Warm-Sandy		Warm-Claypan		Warm-Gravelly	
	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today	50% Mean HRV	Today
Short Fire Return Interval (<25 yrs) X Unknown Grazing Levels	2848	1151	9249	2436	33341	21159	10885	7732	591	145	1074	543	732	577
Long Fire Return Interval (≥25 yrs) X Unknown Grazing Levels	1262	1348	1531	3967	8810	10790	3985	7524	70	98	272	749	1653	219

- **Goals for Grass-Shrub Ecosystem Restoration**

The native ecosystem representation goal identified in the Blackfoot Subbasin Plan was 50% of the historical range of variability for grass-shrub ecosystems of the watershed. For the purposes of quantifying this goal, we have interpreted this to represent 50% of the mean historical range of variability. The results of the cumulative change assessment indicate the number of acres of grass-shrub ecosystems that would require restoration to achieve that goal is 26,410. The primary grass-shrub disturbance state that is under-represented in the watershed today is the short fire return interval x light to moderate grazed condition.

Previous sections of this document describe grass-shrub ecological sites and identify historical state and transition models for each of these ecological sites occurring within the Blackfoot watershed. These descriptions and models describe the influences of historical disturbance processes and their interactions and can be used in disturbance-based range management programs to identify appropriate objectives and priorities for conserving ecosystem and biological diversity within the Blackfoot watershed. This strategy focuses on providing sufficient amounts of functionally similar ecosystems to what occurred historically across the landscape in order to maintain and benefit all native species. The number of acres needed to meet the Blackfoot Subbasin Plan's goal of 50% representation of native grass-shrub ecosystems of the Blackfoot watershed are presented by ecological site and disturbance state (fire disturbance only) in Table 36.

The combined information on historical grass-shrub conditions and estimates of acres needed to meet restoration objectives, provide the foundation for implementing an effective restoration strategy for native grass-shrub ecosystems of the Blackfoot watershed.

Table 36. The number of restoration acres required to reach the goal of maintaining 50% (mean HRV) of the historical grass-shrub native ecosystems of the Blackfoot watershed.

Disturbance Regime	Hot-Droughty	Hot-Loamy	Warm-Droughty	Warm-Loamy	Warm-Sandy	Warm-Claypan	Warm-Gravelly	Total
Short Fire Return Interval (<25 yrs) x Unknown Grazing Levels	1697	6812	12182	3153	446	531	155	**24976**
Long Fire Return Interval (≥25) x Unknown Grazing Levels							1434	**1434**

RESTORING NATIVE TERRESTRIAL ECOSYSTEM DIVERSITY

It is worth re-emphasizing that the objectives for conducting a landscape assessment based on the historical reference are not to return the entire Blackfoot watershed to an historical condition. The Blackfoot Subbasin Plan goal of maintaining or restoring 50% or more of the native ecosystem diversity of the watershed is based on the assumption that if all of the ecosystems that occurred under historical disturbance regimes are sufficiently represented across the planning landscape at all times, then these ecosystems will provide the habitat conditions to support the full complement of biological diversity for that landscape. Habitat loss is acknowledged as one of the greatest threats to biological diversity at the species level (Ehrlich and Ehrlich 1981, Noss et al. 1996). The long-term persistence of ecosystem and biological diversity requires that land managers provide suitable conditions for a high likelihood of maintaining these ecological components. However, the conditions that enhance this likelihood may sometimes be in conflict with the production of economic or social goods and demands. Therefore, objectives for ecological sustainability must strive to define conditions that provide an acceptable likelihood of the long-term persistence of ecosystem and biological diversity. Selecting an acceptable probability of persistence is a value judgment, as some would forgo economic or social benefits for a higher probability of maintaining ecological objectives while others would accept a lower probability in exchange for increased goods or services. Balancing these considerations has and continues to be a primary objective for the land managers and landowners in this landscape.

The benefits of a landscape-scale assessment for setting priorities are numerous. When planning for a large watershed, it is tempting to focus on places where projects can be implemented most expeditiously. Too often, priorities are determined by how feasible a project is to complete rather than where the greatest restoration need occurs. Obviously, practical considerations should be evaluated, but a spatial, ecological analysis of priorities serves as a useful framework into which we can incorporate a more informed assessment of feasibility. Also, without a landscape assessment it becomes hard to estimate how much total work there is to accomplish. Clearly defined restoration goals and priorities will also help in the development of monitoring plans to evaluate progress toward those goals. Establishing priorities can help agencies and collaborative groups communicate why and where a restoration project is important to implement. Such communication is often crucial for helping the public to understand and appreciate the need for restoration treatments. The collaborative process is facilitated when informed by landscape-level data. Different scenarios for treatment can be considered, and stakeholders can actively engage in how the information should be used to set priorities. There is benefit to applying a consistent approach to prioritize restoration treatments across broad landscapes.

While restoration of historical ecosystem conditions is a critical component of conservation, adjustments to these conditions will be needed. The historical reference assumes a relatively stable climate, and also assumes that the location of ecological sites is a static feature of a landscape. However, with our current understanding of changes occurring to our climate, planning for future desired conditions must take these predicted changes into account. While this does not reduce the importance of using historical reference conditions, it may require adjustments to desired future conditions to make them sustainable under future predicted climate conditions. Two ways can be suggested to accomplish this. One is to adjust the desired plant community of existing ecological sites so that it will be sustainable under future precipitation and temperature conditions. If a species that historically occurred in a plant community is at the edge of its environmental envelope in the Blackfoot watershed, and predicted future conditions will push precipitation or temperature conditions outside of that envelope, then that species should be replaced with a species more suited for the predicted climate, but that will serve a similar function in the community. A second alternative is to reevaluate the location of ecological sites, and shift sites to be more consistent with predicted future climate conditions. This may mean that Warm-Moist sites at lower elevations of this type may switch to warm dry sites, or some cool dry sites may shift to warm dry sites. An additional challenge will be to determine how future fires will operate in the landscape. Predictions call for reduced snowpack, earlier melt off of high elevation snows, reduced stream flows, and other changes. What may have normally been barriers to fire spread in most years, such as greener high elevation vegetation or moist riparian areas, may not be present in future years, allowing much larger fires to occur. Planning for such future fire conditions needs to be part of the restoration strategy.

Forest Ecosystems

In recent years, forest scientists have begun to recommend disturbance-based forest management that approximates the species compositions and structure (McComb et al. 1993, Stuart-Smith 2002, Hillis et al. 2001, Cushman et al. 2008), spatial distributions (Franklin and Forman 1987, Andison and Marshall 1999), and frequencies (Cissel et al. 1999) of historical fire regimes in forest restoration programs (Blocker et al. 2008). While many differences between historical disturbance and timber harvests will remain, disturbance-based forest management based on the historical reference will be the best chance we have to achieve native forest ecosystem restoration goals. Without such detailed attention to ecological relationships and identification of specifically needed native ecosystems, the effectiveness of conservation efforts will be greatly reduced, resulting in questionable outputs in terms of both ecosystem and biodiversity conservation.

Implementing Restoration Goals

Achieving forest ecosystem restoration goals in the Blackfoot watershed will require cooperation between state and federal agencies, public and private organizations, and private landowners. The desired native forest ecosystem conditions to be maintained or restored on each ecological site have been described in this document. When prioritizing restoration efforts, the historical disturbance states that have the least representation on the landscape today when compared with the amounts that were likely to have occurred historically should be targeted for restoration. For the Blackfoot watershed, the historical states that are likely to be the least represented on the landscape today were conditions produced under non-lethal and mixed-severity fire regimes.

A combination of practices should be identified and evaluated for each selected restoration site to produce the desired species composition, structure, and processes. To develop site specific restoration plans, the detailed descriptions of historical forest conditions developed for each of the seven forest ecological sites, should be consulted. In addition, we offer the following management recommendations:

Management Recommendations

1. New permanent roads should be minimized to protect the integrity of the riparian/wetland and aquatic systems in the watershed.
2. Best management practices to protect water quality values in the watershed should be fully utilized.
3. Maximize retention and protection of large trees wherever they occur to provide opportunities for restoration of historical late-seral forest conditions.
4. Wildfire fuel mitigation programs and establishment of the Wildland Urban Interface should be developed with full consideration given to the ecosystem restoration goals identified in this assessment.
5. Forest management considerations should focus on what is left behind, rather than the more conventional focus on what is taken; snags and broken-topped trees should be considered desirable features.
6. Reduce tree densities to basal areas more closely resembling historical conditions, while leaving enough trees to restore densities and diameter distributions where they are lacking.
7. Ponderosa pine more naturally grows in a relatively clumped manner, often with interlocking crowns. Some wildlife species are particularly dependent on the combination of this vertical and horizontal structure. An even distribution of trees is not desirable, particularly on drier ecological sites.
8. Some openings should be maintained over time, especially where they occurred historically.
9. Heavy to moderate slash will need to be removed to avoid unnatural wildfire intensities in the drier ecological sites.
10. Re-establish historical fire regimes where possible to reduce uncharacteristic fire, expose mineral soils, provide a nutrient flush for vegetation, reduce competition, and stimulate production of grasses and forbs.
11. Where prescribed burning is used, duff that may have accumulated around the base of remaining large trees may need to be raked away from the trees so that these trees won't be killed by the heat generated from the initial burn following a long period of fire exclusion and duff accumulation.
12. Particular emphasis should be placed on restoring mixed-severity conditions where they were likely to have occurred historically. The presence of large, scattered western larch and Douglas-fir in today's overstory, may indicate mixed-severity conditions that occurred historically. Where these large old trees occur, emphasis should be given to treatments that will help restore their diverse structures and species compositions, and for the short-term, protect them from future lethal fires in the surrounding stands.

13. Today, many stands are generally considered to be less structurally diverse and less diverse in terms of patch sizes and patch shapes at the landscape level than what occurred historically. Future treatment should attempt to restore the historical mosaic of more diverse conditions.
14. Investigate the historical role and distribution of western white pine in the Blackfoot watershed and develop a restoration program, if appropriate.
15. Retain as much as possible of the surviving whitebark pine in current forests and provide openings for its regeneration. Planting of blister rust resistant whitebark pine may be necessary, where feasible.
16. Maintaining a mosaic of relatively pure and mixed species stands would reflect the historical pattern of mixed-severity and lethal fire regimes.
17. High elevation treatment activities should be very low impact due to the harsh, fragile nature of these sites.

GRASS-SHRUB ECOSYSTEMS

While disturbance-based management that tries to simulate the effects of historical disturbance regimes on grass-shrub ecosystems is a relatively new concept in grass-shrub ecosystem restoration programs, it has great application to these systems as well. Studies have demonstrated that cattle grazing does not exactly simulate historical bison grazing when it comes to overall native species composition and structure, but it does produce relatively similar dominant native species compositions and structures. When managed with restoration in mind, livestock grazing can be a useful tool to help establish more representative native ecosystem conditions, in areas where it no longer represents historical conditions in the watershed. In addition, native grazers such as elk may be important to achieving certain restoration objectives. Prescribed burning is another critical tool that will be important to restoring historical fire regimes in these systems.

Implementing Restoration Goals

Achieving grass-shrub ecosystem restoration goals in the Blackfoot watershed will have different challenges when compared to forest ecosystems. Many of the grass-shrub ecosystems in the Blackfoot watershed are under private ownership. To reach the restoration goals identified, restoration objectives must be implemented on working lands of willing agricultural producers, using innovative incentive-based programs and practices to address the restoration need while respecting and addressing the needs of the producer. Opportunities for restoration on public lands should also be evaluated and coordinated between the appropriate land management agencies

Innovative combinations of practices will need to be applied and monitored to document both conservation gains and for private landowners, projected increases in productivity. If overall productivity can be sufficiently increased or not impacted, it will be possible to incorporate new practices that would provide or simulate historical disturbance, while maintaining the overall productivity of a producer. Producing these gains, monitoring their occurrence, and documenting their effectiveness for dissemination to others are key components of developing restoration objectives in this landscape.

The desired native grass-shrub ecosystem conditions to be maintained or restored on each ecological site have been described in this document. Where possible, the historical disturbance state that has the least representation on the landscape today when compared with the amounts that were likely to have occurred historically should be targeted for restoration. For the Blackfoot watershed, the historical state that is likely to be the least represented on the landscape today were conditions produced under frequent fire regimes and light grazing. This is particularly true for the more productive grass-shrub ecological sites, as a higher percentage of these sites have been converted to other uses.

A combination of practices need to be identified for each selected area and should be designed to produce the desired species composition, structure, and processes. These practices may include: prescribed burning, control of introduced weeds, interseeding with desired native grass and forb species appropriate for each ecological site, planting to establish appropriate native plant communities on any croplands to be restored, and prescribed grazing implemented through long-term grazing plans to maintain the desired conditions. Each site should be individually evaluated to determine the combination of practices that are most likely to produce the desired conditions.

Treatments developed for a particular site should be based on consideration of the underlying ecological site and the current condition on the site. For many areas, incorporating prescribed burning will be an important practice. Where feasible, the prescribed burning should be planned to simulate historical fire patterns for that ecological site. Introduced species will likely never be totally eliminated from restoration sites, but they should be suppressed to the extent that is practical and feasible. Suppression of introduced species may be achieved through herbicide application, prescribed burning, prescribed grazing, interseeding or planting of desired native species, or a combination of these treatments. No single prescription is envisioned as a universal solution, as the combination of site differences, current conditions, weather patterns, landscape influences, and other factors mean that treatment selection must be flexible yet site specific, and responses will undoubtedly be variable.

Programs and Practices to Achieve Restoration Goals

Identifying applicable programs and practices that can be used to achieve the restoration goals identified in this document should be an ongoing process for agencies, organizations and landowners. The following sections will review existing programs and practices available through the Farm Bill. The applicable programs of the Farm Bill are administered by the Natural Resources Conservation Service (NRCS) and are available to private landowners. The following sections provide a summary of the programs and practices administered by NRCS that could be used to achieve some of the restoration goals presented in this report. A landowner should contact their local NRCS office to discuss these programs and practices, along with their objectives for their property, with agency representatives and partners.

Programs

Wildlife Habitat Incentive Program (WHIP)

The Wildlife Habitat Incentive Program (WHIP) is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Tribal land.

The Food, Conservation, and Energy Act of 2008 reauthorized WHIP as a voluntary approach to improving wildlife habitat in our Nation. The Natural Resources Conservation Service administers WHIP to provide both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. WHIP cost-share agreements between NRCS and the participant generally last from one year after the last conservation practice is implemented but not more than 10 years from the date the agreement is signed.

In order to provide direction to the State and local levels for implementing WHIP to achieve its objective, NRCS has established the following national priorities:

- Promote the restoration of declining or important native fish and wildlife habitats.
- Protect, restore, develop or enhance fish and wildlife habitat to benefit at-risk species
- Reduce the impacts of invasive species on fish and wildlife habitats; and
- Protect, restore, develop or enhance declining or important aquatic wildlife species' habitats

Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program is a voluntary program that seeks to promote agricultural production and environmental protection as common goals. Technical and financial assistance is provided to cover conservation activities and to replace income to the landowner that may be reduced by these activities. EQIP contracts typically extend over a two to three year period but can range from a minimum of 1 year to a maximum of 10 years. Emphasis is placed on conservation actions that include:

- nutrient, residue or air quality management,
- Invasive species management,
- Pollinator habitat;
- Animal carcass management technology, and
- pest management.

Eligible lands include private and tribal cropland, grassland, rangeland, pasture, wetlands, non-industrial forest land and other agricultural land on which farm or forest-related products are produced. Public lands that are actively managed as part of a participant's private operation (i.e., grazing allotments) and on which the proposed activities would directly benefit the private holdings are also eligible.

Conservation Stewardship Program (CSP)

The Conservation Stewardship Program is a voluntary conservation program that offers payments to producers who maintain a high level of conservation on their land and who agree to adopt higher levels of stewardship. Eligible lands include cropland, pastureland, rangeland and non-industrial forestland.

Eligible applications receive a field visit and a ranking score. Applicants selected for funding will enter into 5-year contracts and may receive up to $40,000 per year. CSP is available on Tribal and private agricultural lands. The program provides equitable access to all producers, regardless of operation size, crops produced, or geographic location.

Grassland Reserve Program (GRP)

The Grassland Reserve Program is a voluntary conservation program that emphasizes support for working grazing operations, enhancement of plant and animal biodiversity, and protection of grassland under threat of conversion to other uses.

Participants voluntarily limit future development and cropping uses of the land while retaining the right to conduct common grazing practices and operations related to the production of forage and seeding, subject to certain restrictions during nesting seasons of bird species that are in significant decline or are protected under Federal or State law. A grazing management plan is required for participants.

Healthy Forests Reserve Program (HFRP)

The purpose of the Healthy Forests Reserve Program is to assist landowners, on a voluntary basis, in restoring, enhancing and protecting forestland resources on private lands through easements, 30-year contracts and 10-year cost-share agreements.
The objectives of HRFP are to:

1. Promote the recovery of endangered and threatened species under the Endangered Species Act (ESA);
2. Improve plant and animal biodiversity; and
3. enhance carbon sequestration.

The HFRP was signed into law as part of the Healthy Forests Restoration Act of 2003. It was amended in the 2008 Farm Bill. Restoring and protecting forests contributes to the economy, provides biodiversity of plants and animal populations, and improves environmental quality. Landowner Protections will be made available to landowners enrolled in HFRP who agree, for a specified period to restore or improve their land for threatened or endangered species habitat. In exchange they avoid certain regulatory restrictions under the Endangered Species Act on the use of that land. The HFRP provides financial assistance in the form of easement payments and costs-share for specific conservation action completed by the landowner.

The Program offers three enrollment options:

1. A 10-year restoration cost-share agreement; for which the landowner may receive 50 percent of the average cost of the approved conservation practices.
2. A 30-year easement, for which the landowner may receive 75 percent of the easement value of the enrolled land plus 75 percent of the average cost of the approved conservation practices.

3. Permanent easements for which landowners may receive 100 percent of the easement value of the enrolled land plus 100 percent the average cost of the approved conservation practices.

To be eligible for enrollment, land must be private land or Tribal land which will restore enhance or measureable increase the likelihood of recovery of a threatened or endangered species must improve biological diversity or increase carbon sequestration.

Conservation Practice Standards

NRCS conservation practice standards provide guidance for applying conservation technology on the land and set minimum acceptable levels for application of the technology. Each state NRCS office determines which National conservation practice standards are applicable to their state. The appropriate state-level technical detail is added to effectively use the standards at the state-level. A listing of 2010 conservation practice standards applicable to Montana is provided in Table 37.

Table 37. Natural Resource Conservation Service 2010 conservation practice standards applicable to Montana.

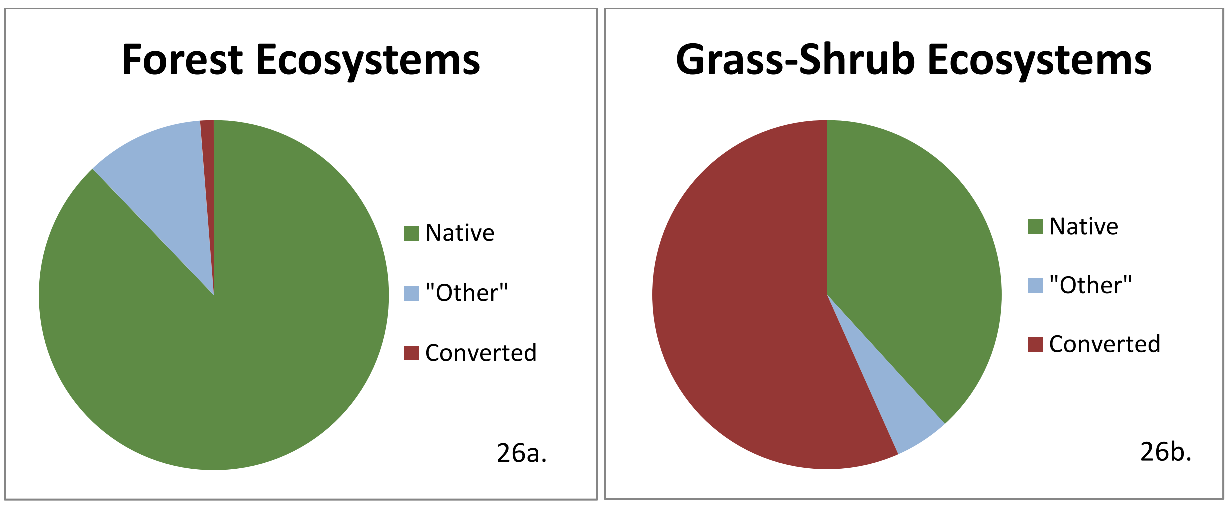
Conservation Practice (Code)	Definition	Aplicable purpose
Brush Management (314)	Removal, reduction, or manipulation of non-herbaceous plants	Restore natural plant community balance; create the desired plant community; maintain or enhance wildlife habitat; protect life and property from wildfire hazards
Conservation Cover (327)	Establishing and maintaining permanent vegetation cover	Enhance wildlife habitat
Cover Crop (340)	Grasses, legumes, forbs, or other herbacous plants established for conservation purposes	Increase biodiversity; weed suppression
Critical Area Planting (342)	Establishing permanent vegetation on sites that have or are expected to have high erosion rates, or have conditions that prevent the establishment of vegetation with normal practices	Rehabilitate and revegetate degraded sites that cannot be stabilized through normal practices
Early Successional Habitat (647)	Manage early plant succession to benefit desired wildlife or natural communities	Increase plant community diversity to provide habitat for early successional species
Forest slash treatment (384)	Treating woody plant residues created during forestry, agroforestry and horticultural activities to achieve management objectives	Reduce hazardous fuels; Improve the site for natural or artificial regeneration
Forest Stand Improvement (666)	The manipulation of species composition, stand structure and stocking by cutting or killing selected trees and understory vegetation	Reduce wildfire hazard ;Restore natural plant communities; Improve wildlife habitat
Herbaceous Weed Control (797)	Removal, control, or manipulation of herbaceous weeds	Restore natural plant communities; create desired plant communities based on resource needs and producer objectives; maintain or enhance wildlife habitat

Table 37, continued. Natural Resource Conservation Service 2010 conservation practice standards applicable to Montana.

Conservation Practice (Code)	Definition	Aplicable purpose
Prescribed Burning (338)	Controlled fire applied to a predetermined area	Restore and maintain ecological sites; improve wildlife habitat; reduce wildfire hazards; control undesirable vegetation
Prescribed Forestry (409)	Manage forested areas for forest health, wood and/or fiber, water, recreation, aesthetics, wildlife habitat and plant biodiversity	Maintain or improve forest health; maintain or improve plant diversity; improve wildlife habitat
Prescribed Grazing (528)	Managing the controlled harvest of vegetation with grazing and/or browsing animals	Improve or maintain desired species composition and vigor of plant communities; Improve or maintain the quantity and quality of food and/or cover available for wildlife.
Range Planting (550)	Establishment of adapted perennial vegetation such as grasses, forbs, legumes, shrubs, and trees.	Restore a plant community similar to its historic climax or the desired plant community
Restoration and Management of Rare or Declining Habitats (643)	Restoring and managing rare and declining habitats and their associated wildlife species to conserve biodiversity.	Provide habitat for rare and declining species
Tree/Shrub Establishment (612)	Establishing woody plants by planting seedlings or cuttings, direct seeding, or natural regeneration.	Improving or restoring natural diversity; wildlife habitat
Tree/Shrub Site Preparation (490)	Treatment of areas to improve site conditions for establishing trees and/or shrubs	Encourage natural regeneration of desirable woody plants; Permit artificial establishment of woody plants.
Upland Wildlife Habitat Management (645)	Provide and manage upland habitats and connectivity within the landscape for wildlife.	Treating upland wildlife habitat concerns identified during the conservation planning process.

SUMMARY

When compared to many other regions of the country where less than 10% of the native ecosystem diversity remains (e.g., SD Department of Game, Fish, and Parks 2006, Haufler et al. 2008, Vodehnal and Haufler 2008), the amounts of native terrestrial ecosystems in the Blackfoot watershed are relatively high. Overall, direct conversions of native ecosystems are relatively low in this landscape. However, when considered by ecosystem type, we see that forest ecosystems have received very little direct conversion from native conditions while grass-shrub ecosystems have experienced a great deal of conversion, especially in some of the more productive ecological sites (Figure 26). Vegetation conditions that no longer represent conditions that occurred historically are identified as "other". Both forest and grass-shrub ecosystems are characterized by relatively small amounts of these "other" conditions today. Native conditions are still common in forest ecosystems but have been significantly reduced in grass-shrub ecosystems.



Figures 26a and 26b. The amount of native forest and native grass-shrub ecosystems remaining in the Blackfoot watershed, relative to converted and "other" conditions (see text for a description of these conditions).

While the amounts of native ecosystem conditions are still relatively high overall in the Blackfoot watershed, alteration of historical disturbance regimes and past land management practices have combined to change the amounts and distributions of native ecosystem diversity, with much fewer acres today representing the more common historical structures, species compositions, and landscape patterns. In forest ecosystems, we see a substantial reduction in the number of acres influenced by non-lethal and mixed-severity A fire regimes to many more acres influenced by lethal fire regimes today (Figure 27). Mixed-severity B fire regimes have been reduced overall in the landscape but less so than the non-lethal and mixed-severity A fire regimes.

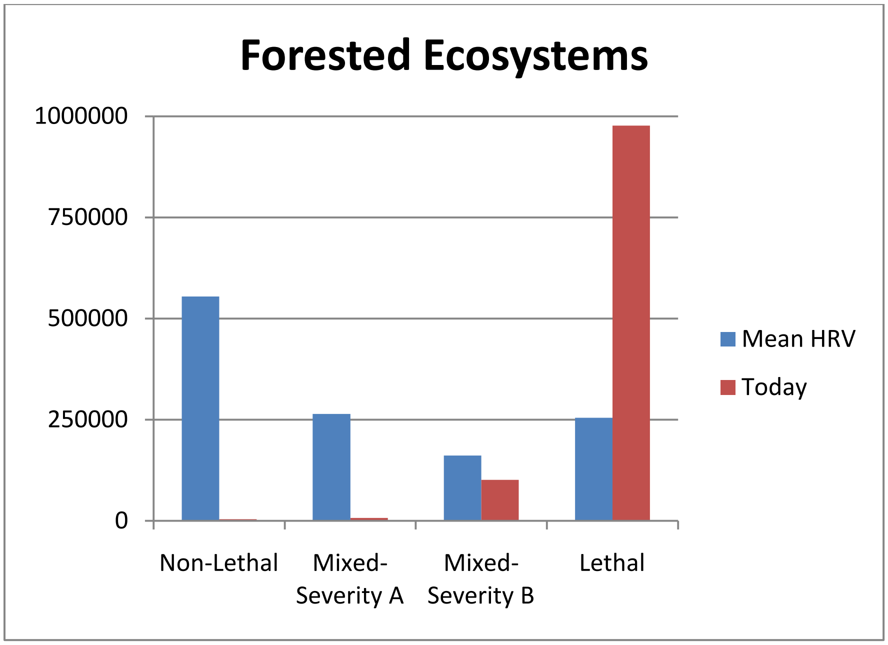


Figure 27. A comparison of the number of acres of each of the 4 historical fire regimes relative to mean historical range of variability (HRV) and today's conditions, for the Blackfoot watershed.

When the alterations to fire regimes are assessed relative to ecological sites, some more dramatic and concerning changes are also observed. Specifically, the non-lethal fire regime was the primary type of disturbance on the low elevation ecological sites and has been almost entirely lost from these sites today (Figure 28). Mixed-severity A fire regimes have also been greatly reduced across all ecological sites (Figure 29). Mixed-severity B fire regimes are greatly reduced from historical conditions (Figure 30). However, lethal fire regimes (Figure 31) have greatly increased from historical conditions. When you consider the patterns of historical compared to today's conditions across all four of these charts, it is easy to see that the ecological sites that were predominantly influenced by the non-lethal and mixed-severity A fire regimes are now being influenced primarily by the lethal fire regime and to a lesser extent, the mixed-severity B fire regime. While the overall acres of the mixed-severity B fire regime have not changed as significantly as the non-lethal and mixed-severity B, their distribution among ecological sites has changed to a large degree.

The cumulative changes resulting from the alteration of these historical fire regimes and past timber management practices in the Blackfoot watershed has had and continues to have profound influences on the structure and species composition of the native forest ecosystems. A high percentage of native forest ecosystems that were present historically are present in small amounts today compared to their historical amounts, and are thus reduced in functional quality. While native conditions are still found across all forested ecological sites, the amount of each of the five disturbance states has changed considerably (Figure 32). Today's forest ecosystems are primarily represented by the four early to mid-seral disturbance states which were, relative to the late-seral disturbance state, not common historically. Whereas the late-seral disturbance state, which was very common historically, is poorly represented on the landscape today.

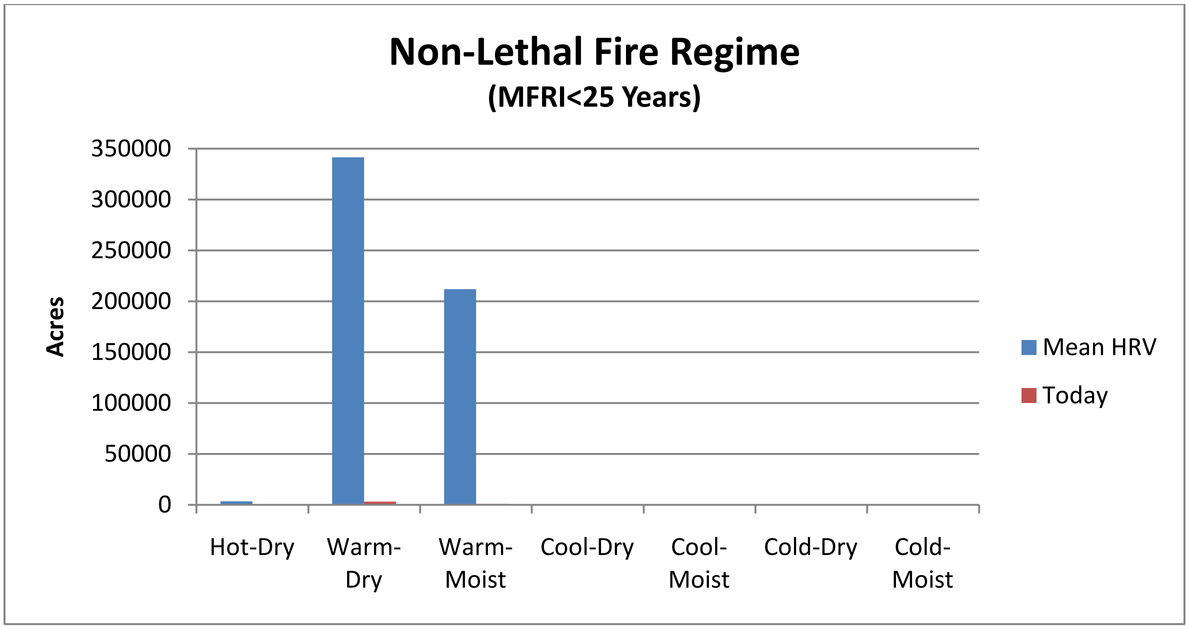


Figure 28. A comparison of the number of acres of the non-lethal fire regime relative to mean historical range of variability (HRV) and today's conditions by forest ecological site, for the Blackfoot watershed.

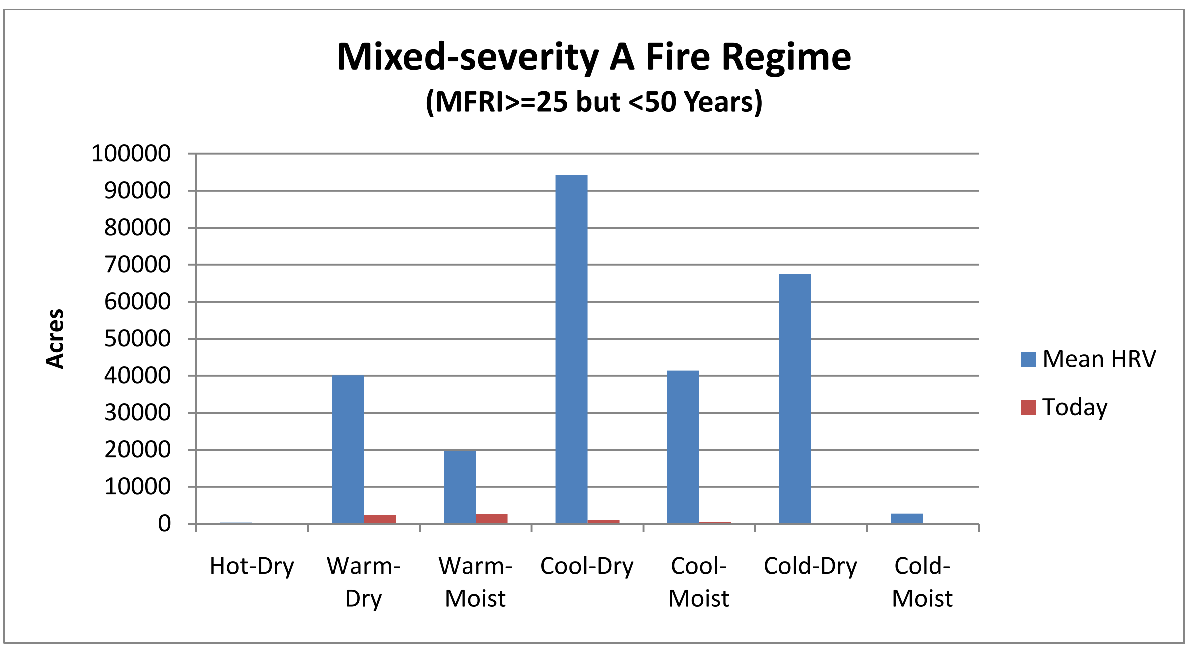


Figure 29. A comparison of the number of acres of the mixed-severity A fire regime relative to mean historical range of variability (HRV) and today's conditions by forest ecological site, for the Blackfoot watershed.

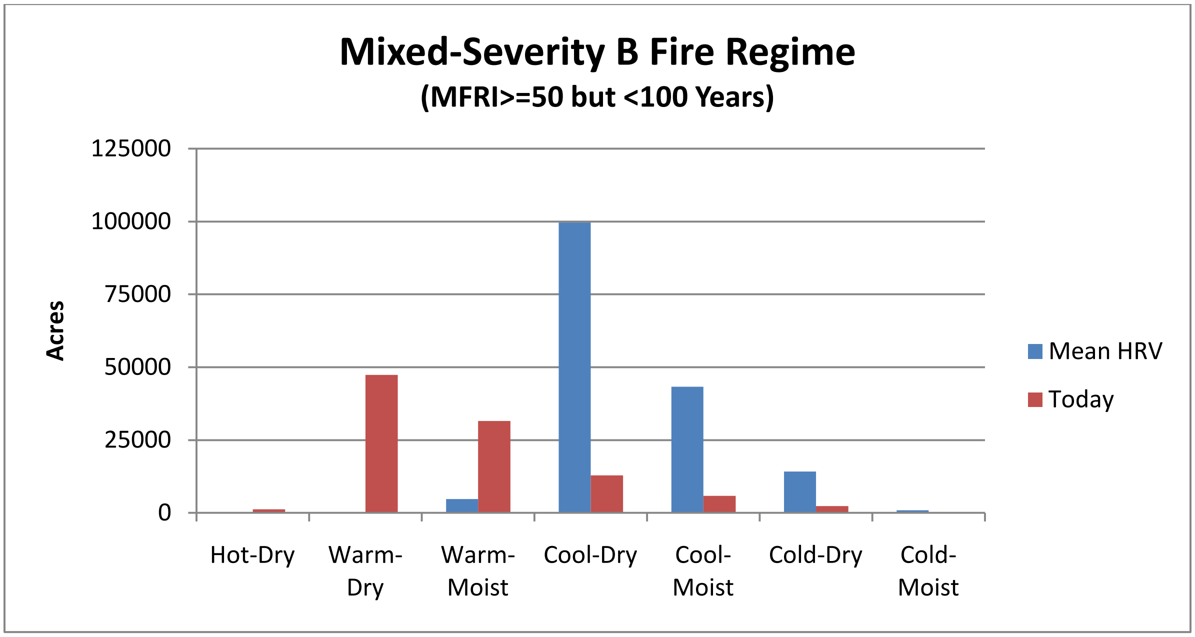


Figure 30. A comparison of the number of acres of the mixed-severity B fire regime relative to mean historical range of variability (HRV) and today's conditions by forest ecological site, for the Blackfoot watershed.

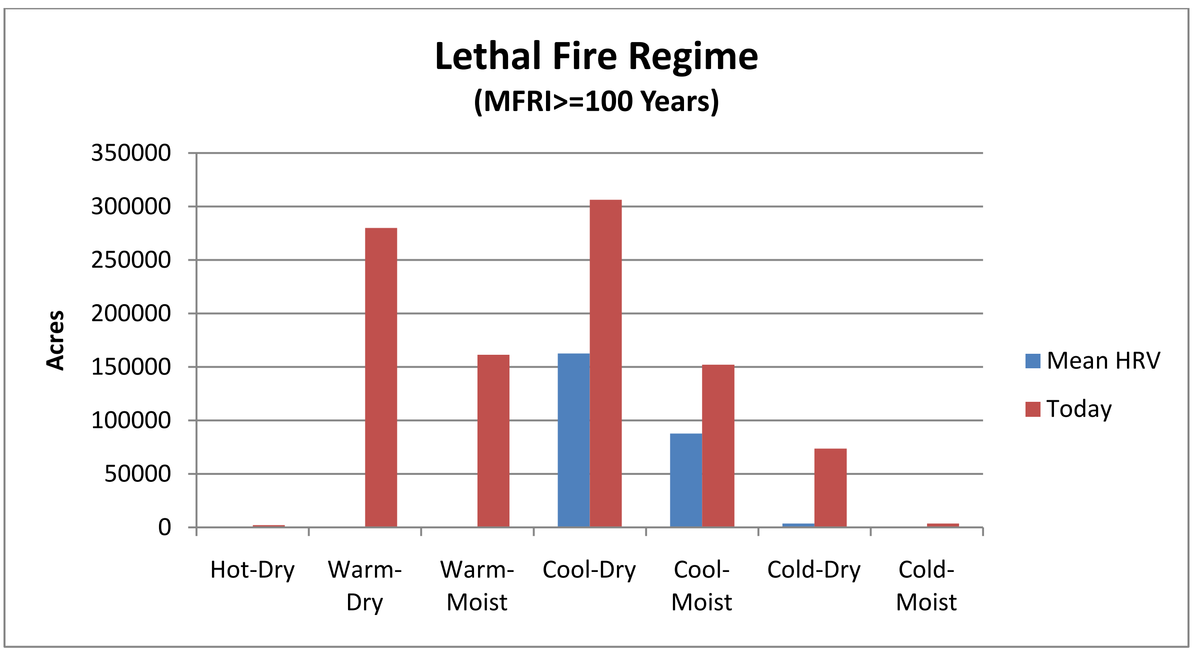


Figure 31. A comparison of the number of acres of the lethal fire regime relative to mean historical range of variability (HRV) and today's conditions by forest ecological site, for the Blackfoot watershed.

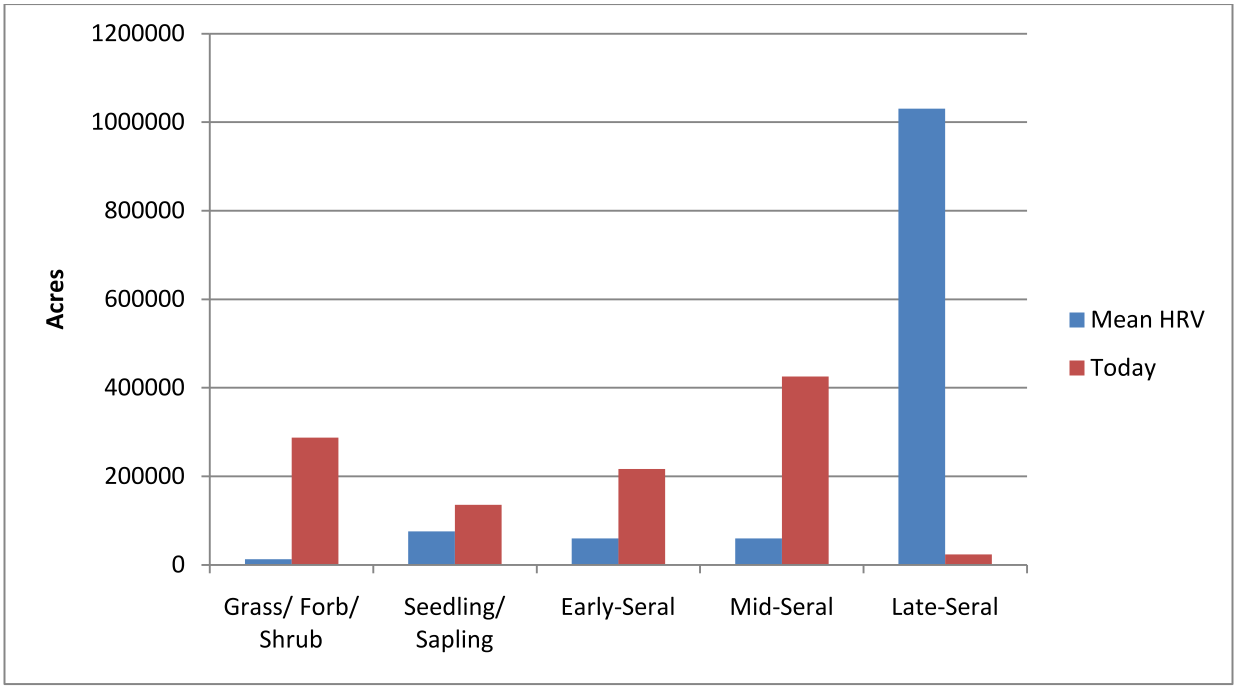


Figure 32. A comparison of the number of acres of forest ecosystem disturbance states relative to mean historical range of variability (HRV) and today's conditions, for the Blackfoot watershed.

Similar to forest ecosystems, today's grass-shrub ecosystems have also seen a significant reduction in the number of acres influenced by the short-interval fire regime (Figure 33). The long-interval fire regime has seen only a slight reduction in the number of acres influenced today versus historically. The short-interval fire regime trend is still evident when evaluated relative to grass-shrub ecological sites (Figure 34). However, the long interval fire regime is more variable, with the Moist-Droughty and Moist Gravelly sites experiencing a significant reduction in the influences of the long-interval fire regime, and the Dry-Loamy ecological site experiencing an increase (Figure 35). The implication of this change to historical fire regimes in grass-shrub ecosystems is a shift in species composition and structure from predominantly grass dominated communities to shrub and grass dominated communities. As discussed previously, we were unable to evaluate the status of grazing level changes to grass-shrub ecosystems as a component of this project, however, this should be a priority for future research.

The results of the cumulative change assessment of the Blackfoot watershed has identified many opportunities for ecosystem restoration for both forest and grass-shrub systems in this landscape. Figure 36 identifies the required forest restoration acres by ecological site to reach the Blackfoot Subbasin Plan goal of maintaining 50% of the historical range of variability. Figure 37 does the same for grass-shrub ecosystems of the Blackfoot watershed. Reaching these restoration goals will be challenging and will require the coordination of both private and public landowners in the Blackfoot watershed. Existing and future management and restoration programs will need to look beyond property boundaries and conflicting objectives to create a visionary plan that balances land use needs, public safety, and endangered species requirements, with the identified ecosystem restoration goals.

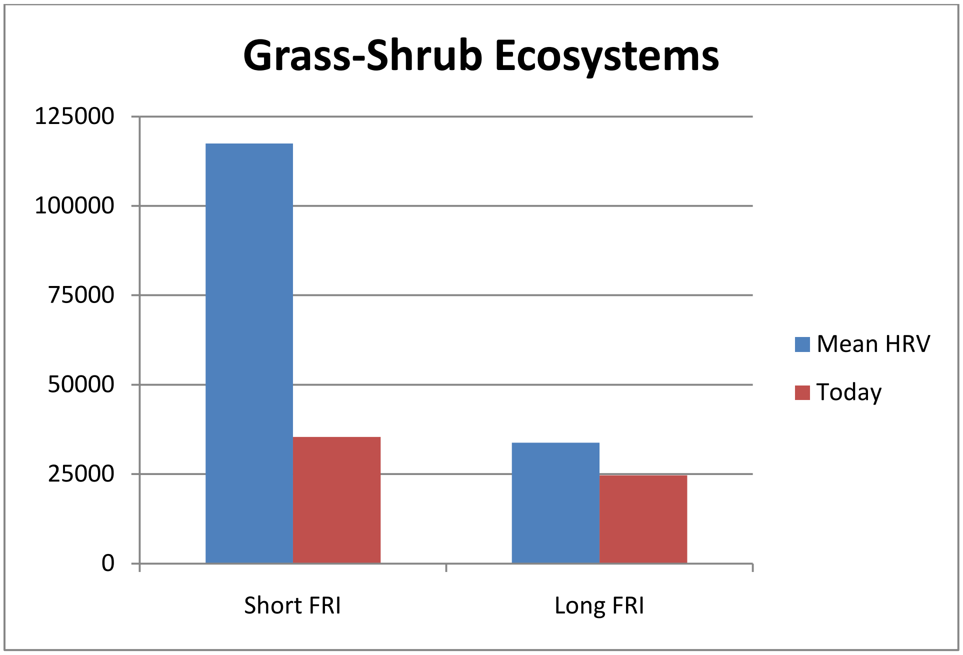


Figure 33. A comparison of the number of acres of the short and long fire return intervals (FRI) relative to mean historical range of variability (HRV) and today's conditions, for the Blackfoot watershed.

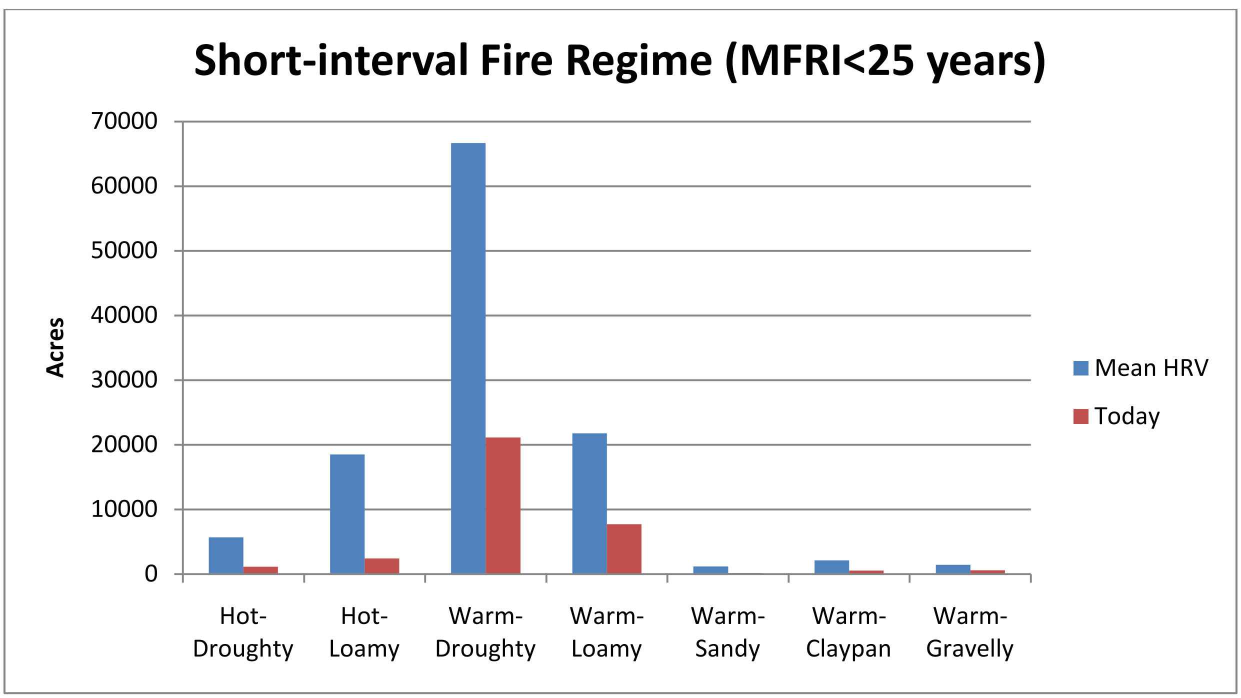


Figure 34. A comparison of the number of acres of the short-interval fire regime relative to mean historical range of variability (HRV) and today's conditions by grass-shrub ecological site, for the Blackfoot watershed.

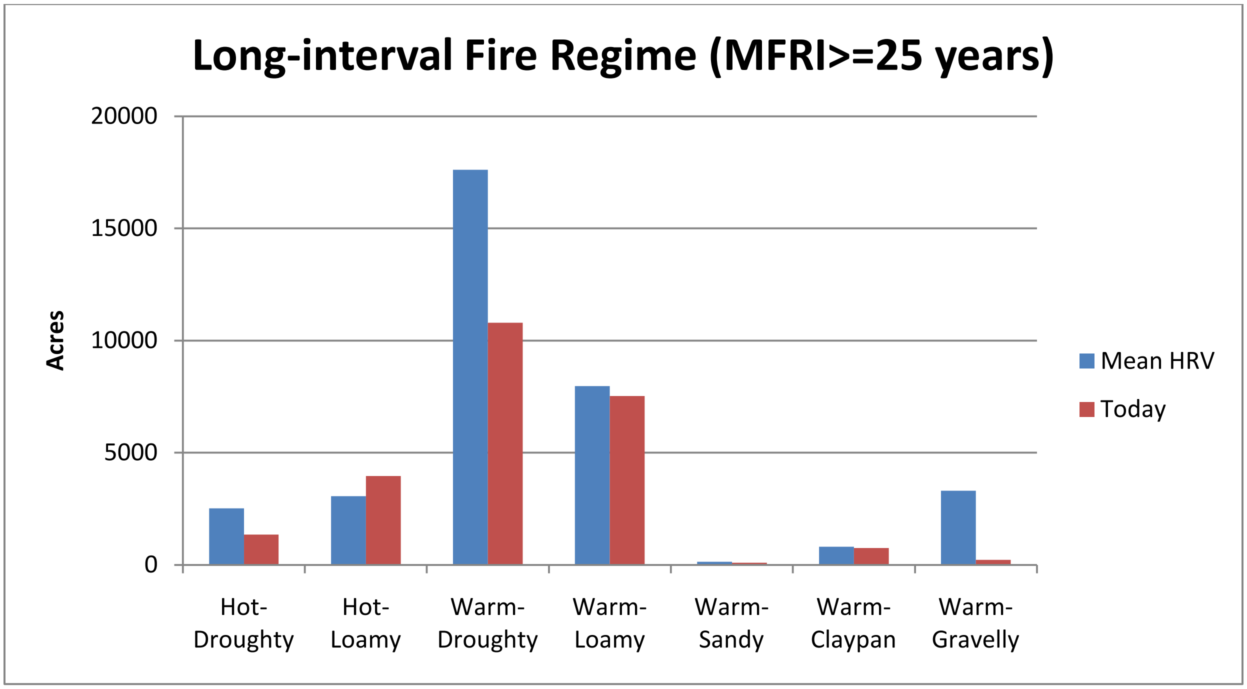


Figure 35. A comparison of the number of acres of the long-interval fire regime relative to mean historical range of variability (HRV) and today's conditions by grass-shrub ecological site, for the Blackfoot watershed.

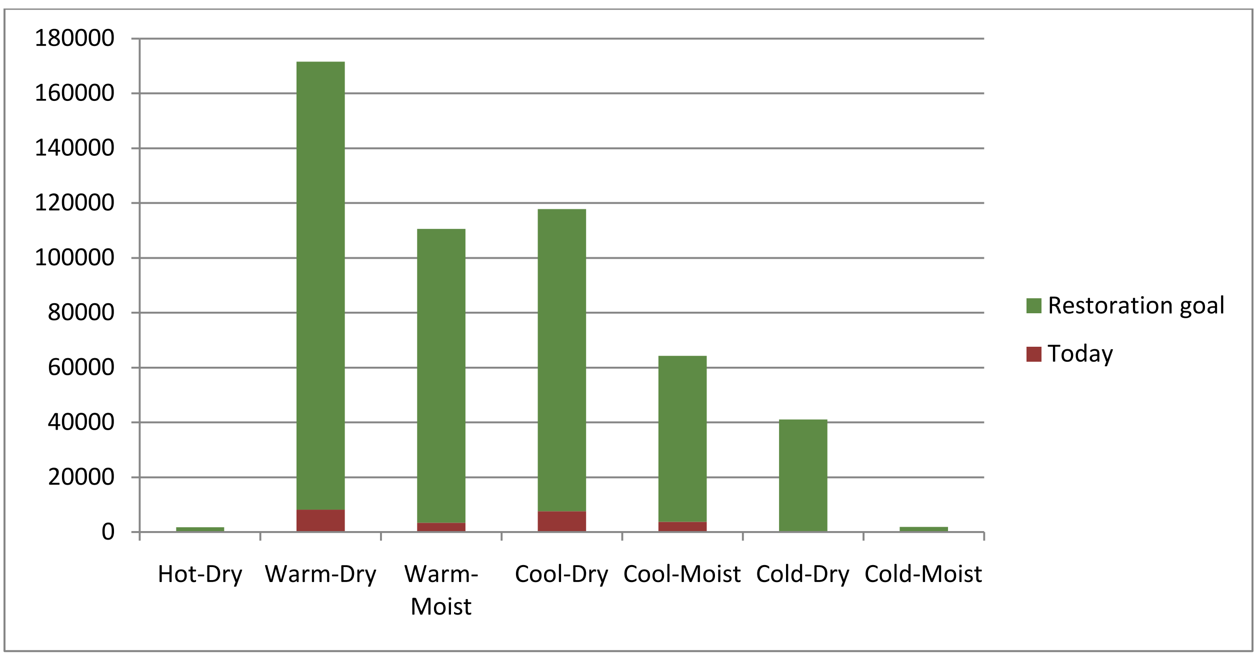


Figure 36. Number of acres required to restore native forest ecosystems to conditions representing 50% of the historical range of variability, as identified by the cumulative change assessment for the Blackfoot watershed.

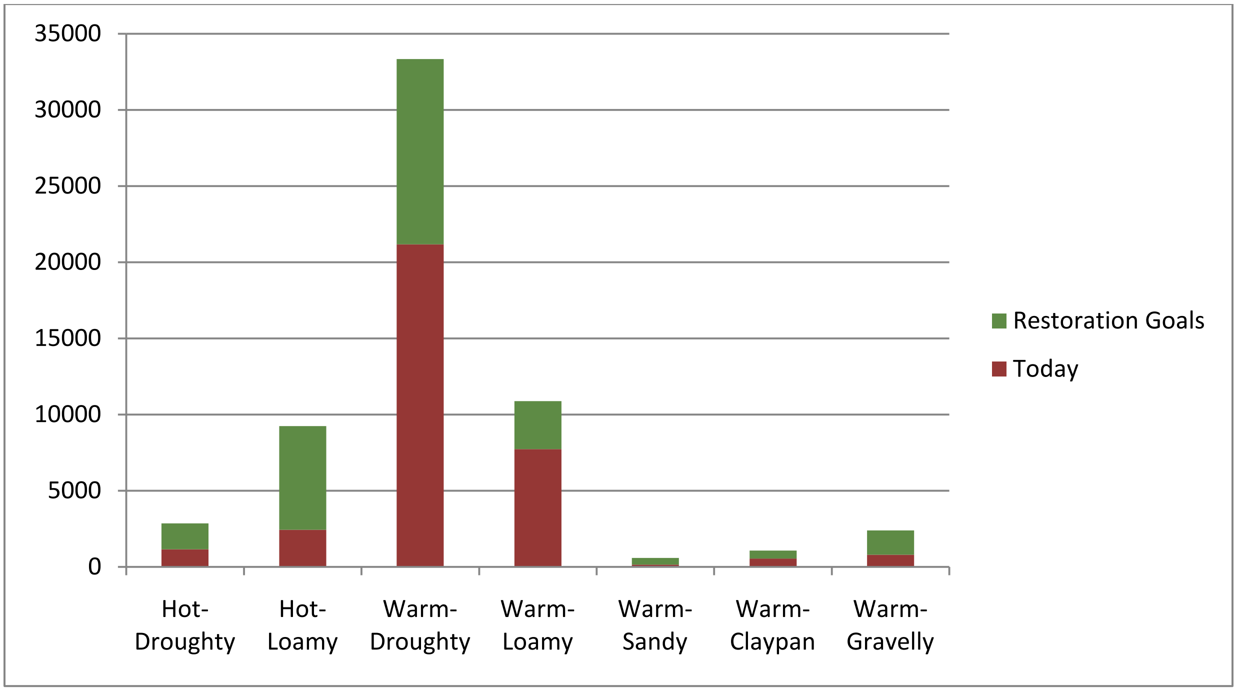


Figure 37. Number of acres required to restore native grass-shrub ecosystems to conditions representing 50% of the historical range of variability, as identified by the cumulative change assessment for the Blackfoot watershed.

In addition to identifying priorities for restoration of native terrestrial ecosystem diversity, this project evaluated the potential for use of NRCS ecological sites for conservation planning in the Blackfoot watershed. The findings and results of the analysis conducted clearly demonstrate the important role that ecological sites can play in evaluating cumulative effects at landscape scales, setting restoration objectives, and developing descriptions of reference communities. In the Blackfoot watershed, grass-shrub ecological sites still require additional field sampling and development of more detailed descriptions of existing and reference plant communities. However, it is apparent from the results presented that the application of ecological sites and historical analyses provide critical information for ecosystem restoration and conservation planning. For forest ecosystems, linking ecological sites with habitat types is important because of the past emphasis that has been place in the development and use of the habitat type classification. However, by using ecological sites, a consistent framework is provided for classification and description of all terrestrial ecosystems. This project demonstrates the importance and utility of using ecological sites as a consistent classification system in the inherent ecosystem diversity present in a landscape.

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APPENDIX A

Table A-1. Plant species that are commonly associated with the Hot-Dry forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Achillea millefolium	common yarrow	ACMI2	Forb	I
Agoseris glauca	pale agoseris	AGGL	Forb	na
Allium cernuum	nodding onion	ALCE2	Forb	na
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	Shrub	I
Anemone multifida	Pacific anemone	ANMU	Forb	na
Antennaria howellii	Howell's pussytoes	ANHOH	Forb	na
Antennaria luzuloides	rush pussytoes	ANLU2	Forb	na
Antennaria microphylla	littleleaf pussytoes	ANMI3	Forb	D
Antennaria rosea	rosy pussytoes	ANRO2	Forb	NC or I
Apocynum androsaemifolium	spreading dogbane	APAN2	Forb	I
Arabis holboellii	Holboell's rockcress	ARHO2	Forb	NC
Arenaria congesta	ballhead sandwort	ARCO5	Forb	D or NC
Artemisia frigida	prairie sagewort	ARFR4	Shrub	NC or I
Artemisia ludoviciana	white sagebrush	ARLU	Shrub	D
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	Shrub	D
Artemisia tridentata	mountain big sagebrush	ARTRV	Shrub	D
Aster spp.	aster spp.	ASTER	Forb	I
Astragalus miser	timber milkvetch	ASMI9	Forb	I
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	Forb	I
Berberis repens	Oregon grape	BERE	Shrub	NC or I
Campanula rotundifolia	harebell	CARO2	Forb	na
Carex geyeri	Geyer's sedge	CAGE2	Sedge	I
Carex rossi	Ross's sedge	CARO5	Sedge	I
Castilleja hispida	harsh Indian paintbrush	CAHI9	Forb	NC or I
Cerastium arvense	field chickweed	CEAR4	Forb	na
Collinsia parviflora	maiden blue eyed Mary	COPA3	Forb	I
Collomia linearis	narrowleaf mountain trumpet	COLI2	Forb	na
Crepis acuminata	tapertip hawksbeard	CRAC2	Forb	na
Crepis atribarba	slender hawksbeard	CRATO	Forb	na
Cystopteris fragilis	brittle bladderfern	CYFR2	Fern	na
Epilobium brachycarpum	tall annual willowherb	EPBR3	Forb	I
Erigeron caespitosus	tufted fleabane	ERCA2	Forb	na
Erigeron divergens	spreading fleabane	ERDI4	Forb	na
Eriogonum umbellatum	buckwheat	ERUM	Forb	na
Festuca campestris	rough fescue	FECA4	Grass	D
Festuca idahoensis	Idaho fescue	FEID	Grass	D or NC
Fragaria virginiana	Virginia strawberry	FRVI	Forb	NC or I
Gaillardia aristata	common gaillardia	GAAR	Forb	I
Galium boreale	northern bedstraw	GABO2	Forb	NC or I
Geum triflorum	prairie smoke	GETR	Forb	NC or I
Gutierrezia sarothrae	broom snakeweed	GUSA2	Shrub	D or NC

Table A-1. Plant species that are commonly associated with the Hot-Dry forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Hedysarum occidentale	western sweetvetch	HEOC	Forb	I
Hesperostipa comata	needleandthread	HECO26	Grass	NC or I
Heterotheca villosa	hairy false goldenaster	HEVI4	Forb	na
Hieracium cynoglossoides	houndstongue hawkweed	HICY	Forb	D or NC
Juniperus communis	common juniper	JUCO6	Shrub	D
Juniperus scopulorum	Rocky Mountain Juniper	JUSC2	Tree	D or NC
Koeleria macrantha	prairie Junegrass	KOMA	Grass	I
Lithospermum ruderale	western stoneseed	LIRU4	Forb	na
Lomatium triternatum	nineleaf biscuitroot	LOTR2	Forb	na
Lupinus spp.	Lupine species	LUPIN	Forb	NC or I
Packera cana	woolly groundsel	PACA15	Forb	D or I
Penstemon albertinus	Alberta beardtongue	PEAL11	Forb	NC or I
Penstemon wilcoxii	Wilcox's penstemon	PEWI	Forb	NC or I
Phacelia linearis	threadleaf phacelia	PHLI	Forb	na
Philadelphus lewisii	Lewis's mock orange	PHLE4	Shrub	I
Physocarpus malviceus	mallow ninebark	PHMA5	Shrub	D or NC
Pinus ponderosa	ponderosa pine	PIPO	Tree	I
Poa nervosa	Wheeler bluegrass	PONE2	Grass	I
Polygonum douglasii	Douglas' knotweed	PODO4	Forb	na
Prunus virginiana	chokecherry	PRVI	Shrub	I
Pseudoroegneria spicata	bluebunch wheatgrass	PSSPS	Grass	VAR
Pseudotsuga menziesii	douglas-fir	PSME	Tree	VAR
Pulsatilla patens	cutleaf anemone	PUPAM	Forb	na
Purshia tridentata	Antelope bitterbrush	PUTR2	Shrub	D
Rhus trilobata	skunkbush sumac	RHTR	Shrub	I
Ribes cereum	wax currant	RICE	Shrub	NC or I
Rosa woodsii	Wood's rose	ROWO	Shrub	VAR
Sedum stenopetalum	wormleaf stonecrop	SEST2	Forb	na
Shepherdia canadensis	russet buffaloberry	SHCA	Shrub	NC or I
Solidago missouriensis	Missouri goldenrod	SOMI2	Forb	I
Spiraea betulifolia	white spiraea	SPBE2	Shrub	I
Symphoricarpos albus	common snowberry	SYAL	Shrub	NC or I
Symphoricarpos oreophilus	mountain snowberry	SYOC	Shrub	NC
Zigadenus elegans	Mountain deathcamas	ZIEL2	Forb	VAR

[a] From the USDA PLANTS database

[b] D=Decreases, I=Increases, NC=No change, VAR=Variable response depending on conditions, na= information not available

[c] Fischer and Bradley 1987, FEIS Database, and other sources

Table A-2. Plant species that are commonly associated with the Warm-Dry forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Achillea millefolium	common yarrow	ACMI2	Forb	I
Allium cernuum	nodding onion	ALCE2	Forb	na
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	Shrub	I
Antennaria racemosa	raceme pussytoes	ANRA	Forb	D
Antennaria rosea	rosy pussytoes	ANRO2	Forb	NC or I
Apocynum androsaemifolium	spreading dogbane	APAN2	Forb	I
Arabis holboellii	Holboell's rockcress	ARHO2	Forb	NC
Arctostaphylos uva-ursi	kinnikinnick	ARUV	Shrub	D or NC
Arenaria congesta	ballhead sandwort	ARCO5	Forb	D or NC
Arnica cordifolia	heartleaf arnica	ARCO9	Forb	I
Aster spp.	aster spp.	ASTER	Forb	I
Astragalus miser	timber milkvetch	ASMI9	Forb	I
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	Forb	I
Berberis repens	Oregon grape	BERE	Shrub	NC or I
Calamagrostis rubescens	pinegrass	CARU	Grass	NC or I
Campanula rotundifolia	harebell	CARO2	Forb	na
Carex concinnoides	northwestern sedge	CACO11	Sedge	NC
Carex geyeri	Geyer's sedge	CAGE2	Sedge	I
Carex rossi	Ross's sedge	CARO5	Sedge	I
Ceanothus velutinus	snowbrush ceanothus	CEVE	Shrub	I
Chamerion angustifolium	fireweed	CHANA2	Forb	I
Clematis columbiana	rock clematis	CLPS2	Forb	na
Collinsia parviflora	maiden blue eyed Mary	COPA3	Forb	I
Collomia linearis	narrowleaf mountain trumpet	COLI2	Forb	na
Dasiphora fruticosa	shrubby cinquefoil	DAFR6	Shrub	VAR
Dodecatheon conjugens	Bonneville shootingstar	DOCO	Forb	I
Erigeron speciosus	aspen fleabane	ERSP4	Forb	na
Erythronium grandiflorum	yellow avalance-lily	ERGR9	Forb	na
Festuca campestris	rough fescue	FECA4	Grass	D
Festuca idahoensis	Idaho fescue	FEID	Grass	D or NC
Festuca occidentalis	western fescue	FEOC	Grass	D
Fragaria vesca	woodland strawberry	FRVE	Forb	NC or I
Fragaria virginiana	Virginia strawberry	FRVI	Forb	NC or I
Gaillardia aristata	common gaillardia	GAAR	Forb	I
Galium boreale	northern bedstraw	GABO2	Forb	NC or I
Geranium viscosissimum	sticky purple geranium	GEVI2	Forb	I
Geum triflorum	prairie smoke	GETR	Forb	NC or I
Goodyera oblongifolia	western rattlesnake plantain	GOOB2	Forb	D
Hedysarum occidentale	western sweetvetch	HEOC	Forb	I
Hedysarum sulphurescens	white sweetvetch	HESU	Forb	I
Heuchera cylindrica	roundleaf alumroot	HECY2	Forb	na
Hieracium albiflorum	white hawkweed	HIAL2	Forb	D
Hieracium scouleri	Scouler's woollyweed	HISCA	Forb	na
Holodiscus discolor	oceanspray	HODI	Shrub	I
Juniperus communis	common juniper	JUCO6	Shrub	D
Juniperus scopulorum	Rocky Mountain Juniper	JUSC2	Tree	D or NC

Table A-2. Plant species that are commonly associated with the Warm-Dry forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Koeleria macrantha	prairie Junegrass	KOMA	Grass	I
Lithospermum ruderale	western stoneseed	LIRU4	Forb	na
Lomatium triternatum	nineleaf biscuitroot	LOTR2	Forb	na
Lupinus spp.	Lupine species	LUPIN	Forb	NC or I
Maianthemum racemosum	feathery false lily of the valley	MARAA	Forb	NC
Maianthemum stellatum	starry false lily of the valley	MAST4	Forb	NC or I
Orthilia secunda	sidebells wintergreen	ORSE	Forb	D
Osmorhiza berteroi	sweetcicely	OSBE	Forb	I
Penstemon albertinus	Alberta beardtongue	PEAL11	Forb	NC or I
Physocarpus malviceus	mallow ninebark	PHMA5	Shrub	D or NC
Pinus contorta	lodgepole pine	PICO	Tree	VAR
Pinus monticola	western white pine	PIMO	Tree	VAR
Pinus ponderosa	ponderosa pine	PIPO	Tree	I
Poa nervosa	Wheeler bluegrass	PONE2	Grass	I
Populus tremuloides	quaking aspen	POTR5	Tree	I
Potentilla glandulosa	sticky purple cinquefoil	POGL9	Forb	NC or I
Prosartes trachycarpa	roughfruit fairybells	PRTR4	Forb	na
Pseudoroegneria spicata	bluebunch wheatgrass	PSSPS	Grass	VAR
Pseudotsuga menziesii	Douglas-fir	PSME	Tree	VAR
Ribes viscosissimum	sticky currant	RIVI3	Shrub	I
Rosa acicularis	prickly rose	ROAC	Shrub	NC or I
Rosa bridgesii	pygmy rose	ROBR3	Shrub	NC or I
Rosa woodsii	Wood's rose	ROWO	Shrub	VAR
Rubus parviflorus	thimbleberry	RUPA	Shrub	I
Salix scouleriana	Scouler's willow	SASC	Shrub	I
Sedum stenopetalum	wormleaf stonecrop	SEST2	Forb	na
Shepherdia canadensis	russet buffaloberry	SHCA	Shrub	NC or I
Solidago missouriensis	Missouri goldenrod	SOMI2	Forb	I
Spiraea betulifolia	white spiraea	SPBE2	Shrub	I
Symphoricarpos albus	common snowberry	SYAL	Shrub	NC or I
Thalictrum occidentale	western meadow-rue	THOC	Forb	D
Valeriana dioica	marsh valerian	VADI	Forb	na
Zigadenus elegans	Mountain deathcamas	ZIEL2	Forb	VAR

[a] From the USDA PLANTS database

[b] D=Decreases, I=Increases, NC=No change, VAR=Variable response depending on conditions, na= information not available

[c] Fischer and Bradley 1987, FEIS Database, and other sources

Table A-3. Plant species that are commonly associated with the Warm-Moist forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity.
(Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Abies lasiocarpa	subalpine fir	ABLA	Tree	D
Acer glabrum	Rocky Mountain maple	ACGL	Shrub	I
Achillea millefolium	common yarrow	ACMI2	Forb	I
Allium cernuum	nodding onion	ALCE2	Forb	na
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	Shrub	I
Antennaria howellii	Howell's pussytoes	ANHOH	Forb	na
Antennaria racemosa	raceme pussytoes	ANRA	Forb	D
Apocynum androsaemifolium	spreading dogbane	APAN2	Forb	I
Arctostaphylos uva-ursi	kinnikinnick	ARUV	Shrub	D or NC
Arnica cordifolia	heartleaf arnica	ARCO9	Forb	I
Arnica latifolia	broadleaf arnica	ARLA8	Forb	I
Aster spp.	aster spp.	ASTER	Forb	I
Astragalus miser	timber milkvetch	ASMI9	Forb	I
Berberis repens	Oregon grape	BERE	Shrub	NC or I
Calachortus apiculatus	poineted tip mariposa lily	CAAP	Forb	NC or I
Calamagrostis rubescens	pinegrass	CARU	Grass	NC or I
Campanula rotundifolia	harebell	CARO2	Forb	na
Carex concinnoides	northwestern sedge	CACO11	Sedge	NC
Carex geyeri	Geyer's sedge	CAGE2	Sedge	I
Ceanothus velutinus	snowbrush ceanothus	CEVE	Shrub	I
Chamerion angustifolium	fireweed	CHANA2	Forb	I
Chimaphila umbellata	pipsissewa	CHUM	Forb	NC
Clematis columbiana	rock clematis	CLPS2	Forb	na
Collinsia parviflora	maiden blue eyed Mary	COPA3	Forb	I
Dasiphora fruticosa	shrubby cinquefoil	DAFR6	Shrub	VAR
Elymus glaucus	blue wildrye	ELGL	Grass	NC
Erythronium grandiflorum	yellow avalance-lily	ERGR9	Forb	na
Festuca idahoensis	Idaho fescue	FEID	Grass	D or NC
Festuca occidentalis	western fescue	FEOC	Grass	D
Fragaria vesca	woodland strawberry	FRVE	Forb	NC or I
Fragaria virginiana	Virginia strawberry	FRVI	Forb	NC or I
Galium boreale	northern bedstraw	GABO2	Forb	NC or I
Goodyera oblongifolia	western rattlesnake plantain	GOOB2	Forb	D
Hedysarum sulphurescens	white sweetvetch	HESU	Forb	I
Heuchera cylindrica	roundleaf alumroot	HECY2	Forb	na
Hieracium albiflorum	white hawkweed	HIAL2	Forb	D
Hieracium scouleri	Scouler's woollyweed	HISCA	Forb	na
Holodiscus discolor	oceanspray	HODI	Shrub	I
Juniperus communis	common juniper	JUCO6	Shrub	D
Larix occidentalis	western larch	LAOC	Tree	I
Linnaea borealis	twinflower	LIBO3	Shrub	D or NC
Lupinus sericeus	silky lupine	LUSE4	Forb	NC or I

Table A-3. Plant species that are commonly associated with the Warm-Moist forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Lupinus spp.	Lupine species	LUPIN	Forb	NC or I
Maianthemum racemosum	feathery false lily of the valley	MARAA	Forb	NC
Maianthemum stellatum	starry false lily of the valley	MAST4	Forb	D
Orthilia secunda	sidebells wintergreen	ORSE	Forb	D
Osmorhiza berteroi	sweetcicely	OSBE	Forb	I
Pachistima myrsinites	Oregon boxleaf	PAMY	Shrub	NC or I
Physocarpus malviceus	mallow ninebark	PHMA5	Shrub	D or NC
Pinus contorta	lodgepole pine	PICO	Tree	VAR
Pinus ponderosa	ponderosa pine	PIPO	Tree	I
Piperia elegans	elegant piperia	PIELE4	Forb	na
Populus tremuloides	quaking aspen	POTR5	Tree	I
Prosartes trachycarpa	roughfruit fairybells	PRTR4	Forb	na
Pseudotsuga menziesii	douglas-fir	PSME	Tree	VAR
Ribes viscosissimum	sticky currant	RIVI3	Shrub	I
Rosa acicularis	prickly rose	ROAC	Shrub	NC or I
Rosa bridgesii	pygmy rose	ROBR3	Shrub	NC or I
Rosa woodsii	Wood's rose	ROWO	Shrub	VAR
Rubus parviflorus	thimbleberry	RUPA	Shrub	I
Salix scouleriana	Scouler's willow	SASC	Shrub	I
Shepherdia canadensis	russet buffaloberry	SHCA	Shrub	NC or I
Silene menziesii	Menzie's campion	SIME	Forb	na
Spiraea betulifolia	white spiraea	SPBE2	Shrub	I
Symphoricarpos albus	common snowberry	SYAL	Shrub	NC or I
Thalictrum occidentale	western meadow-rue	THOC	Forb	D
Vaccinium cespitosum	dwarf bilberry	VACE	Forb	NC or I
Vaccinium membranaceum	thinleaf huckleberry	VAME	Shrub	D or NC
Vaccinium scoparium	grouse whortleberry	VASC	Shrub	D or NC
Valeriana dioica	marsh valerian	VADI	Forb	na
Viola adunca	hookedspur violet	VIAD	Forb	I
Xerophyllum tenax	common beargrass	XETE	Forb	VAR

[a] From the USDA PLANTS database

[b] D=Decreases, I=Increases, NC=No change, VAR=Variable response depending on conditions,
na= information not available

[c] Fischer and Bradley 1987, FEIS Database, and other sources

Table A-4. Plant species that are commonly associated with the Cool-Dry forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Abies grandis	grand fir	ABGR	Tree	D
Abies lasiocarpa	subalpine fir	ABLA	Tree	D
Acer glabrum	Rocky Mountain maple	ACGL	Shrub	I
Alnus viridis spp sinuata	Sitka alder	ALVIS	Shrub	I
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	Shrub	I
Antennaria racemosa	raceme pussytoes	ANRA	Forb	D
Arctostaphylos uva-ursi	kinnikinnick	ARUV	Shrub	D or NC
Arnica cordifolia	heartleaf arnica	ARCO9	Forb	I
Arnica latifolia	broadleaf arnica	ARLA8	Forb	I
Aster spp.	aster spp.	ASTER	Forb	I
Berberis repens	Oregon grape	BERE	Shrub	NC or I
Calamagrostis rubescens	pinegrass	CARU	Grass	NC or I
Campanula rotundifolia	harebell	CARO2	Forb	na
Carex concinnoides	northwestern sedge	CACO11	Sedge	NC
Carex geyeri	Geyer's sedge	CAGE2	Sedge	I
Chamerion angustifolium	fireweed	CHANA2	Forb	I
Chimaphila umbellata	pipsissewa	CHUM	Forb	NC
Clematis columbiana	rock clematis	CLPS2	Forb	na
Erythronium grandiflorum	yellow avalance-lily	ERGR9	Forb	na
Fragaria vesca	woodland strawberry	FRVE	Forb	NC or I
Fragaria virginiana	Virginia strawberry	FRVI	Forb	NC or I
Galium boreale	northern bedstraw	GABO2	Forb	NC or I
Galium triflorum	fragrant bedstraw	GATR3	Forb	NC or I
Goodyera oblongifolia	western rattlesnake plantain	GOOB2	Forb	D
Hieracium albiflorum	white hawkweed	HIAL2	Forb	D
Juniperus communis	common juniper	JUCO6	Shrub	D
Larix occidentalis	western larch	LAOC	Tree	I
Linnaea borealis	twinflower	LIBO3	Shrub	D
Lonicera utahensis	Utah honeysuckle	LOUT2	Shrub	D
Lupinus spp.	Lupine species	LUPIN	Forb	NC or I
Luzula glabrata	Hitchcock's smooth woodrush	LUGL2	Forb	I
Menziesia ferruginea	rusty menziesia	MEFE	Shrub	D
Orthilia secunda	sidebells wintergreen	ORSE	Forb	D
Osmorhiza berteroi	sweetcicely	OSBE	Forb	I
Pachistima myrsinites	Oregon boxleaf	PAMY	Shrub	NC or I
Picea engelmannii	Engelmann spruce	PIENE	Tree	D
Pinus albicaulis	whitebark pine	PIAL	Tree	I
Pinus contorta	lodgepole pine	PICO	Tree	VAR
Pinus monticola	western white pine	PIMO	Tree	VAR

Table A-4. Plant species that are commonly associated with the Cool-Dry forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Pinus ponderosa	ponderosa pine	PIPO	Tree	I
Pseudotsuga menziesii	douglas-fir	PSME	Tree	VAR
Pyrola chlorantha	greenflowered wintergreen	PYCH	Forb	na
Ribes lacustre	prickly currant	RILA	Shrub	I
Ribes viscosissimum	sticky currant	RIVI3	Shrub	I
Rosa acicularis	prickly rose	ROAC	Shrub	NC or I
Rosa bridgesii	pygmy rose	ROBR3	Shrub	NC or I
Rubus parviflorus	thimbleberry	RUPA	Shrub	I
Salix scouleriana	Scouler's willow	SASC	Shrub	I
Sambucus racemosa	red elderberry	SARA2	Shrub	NC
Shepherdia canadensis	russet buffaloberry	SHCA	Shrub	NC or I
Sorbus scopulina	Greene's mountain ash	SOSCS	Tree	na
Spiraea betulifolia	white spiraea	SPBE2	Shrub	I
Vaccinium cespitosum	dwarf bilberry	VACE	Forb	NC or I
Vaccinium membranaceum	thinleaf huckleberry	VAME	Shrub	D or NC
Vaccinium myrtillus	whortleberry	VAMY2	Shrub	NC or I
Vaccinium scoparium	grouse whortleberry	VASC	Shrub	D or NC

[a] From the USDA PLANTS database

[b] D=Decreases, I=Increases, NC=No change, VAR=Variable response depending on conditions, na= information not available

[c] Fischer and Bradley 1987, FEIS Database, and other sources

Table A-5. Plant species that are commonly associated with the Cool-Moist forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Abies grandis	grand fir	ABGR	Tree	D
Abies lasiocarpa	subalpine fir	ABLA	Tree	D
Acer glabrum	Rocky Mountain maple	ACGL	Shrub	I
Actaea rubra	red baneberry	ACRU2	Forb	NC
Adenocaulon bicolor	American trailplant	ADBI	Forb	D or NC
Alnus viridis spp sinuata	Sitka alder	ALVIS	Shrub	I
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	Shrub	I
Anemone piperi	Piper's anemone	ANPI	Forb	na
Antennaria racemosa	raceme pussytoes	ANRA	Forb	D
Aralia nudicualis	wild sarsaparilla	ARNU2	Forb	NC
Arctostaphylos uva-ursi	kinnikinnick	ARUV	Shrub	D or NC
Arnica cordifolia	heartleaf arnica	ARCO9	Forb	I
Arnica latifolia	broadleaf arnica	ARLA8	Forb	I
Aster spp.	aster spp.	ASTER	Forb	I
Athyrium filix-femina	common ladyfern	ATFI	Fern	NC
Berberis repens	Oregon grape	BERE	Shrub	NC or I
Bromus vulgaris	Columbia brome	BRVU	Grass	D or NC
Calamagrostis rubescens	pinegrass	CARU	Grass	NC or I
Carex concinnoides	northwestern sedge	CACO11	Sedge	NC
Carex geyeri	Geyer's sedge	CAGE2	Sedge	I
Chamerion angustifolium	fireweed	CHANA2	Forb	I
Chimaphila umbellata	pipsissewa	CHUM	Forb	NC
Clematis columbiana	rock clematis	CLPS2	Forb	na
Clintonia uniflora	bride's bonnet	CLUN2	Forb	D
Cornus canadensis	bunchberry dogwood	COCA13	Shrub	NC
Cornus sericea	redosier dogwood	COSE16	Shrub	NC
Elymus glaucus	blue wildrye	ELGL	Grass	NC
Festuca occidentalis	western fescue	FEOC	Grass	D
Fragaria vesca	woodland strawberry	FRVE	Forb	NC or I
Fragaria virginiana	Virginia strawberry	FRVI	Forb	NC or I
Galium boreale	northern bedstraw	GABO2	Forb	NC or I
Galium triflorum	fragrant bedstraw	GATR3	Forb	NC or I
Goodyera oblongifolia	western rattlesnake plantain	GOOB2	Forb	D
Gymnocarpium dryopteris	western oakfern	GYDR	Fern	NC
Hieracium albiflorum	white hawkweed	HIAL2	Forb	D
Juniperus communis	common juniper	JUCO6	Shrub	D
Larix occidentalis	western larch	LAOC	Tree	I
Linnaea borealis	twinflower	LIBO3	Shrub	D
Listera caurina	northwestern twayblade	LICA10	Forb	na
Listera cordata	heartleaf twayblade	LICO6	Forb	na
Lonicera utahensis	Utah honeysuckle	LOUT2	Shrub	D
Lupinus spp.	Lupine species	LUPIN	Forb	NC or I
Maianthemum racemosum	feathery false lily of the valley	MARAA	Forb	NC
Maianthemum stellatum	starry false lily of the valley	MAST4	Forb	D
Melica subulata	Alaska oniongrass	MESU	Grass	NC or I
Menziesia ferruginea	rusty menziesia	MEFE	Shrub	D

Table A-5. Plant species that are commonly associated with the Cool-Moist forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Orthilia secunda	sidebells wintergreen	ORSE	Forb	D
Oryzopsis asperifolia	roughleaf ricegrass	ORAS	Grass	na
Osmorhiza berteroi	sweetcicely	OSBE	Forb	I
Pachistima myrsinites	Oregon boxleaf	PAMY	Shrub	NC or I
Pedicularis racemosa	sickletop lousewort	PERA	Forb	na
Picea engelmannii	Engelmann spruce	PIENE	Tree	D
Pinus albicaulis	whitebark pine	PIAL	Tree	I
Pinus contorta	lodgepole pine	PICO	Tree	D
Pinus monticola	western white pine	PIMO	Tree	VAR
Prosartes hookeri	Oregon drops of gold	PRHOO	Forb	na
Prosartes trachycarpa	roughfruit fairybells	PRTR4	Forb	na
Pseudotsuga menziesii	douglas-fir	PSME	Tree	VAR
Pteridium aquilinum	western brackenfern	PTAQ	Fern	I
Pyrola asarifolia	liverleaf wintergreen	PYAS	Forb	NC
Ribes lacustre	prickly currant	RILA	Shrub	I
Ribes viscosissimum	sticky currant	RIVI3	Shrub	I
Rosa acicularis	prickly rose	ROAC	Shrub	NC or I
Rosa bridgesii	pygmy rose	ROBR3	Shrub	NC or I
Rubus parviflorus	thimbleberry	RUPA	Shrub	I
Salix scouleriana	Scouler's willow	SASC	Shrub	I
Sambucus racemosa	red elderberry	SARA2	Shrub	NCI
Shepherdia canadensis	russet buffaloberry	SHCA	Shrub	NC or I
Sorbus scopulina	Greene's mountain ash	SOSCS	Tree	
Spiraea betulifolia	white spiraea	SPBE2	Shrub	I
Streptopus amplexifolius	claspleaf twistedstalk	STAM2	Forb	D
Symphoricarpos albus	common snowberry	SYAL	Shrub	NC or I
Taxus brevifolia	Pacific yew	TABR2	Shrub	D
Thalictrum occidentale	western meadow-rue	THOC	Forb	D
Tiarella trifoliata	threeleaf foamflower	TITR	Forb	NC
Trillium ovatum	Pacific trillium	TROV2	Forb	na
Vaccinium cespitosum	dwarf bilberry	VACE	Forb	NC
Vaccinium membranaceum	thinleaf huckleberry	VAME	Shrub	D or NC
Vaccinium scoparium	grouse whortleberry	VASC	Shrub	D or NC
Viola orbiculata	darkwoods violet	VIOR	Forb	D
Xerophyllum tenax	common beargrass	XETE	Forb	VAR

[a] From the USDA PLANTS database

[b] D=Decreases, I=Increases, NC=No change, VAR=Variable response depending on conditions, na= information not available

[c] Fischer and Bradley 1987, FEIS Database, and other sources

Table A-6. Plant species that are commonly associated with the Cold-Dry forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Abies lasiocarpa	subalpine fir	ABLA	Tree	D
Achillea millefolium	common yarrow	ACMI2	Forb	I
Agoseris glauca	pale agoseris	AGGL	Forb	na
Antennaria lanata	woolly pussytoes	ANLA3	Forb	na
Antennaria rosea	rosy pussytoes	ANRO2	Forb	NC or I
Arenaria congesta	ballhead sandwort	ARCO5	Forb	D or NC
Arnica cordifolia	heartleaf arnica	ARCO9	Forb	I
Arnica latifolia	broadleaf arnica	ARLA8	Forb	I
Astragalus miser	timber milkvetch	ASMI9	Forb	I
Carex geyeri	Geyer's sedge	CAGE2	Sedge	I
Carex nigricans	black alpine sedge	CANI2	Sedge	na
Carex paysonis	Payson's sedge	CAPA31	Sedge	na
Carex rossi	Ross's sedge	CARO5	Sedge	I
Juncus parryi	Parry's rush	JUPA	Grass	NC
Juniperus communis	common juniper	JUCO6	Shrub	D
Larix lyallii	subalpine larch	LALY	Tree	I
Ledum glandulosum	western Labrador tea	LEGL	Shrub	na
Lupinus spp.	Lupine species	LUPIN	Forb	NC or I
Luzula glabrata	Hitchcock's smooth woodrush	LUGL2	Forb	I
Phyllodoce empetriformis	pink mountainheath	PHEM	Forb	I
Picea engelmannii	Engelmann spruce	PIENE	Tree	D
Pinus albicaulis	whitebark pine	PIAL	Tree	I
Poa nervosa	Wheeler bluegrass	PONE2	Grass	I
Vaccinium scoparium	grouse whortleberry	VASC	Shrub	D or NC

[a] From the USDA PLANTS database

[b] D=Decreases, I=Increases, NC=No change, VAR=Variable response depending on conditions, na= information not available

[c] Fischer and Bradley 1987, FEIS Database, and other sources

Table A-7. Plant species that are commonly associated with the Cold-Moist forest ecological site of the Blackfoot watershed and their expected post-fire response to light to moderate fire severity. (Plant species list developed from Pfister et al. 1977).

Scientific name	Common name	PLANTS Code[a]	Growth Form	Response to Fire[b,c]
Abies lasiocarpa	subalpine fir	ABLA	Tree	D
Achillea millefolium	common yarrow	ACMI2	Forb	I
Agoseris glauca	pale agoseris	AGGL	Forb	na
Antennaria racemosa	raceme pussytoes	ANRA	Forb	D
Arnica cordifolia	heartleaf arnica	ARCO9	Forb	I
Arnica latifolia	broadleaf arnica	ARLA8	Forb	I
Carex geyeri	Geyer's sedge	CAGE2	Sedge	I
Carex rossi	Ross's sedge	CARO5	Sedge	I
Chamerion angustifolium	fireweed	CHANA2	Forb	I
Elymus glaucus	blue wildrye	ELGL	Grass	NC
Erigeron peregrinus	subalpine fleabane	ERPE3	Forb	na
Erythronium grandiflorum	yellow avalance-lily	ERGR9	Forb	na
Fragaria virginiana	Virginia strawberry	FRVI	Forb	NC or I
Goodyera oblongifolia	western rattlesnake plantain	GOOB2	Forb	D
Hieracium gracile	slender hawkweed	HIGRG	Forb	na
Larix lyallii	subalpine larch	LALY	Tree	I
Lupinus spp.	Lupine species	LUPIN	Forb	NC or I
Luzula glabrata	Hitchcock's smooth woodrush	LUGL2	Forb	I
Menziesia ferruginea	rusty menziesia	MEFE	Shrub	D
Orthilia secunda	sidebells wintergreen	ORSE	Forb	D
Pedicularis bracteosa	bracted lousewort	PEBR	Forb	na
Pedicularis contorta	coiled lousewort	PECO	Forb	na
Penstemon albertinus	Alberta beardtongue	PEAL11	Forb	NC or I
Phyllodoce empetriformis	pink mountainheath	PHEM	Forb	I
Picea engelmannii	Engelmann spruce	PIENE	Tree	D
Pinus albicaulis	whitebark pine	PIAL	Tree	I
Pinus contorta	lodgepole pine	PICO	Tree	D
Poa nervosa	Wheeler bluegrass	PONE2	Grass	I
Senecio triangularis	arrowleaf ragwort	SETR	Forb	I
Thalictrum occidentale	western meadow-rue	THOC	Forb	D
Vaccinium membranaceum	thinleaf huckleberry	VAME	Shrub	D or NC
Vaccinium myrtillus	whortleberry	VAMY2	Shrub	NC or I
Vaccinium scoparium	grouse whortleberry	VASC	Shrub	D or NC
Valeriana sitchensis	Sitka valerian	VASI	Forb	na
Veratrum viride	green false hellebore	VEVI	Forb	na
Viola orbiculata	darkwoods violet	VIOR	Forb	D
Xerophyllum tenax	common beargrass	XETE	Forb	VAR

[a] From the USDA PLANTS database

[b] D=Decreases, I=Increases, NC=No change, VAR=Variable response depending on conditions, na= information not available

[c] Fischer and Bradley 1987, FEIS Database, and other sources

APPENDIX B

Appendix B-1. Plant list for the Hot-Droughty grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Achillea millefolium	common yarrow	ACMI2	forb	I	I
Achnatherum hymenoides	Indian ricegrass	ACHY	grass	D	NC
Achnatherum nelsonii	Columbia needlegrass	ACNE9	grass	D	NC or I
Agoseris glauca	pale agoseris	AGGL	forb	I	na
Antennaria rosea	rosy pussytoes	ANRO2	forb	I	NC
Arenaria congesta	ballhead sandwort	ARCO5	forb	I	D
Aristida purpurea	red threeawn	ARPU9	grass	I	D
Arnica sororia Greene	twin arnica	ARSO2	forb	I	D
Artemisia dracunculus	green sagewort	ARDR4	forb	I	D
Artemisia frigida	prairie sagewort	ARFR4	shrub	I	D
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	shrub	I	D
Artemisia tridentata spp. Vaseyana	mountain big sagebrush	ARTRV	shrub	I	D
Aster spp.	aster spp.	ASTER	forb	I	I
Astragalus spp.	milkvetch	ASTRA	forb	I	I
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	forb	I	I
Bouteloua gracilis	blue grama	BOGR2	grass	I	I
Calochortus gunnisonii	Gunnison's mariposa lily	CAGU	forb	na	na
Carex filifolia	threadleaf sedge	CAFI	sedge	I	VAR
Carex spp.	sedge spp.	CAREX	sedge	-	-
Cerastium arvense	field chickweed	CEAR4	forb	I	na
Chrysothamnus viscidiflorus	yellow rabbitbrush	CHVI8	shrub	I	I
Comandra umbellata	bastard toadflax	COUM	forb	I	NC
Dalia spp.	prairie clover	DALEA	forb	D	I
Danthonia intermedia	timber oatgrass	DAIN	grass	I	I
Elymus lanceolatus	thickspike wheatgrass	ELLA3	shrub	I	D
Ericameria nauseosa	rubber rabbitbrush	ERNA10	forb	I	D or NC
Erigeron spp.	fleabane spp.	ERIGE2	forb	I	D
Eriogonum umbellatum	sulfur-flower buckwheat	ERUM	forb	I	I
Festuca campestris	rough fescue	FECA4	grass	D	D
Festuca idahoensis	Idaho fescue	FEID	grass	I	D
Gaillardia aristata	common gaillardia	GAAR	forb	I	D or NC
Geum triflorum	prairie smoke	GETR	shrub	I	D
Gutierrezia sarothrae	broom snakeweed	GUSA2	grass	I	I
Hesperostipa comata	needleandthread	HECO26	forb	I	na
Heterotheca villosa	hairy false goldenaster	HEVI4	tree	I	D
Juniperus scopulorum	Rocky Mountain Juniper	JUSC2	grass	I	I
Koeleria macrantha	prairie Junegrass	KOMA	shrub	D	D
Krascheninnikovia lanata	winterfat	KRLA2	forb	D	I
Liatris punctata	dotted blazing star	LIPU	forb	I	D
Lithospermum ruderale	western stoneseed	LIRU4	forb	I	NC or I
Lomatium macrocarpum	bigseed biscuitroot	LOMA3	grass	D	VAR

Appendix B-1. Plant list for the Hot-Droughty grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Lupinus spp.	Lupine species	LUPIN	forb	I	NC or I
Nassella viridula	green needlegrass	NAVI4	cactus	I	D
Opuntia polyacantha	plains pricklypear	OPPO	forb	I	na
Orthocarpus tenuifolius	thinleaved owl's-clover	ORTE2	grass	I	I
Pascopyrum smithii	western wheatgrass	PASM	forb	I	I
Penstemon spp.	Penstemons	PENST	forb	I	D
Phlox hoodii	Hood's phlox	PHHO	forb	I	I
Plantago patagonica	woolly plantain	PLPA2	grass	I	I
Poa secunda	Sandberg bluegrass	POSE	grass	D	I
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	shrub	I	D
Purshia tridenta	bitterbrush	PUTR	shrub	I	I
Rhus trilobata	skunkbush sumac	RHTR	shrub	I	NC or I
Rosa woodsii	Wood's rose	ROWO	forb	I	NC or I
Sphaeralcea coccinea	scarlet globemallow	SPCO	shrub	I	I
Tetradymia canescens	spineless horsebrush	TECA2	forb	D	I
Vicia americana	American vetch	VIAM	forb	D	I

[a] *Source: USDA PLANTS Database*

[b] *I=increase, D=decrease, NC=no change, VAR=variable, and na=information not available*

Appendix B-2. Plant list for the Hot-Loamy grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Achillea millefolium	common yarrow	ACMI2	forb	I	I
Achnatherum nelsonii	Columbia needlegrass	ACNE9	grass	D	NC or I
Achnatherum hymenoides	Indian ricegrass	ACHY	grass	D	NC
Agoseris glauca	pale agoseris	AGGL	forb	I	na
Allium spp.	onion	ALLIU	forb	-	-
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	shrub	D	I
Antennaria rosea	rosy pussytoes	ANRO2	forb	I	NC
Arenaria congesta	ballhead sandwort	ARCO5	forb	I	D
Arnica sororia Greene	twin arnica	ARSO2	forb	I	D
Artemisia frigida	prairie sagewort	ARFR4	shrub	I	D
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	shrub	I	D
Tripartita	tree-tip sagebrush	ARTRT2	shrub	I	D
Astragalus spp.	milkvetch	ASTRA	forb	I	I
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	forb	I	I
Bouteloua gracilis	blue grama	BOGR2	grass	I	I
Calamagrostis rubescens	pinegrass	CARU	grass	I	I
Carex duriuscula	needleleaf sedge	CADU6	sedge	I	na
Carex filifolia	threadleaf sedge	CAFI	sedge	I	VAR
Carex spp.	sedge spp.	CAREX	sedge	-	-
Chrysothamnus viscidiflorus	yellow rabbitbrush	CHVI8	shrub	I	I
Collomia linearis	narrowleaf mountain trumpet	COLI2	forb	I	na
Comandra umbellata	bastard toadflax	COUM	forb	I	NC
Elymus lanceolatus	thickspike wheatgrass	ELLA3	grass	I	I
Ericameria nauseosa	rubber rabbitbrush	ERNA10	shrub	I	D
Erigeron pumilus	shaggy fleabane	ERPU2	forb	I	D or NC
Eriogonum microthecum	slender buckwheat	ERMI4	shrub	I	D
Festuca campestris	rough fescue	FECA4	grass	D	D
Festuca idahoensis	Idaho fescue	FEID	grass	I	D
Gaillardia aristata	common gaillardia	GAAR	forb	I	I
Geranium viscosissimum	sticky geranium	GEVI2	forb	D	I
Gutierrezia sarothrae	broom snakeweed	GUSA2	shrub	I	D
Hesperostipa comata	needleandthread	HECO26	grass	I	I
Heterotheca villosa	hairy false goldenaster	HEVI4	forb	I	na
Hieracium cynoglossoides	houndstongue hawkweed	HICY	forb	I	D or NC
Koeleria macrantha	prairie Junegrass	KOMA	grass	I	I
Krascheninnikovia lanata	winterfat	KRLA2	shrub	D	D
Lithospermum ruderale	western stoneseed	LIRU4	forb	I	D
Lomatium triternatum	nineleaf biscuitroot	LOTR2	forb	I	NC or I
Lupinus spp.	Lupine species	LUPIN	forb	I	NC or I
Nassella viridula	green needlegrass	NAVI4	grass	D	VAR
Opuntia polyacantha	plains pricklypear	OPPO	cactus	I	D
Pascopyrum smithii	western wheatgrass	PASM	grass	I	I

Appendix B-2. Plant list for the Hot-Loamy grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Penstemon spp.	Penstemons	PENST	forb	I	I
Phlox hoodii	Hood's phlox	PHHO	forb	I	D
Plantago patagonica	woolly plantain	PLPA2	forb	I	I
Poa secunda	Sandberg bluegrass	POSE	grass	I	I
Potentilla glandulosa	sticky cinquefoil	POGL9	forb	I	NC or I
Potentilla gracilis	slender cinquefoil	POGR9	forb	I	I
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	grass	D	I
Rosa woodsii	Wood's rose	ROWO	shrub	I	NC or I
Sphaeralcea coccinea	scarlet globemallow	SPCO	forb	I	NC or I
Stenotus acaulis	stemless mock goldenweed	STAC	forb	na	na
Symphoricarpos albus	common snowberry	SYAL	shrub	I	I
Tetradymia canescens	spineless horsebrush	TECA2	shrub	I	I
Triteleia grandiflora	largeflower triteleia	TRGR7	forb	D	I
Veronia spp.	ironweed spp.	VERNO	forb	-	-
Vicia americana	American vetch	VIAM	forb	D	I
Zigadenus venenosus	meadow deathcamas	ZIVE	forb	I	VAR

[a] *Source: USDA PLANTS Database*

[b] *I=increase, D=decrease, NC=no change, VAR=variable, and na=information not available*

Appendix B-3. Plant list for the Warm-Droughty grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Achillea millefolium	common yarrow	ACMI2	forb	I	I
Achnatherum nelsonii	Columbia needlegrass	ACNE9	grass	D	NC or I
Achnatherum richardsonii	Richardson's needlegrass	ACRI8	grass	D	D
Agoseris glauca	pale agoseris	AGGL	forb	I	na
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	shrub	D	I
Androsace septentrionalis	pygmyflower rockjasmine	ANSE4	forb	na	na
Antennaria luzuloides	rush pussytoes	ANLU2	forb	I	I
Antennaria rosea	rosy pussytoes	ANRO2	forb	I	NC
Apocynum androsaemifolium	spreading dogbane	APAN2	forb	I	I
Arabis holboellii	Holboell's rockcress	ARHO2	forb	na	na
Arenaria spp.	sandwort spp.	AREN	forb	-	-
Arnica sororia Greene	twin arnica	ARSO2	forb	I	D
Artemisia dracunculus	green sagewort	ARDR4	forb	I	D
Artemisia frigida	prairie sagewort	ARFR4	shrub	I	D
Artemisia ludoviciana	white sagebrush	ARLU	shrub	I	I
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	shrub	I	D
Artemisia tripartita spp.tripartita	tree-tip sagebrush	ARTRT2	shrub	I	D
Artemisia tridentata spp. vaseyana	mountain big sagebrush	ARTRV	shrub	I	D
Aster ericoides var. commutatus	white prairie aster	ASER	forb	I	I
Astragalus spp.	milkvetch	ASTRA	forb	I	I
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	forb	I	I
Besseya wyomingensis	Wyoming besseya	BEWY	forb	na	na
Calochortus apiculatus	pointed tip mariposa lily	CAAP	forb	na	na
Campanula rotundifolia	harebell	CARO2	forb	I	na
Carex filifolia	threadleaf sedge	CAFI	sedge	I	VAR
Carex spp.	sedge spp.	CAREX	sedge	-	-
Castilleja pallescens	pale Indian paintbrush	CAPA25	forb	I	I
Cerastium arvense	field chickweed	CEAR4	forb	I	na
Chrysothamnus viscidiflorus	yellow rabbitbrush	CHVI8	shrub	I	I
Collomia linearis	narrowleaf mountain trumpet	COLI2	forb	I	na
Comandra umbellata	bastard toadflax	COUM	forb	I	NC
Crepis intermedia	limestone hawksbeard	CRIN4	forb	D	na
Danthonia intermedia	timber oatgrass	DAIN	grass	I	I
Dodecatheon conjugens	Bonneville shootingstar	DOCO	forb	na	I
Elymus lanceolatus	thickspike wheatgrass	ELLA3	grass	I	I
Ericameria nauseosa	rubber rabbitbrush	ERNA10	shrub	I	D
Erigeron spp.	fleabane spp.	ERIGE2	forb	I	D or NC
Eriogonum heracleaoides	parsnipflower buckwheat	ERHE2	forb	I	D
Eriogonum umbellatum	sulfur-flower buckwheat	ERUM	forb	I	D
Festuca campestris	rough fescue	FECA4	grass	D	D
Festuca idahoensis	Idaho fescue	FEID	grass	I	D
Gaillardia aristata	common gaillardia	GAAR	forb	I	I
Galium boreale	northern bedstraw	GABO2	forb	I	NC or I

Appendix B-3. Plant list for the Warm-Droughty grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Geranium viscosissimum	sticky geranium	GEVI2	forb	D	I
Geum triflorum	prairie smoke	GETR	forb	I	D or NC
Hackelia spp.	stickseeds	HACKE	forb	-	-
Helianthus spp.	sunflowers	HELIA3	forb	-	-
Hesperostipa comata	needleandthread	HECO26	grass	I	I
Heterotheca villosa	hairy false goldenaster	HEVI4	forb	I	na
Heuchera cylindrica	roundleaf alumroot	HECY2	forb	I	na
Hieracium cynoglossoides	houndstongue hawkweed	HICY	forb	I	D or NC
Ipomopsis aggregata	scarlet gilia	IPAG	forb	na	I
Koeleria macrantha	prairie Junegrass	KOMA	grass	I	I
Lithospermum ruderale	western stoneseed	LIRU4	forb	I	D
Lomatium macrocarpum	bigseed biscuitroot	LOMA3	forb	I	NC or I
Lomatium triternatum	nineleaf biscuitroot	LOTR2	forb	I	NC or I
Lupinus sericeus	silky lupine	LUSE4	forb	I	NC or I
Lupinus spp.	Lupine species	LUPIN	forb	I	NC or I
Mahonia repens	creeping barberry	MARE11	shrub	I	I
Monarda fistulosa	horsemint	MOFI	forb	I	na
Opuntia polyacantha	plains pricklypear	OPPO	cactus	I	D
Orthocarpus tenuifolius	thinleaved owl's-clover	ORTE2	forb	I	na
Pascopyrum smithii	western wheatgrass	PASM	grass	I	I
Penstemon spp.	Penstemons	PENST	forb	I	I
Phlox hoodii	Hood's phlox	PHHO	forb	I	D
Plantago patagonica	woolly plantain	PLPA2	forb	I	I
Poa secunda	Sandberg bluegrass	POSE	grass	I	I
Polygonum spp.	knotweed	POLYG4	forb	-	-
Potentilla glandulosa	sticky cinquefoil	POGL9	forb	I	NC or I
Potentilla gracilis	slender cinquefoil	POGR9	forb	I	I
Prunus virginiana	chokecherry	PRVI	shrub	D	I
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	grass	D	I
Purshia tridenta	bitterbrush	PUTR	shrub	I	D
Rhus trilobata	skunkbush sumac	RHTR	shrub	I	I
Rosa woodsii	Wood's rose	ROWO	shrub	I	NC or I
Senecio integerrimus	lambstongue ragwort	SEIN2	forb	na	NC or I
Silene spp.	catchfly	SILEN	forb	-	-
Solidago missouriensis	Missouri goldenrod	SOMI2	forb	I	I
Symphoricarpos albus	common snowberry	SYAL	shrub	I	I
Tetradymia canescens	spineless horsebrush	TECA2	shrub	I	I
Thermopsis rhombifolia	prairie thermopsis	THRH	forb	I	na
Triteleia grandiflora	largeflower triteleia	TRGR7	forb	D	I
Zigadenus venenosus	meadow deathcamas	ZIVE	forb	I	VAR

[a] *Source: USDA PLANTS Database*

[b] *I=increase, D=decrease, NC=no change, VAR=variable, and na=information not available*

Appendix B-4. Plant list for the Warm-Loamy grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Achillea millefolium	common yarrow	ACMI2	forb	I	I
Achnatherum nelsonii	Columbia needlegrass	ACNE9	grass	D	NC or I
Achnatherum richardsonii	Richardson's needlegrass	ACRI8	grass	D	D
Agoseris glauca	pale agoseris	AGGL	forb	I	na
Allium spp.	onion	ALLIU	forb	-	-
Alopecurus spp.	alpinus	ALAL2	grass	-	-
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	shrub	D	I
Anemone cylindrica	candle anemone	ANCY	forb	I	na
Antennaria rosea	rosy pussytoes	ANRO2	forb	I	NC
Aquilegia spp.	columbine	AQUIL	forb	-	-
Arabis holboellii	Holboell's rockcress	ARHO2	forb	na	na
Arenaria congesta	ballhead sandwort	ARCO5	forb	I	D
Aristida purpurea	red threeawn	ARPU9	grass	I	D
Arnica sororia Greene	twin arnica	ARSO2	forb	I	D
Artemisia frigida	prairie sagewort	ARFR4	shrub	I	D
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	shrub	I	D
Artemisia tridentata spp. Vaseyana	mountain big sagebrush	ARTRV	shrub	I	D
Artemisia tripartita spp. Tripartita	tree-tip sagebrush	ARTRT2	shrub	I	D
Aster spp.	aster spp.	ASTER	forb	I	I
Astragalus spp.	milkvetch	ASTRA	forb	I	I
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	forb	I	I
Bouteloua gracilis	blue grama	BOGR2	grass	I	I
Bromus marginatus	mountain brome	BRMA4	grass	D	I
Calamagrostis rubescens	pinegrass	CARU	grass	I	I
Calamogrostis montanensis	plains reedgrass	CAMO	grass	I	I
Calochortus apiculatus	pointed tip mariposa lily	CAAP	forb	na	na
Campanula rotundifolia	harebell	CARO2	forb	I	na
Carex duriuscula	needleleaf sedge	CADU6	sedge	I	na
Carex filifolia	threadleaf sedge	CAFI	sedge	I	VAR
Carex spp.	sedge spp.	CAREX	sedge	-	-
Castilleja spp.	Indian paintbrush	CASTI2	forb	-	-
Cerastium arvense	field chickweed	CEAR4	forb	I	na
Chrysothamnus viscidiflorus	yellow rabbitbrush	CHVI8	shrub	I	I
Collomia linearis	narrowleaf mountain trumpet	COLI2	forb	I	na
Comandra umbellata	bastard toadflax	COUM	forb	I	NC
Danthonia intermedia	timber oatgrass	DAIN	grass	I	I
Danthonia parryi	Parry's oatgrass	DAPA2	grass	D	I
Dasiphora fruticosa	shrubby cinquefoil	DAFR6	shrub	I	D
Delphinium spp.	larkspur	DELPH	forb	I	I
Elymus lanceolatus	thickspike wheatgrass	ELLA3	grass	I	I
Elymus subsecundus	bearded wheatgrass	ELSU3	grass	D	NC or I
Elymus trachycaulus	slender wheatgrass	ELTRS	grass	D	NC or I
Ericameria nauseosa	rubber rabbitbrush	ERNA10	shrub	I	D

Appendix B-4. Plant list for the Warm-Loamy grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Erigeron gracilis	glacier lily	ERGR2	forb	D	D
Erigeron spp.	fleabane spp.	ERIGE2	forb	I	D or NC
Eriogonum heracleaoides	parsnipflower buckwheat	ERHE2	forb	I	D
Eriogonum microthecum	slender buckwheat	ERMI4	shrub	I	D
Eriogonum umbellatum	sulfur-flower buckwheat	ERUM	forb	I	D
Festuca campestris	rough fescue	FECA4	grass	D	D
Festuca idahoensis	Idaho fescue	FEID	grass	I	D
Gaillardia aristata	common gaillardia	GAAR	forb	I	I
Galium boreale	northern bedstraw	GABO2	forb	I	NC or I
Geranium viscosissimum	sticky geranium	GEVI2	forb	D	I
Geum triflorum	prairie smoke	GETR	forb	I	D or NC
Gutierrezia sarothrae	broom snakeweed	GUSA2	shrub	I	D
Hackelia spp.	stickseeds	HACKE	forb	-	-
Hesperostipa comata	needleandthread	HECO26	grass	I	I
Heterotheca villosa	hairy false goldenaster	HEVI4	forb	I	na
Heuchera cylindrica	roundleaf alumroot	HECY2	forb	I	na
Hieracium cynoglossoides	houndstongue hawkweed	HICY	forb	I	D or NC
Iris missouriensis	Rocky Mountain iris	IRMI	forb	I	na
Koeleria macrantha	prairie Junegrass	KOMA	grass	I	I
Lewisia rediviva	bitterroot	LERE7	forb	I	I
Leymus cinerus	basin wildrye	LECI4	grass	D	I
Liatris punctata	dotted blazing star	LIPU	forb	D	I
Linum lewisii	prairie flax	LILE3	forb	I	NC
Lithospermum ruderale	western stoneseed	LIRU4	forb	I	D
Lomatium macrocarpum	bigseed biscuitroot	LOMA3	forb	I	NC or I
Lupinus sericeus	silky lupine	LUSE4	forb	I	NC or I
Lupinus spp.	Lupine species	LUPIN	forb	I	NC or I
Lygodesmia juncea	rush skeletonplant	LYJU	forb	I	na
Melica spectabilis	purple oniongrass	MESP	grass	D	na
Monarda fistulosa	horsemint	MOFI	forb	I	na
Opuntia polyacantha	plains pricklypear	OPPO	cactus	I	D
Orthocarpus tenuifolius	thinleaved owl's-clover	ORTE2	forb	I	na
Pascopyrum smithii	western wheatgrass	PASM	grass	I	I
Penstemon spp.	Penstemons	PENST	forb	I	I
Phlox hoodii	Hood's phlox	PHHO	forb	I	D
Plantago patagonica	woolly plantain	PLPA2	forb	I	I
Poa cusickii	Cusick's bluegrass	POCU3	grass	I	D or NC
Poa secunda	Sandberg bluegrass	POSE	grass	I	I
Polygonum douglasii	Douglas' knotweed	PODO4	forb	na	na
Potentilla glandulosa	sticky cinquefoil	POGL9	forb	I	NC or I
Potentilla gracilis	slender cinquefoil	POGR9	forb	I	I
Prunus virginiana	chokecherry	PRVI	shrub	D	I
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	grass	D	I

Appendix B-4. Plant list for the Warm-Loamy grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Psoralidium spp.	scurfpea	PSORA2	forb	I	na
Purshia tridenta	bitterbrush	PUTR	shrub	I	D
Ratibida columnifera	prairie coneflower	RACO3	forb	I	NC
Rosa woodsii	Wood's rose	ROWO	shrub	I	NC or I
Solidago missouriensis	Missouri goldenrod	SOMI2	forb	I	I
Sphaeralcea coccinea	scarlet globemallow	SPCO	forb	I	NC or I
Stenotus acaulis	stemless mock goldenweed	STAC	forb	na	na
Symphoricarpos albus	common snowberry	SYAL	shrub	I	I
Symphyotrichum ericoides	white heath aster	SYER	forb	na	na
Tetradymia canescens	spineless horsebrush	TECA2	shrub	I	I
Thermopsis rhombifolia	prairie thermopsis	THRH	forb	I	na
Trisetum spicatum	spike trisetum	TRSP2	grass	D	na
Triteleia grandiflora	largeflower triteleia	TRGR7	forb	D	I
Vicia americana	American vetch	VIAM	forb	D	I
Zigadenus venenosus	meadow deathcamas	ZIVE	forb	I	VAR

[a] *Source: USDA PLANTS Database*

[b] *I=increase, D=decrease, NC=no change, VAR=variable, and na=information not available*

Appendix B-5. Plant list for the Warm-Sandy grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Achillea millefolium	common yarrow	ACMI2	forb	I	I
Achnatherum hymenoides	Indian ricegrass	ACHY	grass	D	NC
Agoseris glauca	pale agoseris	AGGL	forb	I	na
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	shrub	D	I
Antennaria rosea	rosy pussytoes	ANRO2	forb	I	NC
Arnica sororia Greene	twin arnica	ARSO2	forb	I	D
Artemisia dracunculus	green sagewort	ARDR4	forb	I	D
Artemisia frigida	prairie sagewort	ARFR4	shrub	I	D
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	shrub	I	D
Artemisia tridentata spp. Vaseyana	mountain big sagebrush	ARTRV	shrub	I	D
Astragalus spp.	milkvetch	ASTRA	forb	I	I
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	forb	I	I
Bromus marginatus	mountain brome	BRMA4	grass	D	I
Carex spp.	sedge spp.	CAREX	sedge	-	-
Dasiphora fruticosa	shrubby cinquefoil	DAFR6	shrub	I	D
Elymus lanceolatus	thickspike wheatgrass	ELLA3	grass	I	I
Erigeron spp.	fleabane spp.	ERIGE2	forb	I	D or NC
Festuca campestris	rough fescue	FECA4	grass	D	D
Festuca idahoensis	Idaho fescue	FEID	grass	I	D
Gaillardia aristata	common gaillardia	GAAR	forb	I	I
Geranium viscosissimum	sticky geranium	GEVI2	forb	D	I
Geum triflorum	prairie smoke	GETR	forb	I	D or NC
Hesperostipa comata	needleandthread	HECO26	grass	I	I
Koeleria macrantha	prairie Junegrass	KOMA	grass	I	I
Lithospermum ruderale	western stoneseed	LIRU4	forb	I	D
Lupinus sericeus	silky lupine	LUSE4	forb	I	NC or I
Pascopyrum smithii	western wheatgrass	PASM	grass	I	I
Phlox hoodii	Hood's phlox	PHHO	forb	I	D
Poa secunda	Sandberg bluegrass	POSE	grass	I	I
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	grass	D	I
Psoralidium spp.	scurfpea	PSORA2	forb	I	na
Rhus trilobata	skunkbush sumac	RHTR	shrub	I	I
Rosa woodsii	Wood's rose	ROWO	shrub	I	NC or I
Symphoricarpos albus	common snowberry	SYAL	shrub	I	I
Thermopsis rhombifolia	prairie thermopsis	THRH	forb	I	na
Vicia americana	American vetch	VIAM	forb	D	I

[a] *Source: USDA PLANTS Database*
[b] *I=increase, D=decrease, NC=no change, VAR=variable, and na=information not available*

Appendix B-6. Plant list for the Warm-Gravelly grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Achillea millefolium	common yarrow	ACMI2	forb	I	I
Achnatherum hymenoides	Indian ricegrass	ACHY	grass	D	NC
Achnatherum nelsonii	Columbia needlegrass	ACNE9	grass	D	NC or I
Achnatherum richardsonii	Richardson's needlegrass	ACRI8	grass	D	D
Allium spp.	onion	ALLIU	forb	-	-
Antennaria rosea	rosy pussytoes	ANRO2	forb	I	NC
Aristida purpurea	red threeawn	ARPU9	grass	I	D
Artemisia dracunculus	green sagewort	ARDR4	forb	I	D
Artemisia frigida	prairie sagewort	ARFR4	shrub	I	D
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	shrub	I	D
Calochortus apiculatus	pointed tip mariposa lily	CAAP	forb	na	na
Carex duriuscula	needleleaf sedge	CADU6	sedge	I	na
Carex filifolia	threadleaf sedge	CAFI	sedge	I	VAR
Collomia linearis	narrowleaf mountain trumpet	COLI2	forb	I	na
Dalia spp.	prairie clover	DALEA	forb	D	I
Delphinium spp.	larkspur	DELPH	forb	I	I
Elymus lanceolatus	thickspike wheatgrass	ELLA3	grass	I	I
Eriogonum heracleaoides	parsnipflower buckwheat	ERHE2	forb	I	D
Festuca campestris	rough fescue	FECA4	grass	D	D
Festuca idahoensis	Idaho fescue	FEID	grass	I	D
Gaillardia aristata	common gaillardia	GAAR	forb	I	I
Gutierrezia sarothrae	broom snakeweed	GUSA2	shrub	I	D
Hesperostipa comata	needleandthread	HECO26	grass	I	I
Heterotheca villosa	hairy false goldenaster	HEVI4	forb	I	na
Koeleria macrantha	prairie Junegrass	KOMA	grass	I	I
Liatris punctata	dotted blazing star	LIPU	forb	D	I
Lithospermum ruderale	western stoneseed	LIRU4	forb	I	D
Lomatium macrocarpum	bigseed biscuitroot	LOMA3	forb	I	NC or I
Lupinus sericeus	silky lupine	LUSE4	forb	I	NC or I
Orthocarpus tenuifolius	thinleaved owl's-clover	ORTE2	forb	I	na
Oxytropis spp.	locoweed	OXYTR	forb	I	na
Pascopyrum smithii	western wheatgrass	PASM	grass	I	I
Penstemon spp.	Penstemons	PENST	forb	I	I
Phlox hoodii	Hood's phlox	PHHO	forb	I	D
Plantago patagonica	woolly plantain	PLPA2	forb	I	I
Poa secunda	Sandberg bluegrass	POSE	grass	I	I
Potentilla gracilis	slender cinquefoil	POGR9	forb	I	I
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	grass	D	I
Rhus trilobata	skunkbush sumac	RHTR	shrub	I	I
Rosa woodsii	Wood's rose	ROWO	shrub	I	NC or I

Appendix B-6. Plant list for the Warm-Gravelly grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Silene spp.	catchfly	SILEN	forb	-	-
Zigadenus elegans	Mountain deathcamas	ZIEL2	forb	I	na
Zigadenus venenosus	meadow deathcamas	ZIVE	forb	I	VAR

[a] *Source: USDA PLANTS Database*

[b] *I=increase, D=decrease, NC=no change, VAR=variable, and na=information not available*

Appendix B-7. Plant list for the Warm-Claypan grass-shrub ecological site. Expected plant response to low to moderate grazing levels andfire are indicated.
(Plant species list and response to disturbance developed from NRCS Ecological Site Descriptions)

Scientific Name	Common Name	PLANTS Code[a]	Growth Form	Low to moderate grazing levels[b]	Fire Response[b]
Achnatherum nelsonii	Columbia needlegrass	ACNE9	grass	D	NC or I
Antennaria luzuloides	rush pussytoes	ANLU2	forb	I	I
Artemisia tridentata	Wyoming big sagebrush	ARTRW8	shrub	I	D
Astragalus spp.	milkvetch	ASTRA	forb	I	I
Carex spp.	sedge spp.	CAREX	sedge	-	-
Festuca campestris	rough fescue	FECA4	grass	D	D
Festuca idahoensis	Idaho fescue	FEID	grass	I	D
Geranium viscosissimum	sticky geranium	GEVI2	forb	D	I
Geum triflorum	prairie smoke	GETR	forb	I	D or NC
Lupinus spp.	Lupine species	LUPIN	forb	I	NC or I
Pascopyrum smithii	western wheatgrass	PASM	grass	I	I
Phlox hoodii	Hood's phlox	PHHO	forb	I	D
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	grass	D	I
Solidago missouriensis	Missouri goldenrod	SOMI2	forb	I	I
Tetradymia canescens	spineless horsebrush	TECA2	shrub	I	I

[a] *Source: USDA PLANTS Database*

[b] *I=increase, D=decrease, NC=no change, VAR=variable, and na=information not available*