

Disruption of Historic Disturbance Regimes



Photos courtesy of WGFD

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Background

A disturbance is any event or series of events that alters ecosystems by affecting functions or processes, habitats, animal populations, or their physical environments, by either natural or human causes. Disturbances are natural components of virtually all ecosystems and can include fires, floods, droughts, storms, herbivory, and disease outbreaks. Humans are significant agents of habitat disturbance, and examples of human-induced disturbances range from pre-European settlement fires set by Native Americans to improve game habitat to modern-day mechanized logging and crop cultivation. Some human activities can mimic natural disturbances and are important in maintaining or enhancing wildlife diversity, while others can degrade habitat and may even lead to species extinctions.

A disturbance regime is distinguished from a single disturbance event by describing a pattern, frequency, and intensity of disturbances across the landscape or watershed. For terrestrial ecosystems, variations in these factors, along with changes in soil and topography as well as competitive interactions among plants, typically result in patches of vegetation in various stages of disturbance and recovery. Patches can be distinguished from each other by the height and structure of individual plants as well as the composition of plant species, both of which change over time as regeneration progresses. “Patch dynamics” and “shifting mosaic steady-state” are concepts used to describe this dynamic. The attributes of various disturbance regimes vary with the natural communities in which they occur.

Disturbances can act both singly and in concert with multiple other disturbances to determine plant and animal communities. The number and type of disturbances can change over time. Maintaining wildlife diversity as well as habitat for individual species often depends upon the availability of a patchwork of cover and habitat types throughout the landscape. In addition to wildlife habitat and plant regeneration, periodic disturbances are essential to maintaining the productivity of an ecosystem and its capacity to

produce clean air and water through facilitating nutrient cycling.

The loss of “historic”¹ disturbances as well as interactions within and between various types of disturbances and associated habitats is a significant cause for the decline and extinction of many wildlife species. Flow alteration is the leading cause for reductions in native plant and animals populations in rivers worldwide (Poff et al. 1999). In the Rocky Mountain West, fire suppression and altered grazing patterns by wild and domestic ungulates have contributed to declines in aspen (Nicholoff 2003). In Wyoming, it is estimated that over half of the recent historic aspen acreage has converted to other community types (Nicholoff 2003). Aspen stands are second only to riparian areas in biodiversity (Kay 1998).

Disturbances such as fire, floods, and insect outbreaks can be detrimental to human health or destructive to human property. There have been efforts to limit natural fluctuations in abundance associated with disturbance cycles in favor of achieving consistent, sustained yields for plants and animals which have high economic or social values such as timber, livestock forage plants, and game animals. Disturbance regimes under which many native habitats and wildlife evolved may be lost, altered, or no longer possible as natural habitats become increasingly fragmented and modified through human development. Additionally, climate change will likely further alter the frequency, type, and intensity of disturbances as well as the local composition of plants and animals responding to these events.

The role of historic disturbances in maintaining native species and habitats has only recently

¹ “Historic” disturbance regime refers to environmental disturbances under which native species and habitats evolved. This term has been selected as opposed to “natural” disturbance regime since it is often not possible, or meaningful, to segregate the influence of pre-Columbian human-induced disturbances caused by Native Americans, such as fires intentionally lit to improve game habitat, from those caused by natural sources, such as lightning strikes.

become known and appreciated by habitat managers. In order to conserve native species and habitats, more effort is being placed on retaining historic disturbances where possible or mimicking their effects by active management where not. While Wyoming habitats are influenced by a diversity of historic disturbances, alterations to historic stream flow, fire, and herbivory regimes are considered the most significant and will be the focus of this chapter.

Scope and Challenges of Integrating Historic Disturbance Regimes into Wildlife Conservation

Disruption of Water Flow Regimes

Variation within and between seasons in the timing, duration, frequency, and magnitude of water flows are typical for rivers and streams in Wyoming. Seasonal spring floods move water and sediment through channels and onto floodplains, depositing or exposing alluvial soils necessary for the establishment of cottonwoods, willows, and other riparian plants (Friedman et al. 1997). High water flows move fine sediments and maintain gravel and cobble habitats, which support diverse aquatic insect communities and fish spawning sites. Spring runoff and high water events also bring woody material into stream channels, providing structure and food for aquatic species. Other important habitat features, such as cobble bars and scour-pools, are also formed and maintained by high flushing and channel-forming flows. The timing of high water events is important to the lifecycles of many aquatic and riparian species. For example, the seed release of riparian trees such as willows and cottonwoods is synchronized with the timing of spring flood recession to maximize dispersal efficiency and germination (Natural Resources Conservation Service 2006).

Natural flow regimes in many stream segments around the state have been severely altered by a number of human activities including irrigation diversions, hydroelectricity, waste disposal, and

flood control. In the United States, only 2% of rivers remain in their natural, unmodified condition (Graf 1993). In Wyoming, the disruption of flow regimes is often a consequence of broad-scale changes in land use and management such as agriculture, grazing, timber harvest, and housing development. These activities can affect the amount and type of streamside vegetation and the quantity and rate at which precipitation flows over and through the land to streams and lakes, altering both ground water cycles and surface flow regimes.

Such flow regime changes can affect plants and animals by altering water quality (e.g., increasing sediment, organic material, and pollutants, raising water temperatures, and reducing dissolved oxygen) and changing physical stream characteristics. Secondary effects can include altered species interactions (e.g., a shift in competitive advantage for one species), increased disease transmission, and accelerated exotic species invasion. Communities may also be negatively impacted by flow alterations from land-use changes by ground water depletions, declines in water quality and flow availability, and more frequent and intense flooding (Natural Resources Conservation Service 2006).

Wyoming is an arid state, and considerable development of dams and water diversions has occurred to control, store, and deliver water, as well as to produce hydroelectric power. There are approximately 1,530 permitted dams in Wyoming which are subject to regulation under Wyoming Safety of Dams Statutes (W.S. 41-3-307 through 41-3-318)² and many smaller dams that are not subject to state or federal Safety of Dams regulations. Most of the dams in the state were constructed to provide water for irrigation, enhance the availability of domestic

² Section 41-3-307 defines the term dam as any artificial barrier, including appurtenant works, used to impound or divert water and which is or will be greater than twenty (20) feet in height or with an impounding capacity of fifty (50) acre-feet or greater. Dams with less than 15 acre-feet capacity regardless of height, or 6 feet or less in height regardless of capacity, are excluded provided that there are no habitable buildings immediately downstream.

water supplies, reduce the risk of flooding, and provide new boating and fishing opportunities on manmade reservoirs.

While water development can threaten native species, some coldwater fish species, such as trout, and warmwater species, such as walleye, have benefited from dam construction. The simplification of natural systems by human development tends to favor species with generalized and broad habitat requirements. For example, the walleye fisheries in the North Platte River reservoirs and Boysen Reservoir depend on the consistent deep water and forage production inherent in these man-made water bodies. Stable stream flow releases from dams, with relatively low peak flows and relatively high base flows, perpetuate productive sport fisheries. The famous “Miracle Mile” trout fishery below Kortez Dam and the “Grey Reef” fishery below Alcova Dam are examples.

Alternatively, dams and water diversions typically result in major alterations to natural flow regimes that negatively impact many species (Annear et al. 2004). Most notably, dams reduce peak flows commonly associated with spring runoff and change the quantity, timing, and consistency of base flows. The loss of high spring flushing flows on dammed rivers greatly reduces the natural cycle of sediment transport and deposition. Depending on a variety of factors, releases from dams can accelerate down-cutting of stream channels to the extent that side channels and shallow water habitats are depleted or eliminated. In other situations, releases can lead to the armoring of the stream channel by removing most of the fine materials from the streambed and leaving an almost impervious surface with diminished value for aquatic insects and fish. These and other changes in channel geomorphology also favor the replacement of native cottonwoods and willows, which are dependent upon seasonal flooding for seedling establishment, by Russian olive and tamarisk (commonly referred to as saltcedar), which are exotic invasive species. Reduction in the size and structural complexity of cottonwood stands, through lack of tree regeneration, has been associated with

declines in riparian bird species diversity (Slater 2006). In Wyoming, cottonwood declines have been linked to flow alterations on the North Platte (Miller et al. 1995) and Bighorn Rivers (Akashi 1988, Bray 1996).

Dams and water diversions can also significantly limit connectivity in stream habitat and prevent seasonal migrations of aquatic species. Dams are a leading cause in the reduction of range-wide sauger numbers and significantly contributed to their extirpation from the North Platte River drainage in Wyoming (Nelson and Walburg 1977, Hesse 1994, Pegg et al. 1996, 1997, Maccina et al. 1998, McMahon and Gardner 2001). Dams and diversion structures have also isolated several Colorado cutthroat trout populations in headwater tributaries within the Little Snake River watershed (Cook 2009).

Reduction in the number and distribution of beaver is another major contributor to altered stream flows. Similar to man-made dams, beaver ponds accumulate sediment, improve water quality, reduce stream velocities, raise water tables, and increase the size of associated riparian zones. These effects create and maintain both terrestrial and aquatic habitats. Beaver ponds also control the timing and duration of flow in streams by slowing surface-water runoff and storing large amounts of water in the surrounding water table. Much of this stored water releases into streams throughout the year, which helps maintain late-season flow in many small streams with high beaver densities. In some active beaver habitats, bird densities have been shown to be three times that of adjacent riparian habitats (Collins 1993). Studies have also shown that trout size and biomass are greater in streams with beaver ponds (Olson and Hubert 1994). Over the centuries, beaver ponds have trapped tens to hundreds of billions of cubic meters of sediment that would otherwise been carried downstream (Naiman et al. 1988). Today, the physical character and vegetation of many meadowlands is the result of historic beaver activity.

Fur trapping in the 19th century greatly reduced beaver numbers and extirpated them from many areas. By the early 21st century, beavers have reoccupied most of their historic range, but at only approximately 10% of the pre-European-contact densities (Naiman et al. 1988). One study found that beavers had been extirpated from more than 25% of first, second, and third order streams in Wyoming, and concluded their historic ecological influence was absent from a far greater percentage (McKinstry et al. 2001).

Predicted future rises in mean temperature and greater variability in precipitation may lead to less snow accumulation, shorter and earlier spring runoffs, and higher evaporation rates (IPCC 2007). These changes will likely further compound the effects of current disruptions to historic flow regimes. Additionally, as the human population of the region grows, additional dams and diversions will likely be created to ease the growing demand for water resources by various user groups.

Notable Wyoming Species of Greatest Conservation Need (SGCN) negatively impacted by alterations to natural flow regimes in Wyoming include bluehead suckers, flannelmouth suckers, roundtail chubs, western silvery minnow, sauger, cutthroat trout (Bonneville, Yellowstone, Snake River, and Colorado River), Wyoming toad, and northern leopard frog.

Alterations to Fire Regimes

Historically, fires were common in Wyoming wherever sufficient fuel accumulated. Semiarid deserts and plains likely burned infrequently, but fires were a regular occurrence in riparian zones, montane forests, some grasslands and dense shrublands and woodlands (Knight 1994).

Fire frequency and severity vary by climatic conditions, site characteristics, and vegetation types. In turn, these variables influence the plants that re-colonize a site and the wildlife species that inhabit it during the vegetation successional stages that follow. Native Americans often started fires to facilitate

hunting, either to attract animals to palatable re-growth or by using fire as a tool to drive game (Knight 1994). A review of historical accounts of fire in the Rocky Mountains concluded that fires set by Native Americans were common in lowlands and may even have occurred annually, though not likely in the same spot in consecutive years (Gruell 1985). In the foothills, prior to European settlement, fire may have occurred every 5 to 25 years (Knight 1994). Fire intervals in sagebrush habitats and forests in Wyoming were more variable and site-specific. In forested areas, fire intervals likely ranged from decades at lower elevations to several hundred years or more in high alpine forests, where fuel levels are low and required climatic conditions rare (Knight 1994). Estimates on historic fire intervals for sagebrush habitats range from every 10 to 400 years or longer depending upon species and site conditions (see Sagebrush Shrublands Habitat Type).

Fire releases nutrients and increases the amount of bare soil. Fire-blackened soils warm quickly, which increases microbial activity, furthering nutrient cycling and encouraging plant growth. In forests, fire can reduce canopy coverage favoring the growth of sun dependent plants. In prairies, fire can remove dead vegetation that hinders new growth, reduce invasive plants³, and encourage native species. Due to variations in plant species tolerance levels, fire can have a significant influence on plant species composition. Because fires kill many young trees and some shrubs it can often create savannas by reducing tree densities. Ponderosa pine habitats in Wyoming were believed to be more savanna-like prior to European settlement as a result of frequent fires (see Xeric Forests Habitat Type).

Intensity has a strong influence on the ecological effects of fire. Extremely hot fires that burn through the forest canopy can kill most of the trees and significantly alter habitats.

³ Fire can also promote the spread of cheatgrass and other invasive species under certain circumstance (Paige and Ritter 1999).

In contrast, surface fires often burn forest floor litter and kill few organisms. Perennial grasses, forbs, and some shrubs and trees have the ability to sprout from surviving roots, leading to recovery in several years (Knight 1994).

Beginning in the 20th century, fire suppression management techniques have been linked to increasing fire severity due to greater fuel load accumulations (Omi and Martinson 2004).

Ponderosa pine, limber pine, and Douglas-fir appear to be increasing in density and expanding their range in part as a result of fire suppression (Knight 1994). Many believe that juniper has expanded its range northward and to lower elevation grasslands and shrublands that previously had higher fire frequencies (Gillihan 2006).⁴ Increasing tree densities and greater age uniformity among lodgepole and ponderosa pine stands have led to increased stress resulting from competition for water and soil nutrients, which may be causing trees to become more susceptible to mountain pine beetle infestations (Knight 1994).

Fire suppression and increased grazing by wild and domestic ungulates have led to notable declines in aspen, true mountain-mahogany, serviceberry, and skunkbush sumac. These species provide important food and cover for a diversity of wildlife. Throughout the West, aspen have declined between 50 to 96% (Bartos and Mitchell 2000).

Changes to historic fire regimes, both natural and prescribed, have also altered the interaction of fire with other disturbances, most notably grazing. Grazing animals are attracted to burned areas immediately following fires to feed on nutritious re-growth. In contrast, most current fire management strategies recommend growing season deferment from livestock grazing for one or more years following fires to facilitate native plant growth and reduce the

establishment of invasive plant species (Bureau of Land Management 2005). Similarly, prescribed fires are often applied to entire pastures during the dormant growing season, whereas historical fires were likely patchy in distribution and occurred during mid to late summer when there is the highest incidence of lightning strikes. Over the past decade, the Wyoming Game and Fish Department's prescribed fire plans have been increasingly focused on promoting patchiness.

Cheatgrass is an increasing annual invasive from Eurasia. Cheatgrass is highly fire-adapted and fire prone and has the potential to increase fire frequency in areas where it becomes widely established (Whisenant 1990). Altered fire regimes can change an entire plant community by converting native grassland, sagebrush, and other plant communities to cheatgrass-dominated landscapes. Of special concern are the loss of crucial sage-grouse and other wildlife habitats along with secondary weed invasions from species such as rush skeletonweed and Medusa-head wild rye (Smith and Enloe 2006).

Climate change is expected to increase precipitation variability and drought frequency (Christensen et al. 2007). Both factors will likely further alter historic fire regimes in Wyoming. The length of the fire season in the U.S. has increased significantly over the past 30 years and is expected to continue to grow in coming years (Westerling et al. 2006, Barnett et al. 2004). Moreover, the amount of acres burned each year in the West over the past two decades has also increased (National Wildlife Federation 2010). Wildfire coupled with a combination of warming temperatures, drought, and vegetation changes resulting from changing climate factors may lead to drastic ecosystem changes in the future.

Alteration to Grazing Regimes

Herbivory has a long history of influencing habitats and associated plants and animals (Milchunas et al. 1988). Before the arrival of Europeans, bison, elk, deer, antelope, prairie dogs, as well as a diversity of other wildlife and

⁴ Some researchers believe that historic climate change may have an equal or greater influence on juniper distribution in the West which has gone through a number of range expansions and contractions (Miller and Wigand 1994).

insects, grazed and browsed Wyoming vegetation. Today, elk, deer, and antelope remain abundant, while domesticated livestock are the predominant grazers across Wyoming ecosystems.

Grazing is a keystone process in maintaining habitat diversity (Collins 1992, Knapp et al. 1999). Historically, the distribution of grazing ungulates was uneven across the landscape. Prior to European settlement, grazing and fire interacted closely to influence bison behavior. Bison were attracted to recently burned areas to graze on palatable, re-sprouting grasses. This localized high grazing pressure permitted vegetation in other areas to accumulate which in turn made these locations more prone to subsequent fire (Fuhlendorf and Engle 2001, Fuhlendorf et al. 2009). Prairie dogs, often thriving in areas recently grazed by bison, lived in large colonies, digging burrows and cropping vegetation. Burrows and open patches of ground created by bison and prairie dog colonies create habitat for other wildlife species including the black-footed ferret, burrowing owls, long-tailed weasel, mountain plover, and swift fox (Kotliar et al. 1999, Kotliar 2000). The resulting patchwork of variation in plant structure and composition shifted across the landscape.

Bison and prairie dogs have experienced substantial reductions in both numbers and range. Other pre-Columbian herbivores, like the Rocky Mountain locust, which likely had a very significant grazing impact during outbreaks, are believed to be extinct (Lockwood 2004).

Cattle and sheep were introduced in large numbers in Wyoming in the 1880s following the elimination of bison in most areas of the state outside Yellowstone National Park. Uncontrolled livestock grazing at the end of the 19th century and the beginning of the 20th century substantially altered some ecosystems (Belsky and Blumenthal 1997). In 1934, the federal Taylor Grazing Act was passed, which led to the creation of grazing districts in which grazing use was apportioned and regulated on

public lands. Since this time, range conditions and grazing practices have improved although some habitats remained modified by this period of overuse through changes in plant composition as well as altered fire frequency (Laycock 1991).

Wildlife species often depend upon habitats produced by one grazing level while others require conditions supported by a diversity of grazing intensities (Derner et al. 2009, Toombs et al. 2010). For example, mountain plover and McCown's longspur prefer habitats that have been intensively grazed while Caspian sparrow thrives in more lightly grazed areas (Knopf 1996). In contrast, many modern rangeland management practices were developed to increase livestock production through evenly distributing livestock and enhancing vegetation use. This strategy emphasized uniform moderate grazing levels thereby eliminating grazing extremes (i.e., none, light, and heavy). Over time, such practices can lead to decreases in plant species and structural diversity (Fuhlendorf and Engle 2001). Although practices such as water placement can create grazing gradients by reducing grazing intensity at distances farther from water sources, such gradients tend to be static if water sources are not moved or altered. In such cases, repeated, heavy, localized grazing can lead to the initial stages of rangeland deterioration (National Research Council 1994).

Riparian areas are often the most diverse and productive habitats in Wyoming. Most riparian habitats evolved with some feeding and trampling from animals; however, repeated intensive use during the same season each year can have negative impacts. Impacts include a change, reduction, or elimination of bank vegetation; increased water temperatures; excessive sedimentation and upland erosion; channel widening and bank sloughing; and heightened coliform bacterial counts (Kauffman and Krueger 1984). Although livestock are often associated with riparian overuse, high concentrations of wild ungulates, particularly elk, have substantial impacts on riparian and aspen communities (Ripple and Beschta 2004).

There has been considerable improvement in conditions for many riparian areas through improvements in livestock management strategies (Smith et al. 1992).

In addition to being a natural component of many Wyoming habitats, grazing is the cornerstone of Wyoming's ranching industry. The continued function of a considerable amount of crucial wildlife habitat located on private land within the state is closely tied to the future sustainability of the state's ranches, which will continue to increase with increasing partnerships between ranchers, conservation organizations, and state and federal land management agencies (see Wyoming Leading Wildlife Conservation Challenges – Rural Subdivision and Development).

Current Initiatives to Maintain, Restore, or Duplicate Historic Disturbance Regimes

Hydrology

In 2001, several habitat types were identified in the WGFD Strategic Habitat Plan (SHP) that are considered particularly important to maintain or enhance. Among these were riparian and wetland habitats, prairie stream systems, and cutthroat trout streams. Declines in late season water flows, water quality, and loss of water flow and native fish due to water diversions are significant factors contributing to less than optimal prairie stream system habitat and adversely affecting cutthroat trout habitat. Updates to the SHP in 2009 and 2015 identified specific regional priority areas for conservation work. These areas included crucial areas, necessary for maintaining terrestrial and aquatic wildlife populations and enhancement areas where there is the potential to enhance or improve important wildlife habitats that have been degraded. Combined, these prioritization efforts will help guide conservation and restoration efforts for aquatic habitats.

In 2008, fish passage goals were added to the SHP and in July 2009, the WGFD designated

fish passage as a department program with an associated budget. Projects completed and continuing around the state include reinstalling or replacing culverts that prevent passage, replacing or modifying diversion dams to provide upstream passage, installing bypass channels around diversion structures, and screening diversion ditches and canals. Fish movement studies continue to be used to evaluate upstream passage at existing diversion structures and fish mortality in various canal systems. The WGFD developed a fish passage database to document fish passage diversions around the state and prioritize projects to address passage issues.

The Bureau of Reclamation, State Engineer's Office, Wyoming Water Development Commission, and the WGFD have worked together to establish formal and informal water management strategies for some reservoirs. These agreements benefit aquatic wildlife, including sport fisheries, while still serving the reservoirs' legislatively authorized purposes. Examples include the Snake River below Jackson Lake Dam, Shoshone River below Buffalo Bill Dam, Green River below Fontenelle Reservoir, Bighorn River below Boysen Reservoir, and the North Platte River below Kortes, Pathfinder, Grey Reef, and Glendo Dams. Maintaining historic flow regimes is typically a secondary consideration compared to traditional focuses on flow releases to benefit agriculture, sport fisheries, and recreation.

Instream flow water rights provide the ability to manage natural flow regimes up to designated base levels for fisheries and, by association, may benefit nearby riparian corridors. The WGFD began evaluating various methods and quantifying instream flow needs for fish in 1979. In 1986, the Wyoming Legislature enacted a statute (41-3-1001 to 41-3-1014) that formally recognizes opportunities to maintain or improve instream flow as a beneficial use. Because water rights can only be issued for uses that have been officially recognized as "beneficial," this designation is of critical importance. Since the inception of the program, the WGFD has

employed biologists to identify priority areas and quantify instream flow regime needs for fish habitat, and the WGFD has submitted applications for over 140 instream flow water rights. The program is reviewed on an annual basis and a water management plan is updated with explicit goals for upcoming efforts.

Wyoming has also undertaken a comprehensive water planning effort which has influence on the management of flow regimes. In 1999, the Wyoming Legislature approved a planning framework and authorized plans for the Bear and Green River Basins (Wyoming Water Development Office 2010). In the years that followed, the Legislature authorized funding for the five remaining river basins. The Platte River Basin Plan was the last plan completed, in May 2006. Anticipating completion of the individual river basin plans, the 2005 Legislature authorized funding for the Statewide Framework Water Plan. The purpose of this plan is to summarize the results of all seven river basin plans and to provide future water resource planning direction to the state. It includes an inventory of the state's water resources and related lands, a summary of the state's present water uses, a projection of future water needs, and potential options for meeting those needs. In early 2010, initial steps were taken to address the plan's environmental and recreational components, including riparian habitats. These needs still require additional consideration and specification in all basin planning documents.

Fire

In Wyoming, the Bureau of Land Management (BLM), US Forest Service (USFS), Wyoming State Forestry Division, and other cooperators utilize the National Fire Plan (NFP) as the overarching plan to guide all fire management activities. NFP primarily focuses on ensuring there is capacity to address wildfire prevention, fire preparedness and suppression, as well as post-fire stabilization and rehabilitation. As one of many objectives, NFP includes elements of both duplicating historic fire regimes and benefitting wildlife habitat.

NFP prioritizes fire suppression responses through District Fire Management Plans and activity level plans. These plans dictate what Fire Management Units receive for fire suppression resources upon the detection of a fire as well as, based on a lightning tracking system, the allocation of resources prior to a fire. Fire Management Units are tied to local USFS Forest Plans, BLM Resource Management Plans (RMP), and Fire Management Plans which incorporate goals of managing for historic fire regimes. The LANDFIRE GIS system and Fire Regime Condition Class methodology are two tools which are used to determine fire fuel loads and departures from historic fire regimes in order to guide management objectives and set priorities for habitat and fuel treatments.

The NFP also establishes an intensive, long-term hazardous fuels reduction program. In many areas fuel loads are unusually high as a result of decades of fire suppression, sustained drought, and increasing infestations by insects, disease, and invasive plants. Hazardous fuels reduction treatments are designed to lower the risks of catastrophic wildfire to people, communities, and natural resources while restoring forest and rangeland ecosystems to closely match their historical structure, function, diversity, and dynamics. Treatments are administered using prescribed fire, mechanical thinning, herbicides, grazing, or combinations of these and other methods. Treatments are being increasingly focused on the expanding wildland/urban interface. Fuels management treatments are developed by teams of natural resource specialists.

When catastrophic fires do occur, stabilization and restoration work begins immediately to restore lands that are unlikely to recover naturally from the effects of wildfires. This work, often implemented over the course of several years following a wildfire, includes reforestation, fence replacement, fish and wildlife habitat restoration, invasive plant treatments, and replanting and reseeding with native or other desirable vegetation.

As the human population grows, concerns for human safety and property loss will diminish the viability of natural and prescribed fire in habitat management. In many locations in Wyoming, commercial timber harvest is also economically important and will continue to be a leading forest management objective (Wyoming State Forestry Division 2009). Under these circumstances, efforts have been placed on duplicating the effects of fire in forest management activities including commercial timber harvest (North and Keeton 2008). Silviculture practices designed to duplicate the effects of historic disturbance regimes typically include increasing forest structural complexity, plant species diversity, and spatial patterns of timber removal and thinning (North and Keeton 2008). Accomplishing these goals may require lengthening tree harvest rotations and retaining large green trees, snags, and logs in harvested areas (Swanson and Franklin 1992, Franklin et al. 1997). While the effects of fire can be duplicated by mechanical and other means, reproducing its influence on soil turnover, soil carbon dynamics, and nutrient cycling is more difficult (North and Keeton 2008).

Herbivory

Nationwide, grazing occurs on approximately 160 million acres of BLM land and 81 million acres of USFS land (Vincent 2012). The terms and conditions for grazing on federal lands (such as stipulations on utilization levels and season-of-use) are set forth in the permits. Grazing permits issued by the USFS and BLM last 10 years and are renewable if it is determined that the terms and conditions of the expiring permit are being met. To achieve desired conditions, these agencies use rangeland health standards and guidelines. The BLM Code of Federal Regulations establishes intervals and standards for monitoring grazing permits. The results of monitoring help managers determine whether changes are necessary for livestock grazing management. The USFS conducts both implementation monitoring annually to evaluate vegetation use

and permit compliance, and effectiveness monitoring every five to six years to assess whether activities and objectives set forth in forest plans, allotment management plans, or other relevant documents are being met.

State-owned lands are typically managed in conjunction with the ownership of surrounding lands including private landowners and federal land management agencies. Every state parcel has a field sheet that describes the land's elevation, topography, annual anticipated precipitation, and soil type. The sheet also contains information about the amount and type of vegetation present which is used to calculate livestock stocking rates. An inspection of each parcel is planned once every 10 years to update the field sheet and address any concerns. Priority is given to known problem areas. The Wyoming Office of State Lands and Investments, which manages state lands, cooperates with the Natural Resources Conservation Services (NRCS) on conservation and wildlife programs as well as with the BLM on allotment plans and local RMPs.

The NRCS, conservation districts, University of Wyoming Cooperative Extension program, and local Coordinated Resource Management teams have numerous programs and initiatives to assist landowners in establishing grazing management plans. Notably, the Environmental Quality Incentives Program (EQIP), administered by the NRCS, offers financial and technical assistance to implement grazing plans and improvements. Many of these programs benefit wildlife and apply disturbance regime management principles; however, duplicating historic disturbance regimes is rarely a predominant management goal in itself.

Current Challenges for Effectively Managing for Historic Disturbance Regimes

Difficulty in quantifying historic disturbance regimes.

The integration of disturbance regimes into habitat management decisions is often difficult because of a lack of the scientific consensus about the historic frequency and extent of some disturbance regimes. This can be complicated by the large time scales that characterize various disturbance events and long-term changes in climate that can alter the type and frequency of disturbances. Additionally, there is debate as to whether historic management practices of indigenous peoples, such as fire setting, should be factored into efforts to manage for disturbance regimes. Others argue it is arbitrary to select a specific historic time period as the benchmark for modern management strategies.

Insufficient financial incentives to offset reduced economic returns and greater time requirements needed to incorporate disturbance regimes into habitat management.

Current habitat management strategies often emphasize managing for a single species or products such as livestock, game, or timber. It is often perceived that increased variability associated with disturbance regimes may reduce sustained yields. Competitive compensation in terms of direct monetary incentives or demonstrated increases in long-term production needs to be provided before historic disturbance regime strategies are widely adopted.

Human-safety and property-loss concerns often limit the degree to which natural disturbances can be allowed to proceed without intervention or can be actively prescribed in habitat management strategies.

Greater numbers of people and structures in areas where fires have historically been common have limited the ability of agencies to allow wildfires to burn or to incorporate prescribed fires into habitat management strategies. Similar

concerns may apply to natural flooding events by rivers and streams. Environmental concerns, including releasing carbon into the atmosphere, may limit future fire activities.

There is often a lack of understanding about the effects of historic disturbance regimes or the landscape implications of individual management actions.

At present, there is often insufficient funding for monitoring. This can limit the ability of agencies to understand the effects of existing management actions or the long-term effects of natural disturbances when they occur. Most disturbance studies monitor the influence of a single factor for a short period of time and are not directed toward evaluating multiple changes to natural systems. There is also a need for more research on how various types of historic disturbances and management actions interact with each other. Consequently, modeling efforts regarding the effects of historic disturbance regimes and their interactions are limited.

Inadequate public and political support for implementing actions that facilitate or duplicate historic disturbance regimes.

The complexity of natural systems and the multiple effects of historic disturbances make educational efforts challenging. The benefits of historic disturbance regime management can be long term and difficult to quantify. Existing knowledge is slow to be incorporated into policy. Additionally, increasing opposition is being raised regarding diminished aesthetic qualities which may follow management treatments such as prescribed fire.

Complexity of grant administration.

WGFD employee surveys have identified grant complexity as one of the leading impediments to expanding habitat work in Wyoming (WGFD 2016). Conflicting year-end funding cycles can make reporting for cooperative projects difficult. This complexity is compounded by differences in reporting requirements. Both these factors result in multiple annual funding reports occurring for individual projects,

typically all with a slightly different formats and content.

Insufficient budgets to administer management treatments.

Administering habitat treatments such as prescribed burns is expensive. Many natural resource agencies are experiencing budget freezes or reductions and have multiple competing interests. Lack of funding limits the ability to use existing funding sources due to difficulty in meeting matching fund requirements.

Regulatory demands, including the National Environmental Protection Act (NEPA) and the Endangered Species Act, can limit the ability to apply habitat management treatments that would duplicate historic disturbance regimes.

The NEPA requirements are lengthy and complex, and federal agencies must seek public comment at many points during the process. These requirements can prevent the application of treatments to duplicate historic disturbance regimes in a timely manner or diminish the cost-effectiveness of management actions due to the time and resources needed to complete the process. Concerns regarding the incidental taking of threatened or endangered species may also limit the ability to administer habitat treatments to duplicate historic disturbance regimes.

Uncertainty surrounding future climate change will compound difficulties for incorporating historic disturbance regimes into habitat management activities.

Climate change will alter the type, frequency, and intensity of historic disturbances as well as the composition of plants and animals responding to these events. While down-scaled climate models provide more spatially precise information about future climates, the uncertainties associated with the global models that were used to generate finer-scale models may remain unresolved, unquantified, and even magnified.

Recommended Conservation Actions

General Recommendations

Incentives should be provided to offset decreased financial returns or increased input costs that may accompany management strategies focused on replicating historic disturbance regimes.

Land and water management strategies are often focused on food, fiber, and energy production. Strategies intended to replicate historic disturbance regimes can result in reductions or delays in access to these resources. Before strategies that emphasize achieving specific ecological outcomes can be widely adopted, incentives need to be developed to compensate for financial losses which do not occur with traditional approaches that are more production-oriented. This is particularly true for privately-owned wildlife habitat.

Efforts should be made to link managing for historic disturbance regimes to natural resource issues of high public importance.

Managing for historic disturbance regimes can be expensive. Budget limitations will frequently require historic disturbance regime management strategies to be linked to high profile issues or the support of existing agency priorities. Disturbance regime management activities that reduce conditions favorable for bark beetle epidemics and catastrophic fires are good examples. Educational efforts are particularly important for habitat management treatments such as fire that have safety concerns, are highly visible, and may result in diminished grazing, recreation, or other uses during recovery periods.

Greater research and professional training efforts regarding interactions between historic disturbances should be pursued.

Most educational material and training for habitat and wildlife professionals concentrates on managing for individual species or products. There is relatively little information available about managing for multiple species and

ecological outcomes, or how various natural processes and disturbances influence one another. Current research gaps need to be identified in order to create effective training programs.

The implications of climate change on historic disturbance regimes should be reviewed and incorporated into habitat management and conservation activities as scientific knowledge improves.

Possible climate warming may result in major changes in historic disturbance regimes, plant and animal dynamics, and hydrological responses, and may further result in entirely unfamiliar species communities (Botkin et al. 2007). Existing climate-modeling science needs to be improved and validated to predict alterations to historic disturbance regimes in specific habitats. Research into localized climate change and associated ecological responses should be continually reviewed and considered in habitat conservation planning and wildlife species conservation and management.

Water-flow Regime Recommendations

Maintain U.S. Geological Survey streamflow monitoring gages.

The maintenance of streamflow gages is a fundamental first step in comparing present-day patterns to historic flow regimes. The U.S. Geological Survey (USGS) maintains a network of 7,292 stream-gaging stations, comprising more than 85% of the nation's total stations⁵. The continuation of gages is always uncertain and subject to federal funding availability. Through the National Streamflow Information Program (NSIP), the USGS can match non-federal investments in the Cooperative Water Program (CWP) on a 50:50 basis. Wyoming is a cooperator in the CWP through the State Engineer's Office, the Department of Environmental Quality, Department of

⁵ Stage and flow or discharge are the two key factors measured at most stream-gaging stations. Stage is water depth above some arbitrary datum, commonly measured in feet. Discharge is the total volume of water that flows past a point on the river for some period of time, usually measured in cubic feet per second or gallons per minute.

Agriculture, and several other entities. In addition to the economic and infrastructure concerns, streamflow and water-quality data available through these programs are critical for designing stream habitat restorations, designing fish passage approaches, administering water rights, monitoring and protecting water quality, managing wetlands, and for analyzing climate change and identifying response options. To ensure that USGS stream-gaging stations are maintained, steps or a process to provide unified state support of the NSIP and CWP programs should be identified.

Explore statutory solutions and administrative policies that allow private water-rights holders to temporarily change the use of existing water rights to in-channel flows for fish and wildlife and retain ownership of those rights without diminishing their priority or standing.

Although Wyoming law allows protection of base level streamflow, the opportunities for dedicating existing water rights to restore stream flows are limited. Slight modifications to existing temporary use legislation and instream flow law that would support temporary in channel uses would greatly improve the state's ability to address fish and wildlife improvements primarily on private land. Such added flexibility would also allow the state to participate more effectively with federal resource objectives on matters such as clean water, endangered species, and federal farm programs, but do so under a framework that allows existing private landowners and the state to retain ownership and control of water rights.

Increase beaver restoration including the creation of a stream-prioritization system for future reintroductions.

Beaver are keystone species in creating and maintaining riparian habitats through dam-building activities. In Wyoming, beaver are entirely absent or present in significantly reduced numbers from much of their historic range. A system should be established to analyze and prioritize streams for reintroductions. Prioritization should take into consideration potential conflicts through

unwanted flooding and tree damage. On average, 10 beavers are moved annually to promote riparian benefits. In 2015, a pilot effort began to test a Beaver Restoration Assessment Tool (BRAT; Wheaton and McFarlane 2014) in the Green River Basin. The tool uses GIS data to model historic and current beaver habitat to identify best locations to move beaver. This approach has been used extensively in Utah and may be applied across Wyoming pending the outcome of the pilot work.

Enhance fish passage work by fostering coordination among various groups.

Wyoming Water Strategy (2015) identifies collaboration on fish passage as one of 10 initiatives to maintain Wyoming's water resources. A variety of organizations have an interest in the ability of fish and other aquatic organisms to freely access habitats within their range. These organizations include the WGFD, Wyoming Water Development Commission, Trout Unlimited, Conservation Districts, NRCS, U.S. Fish and Wildlife Service, BLM, U.S. Forest Service, Bureau of Reclamation, and irrigation districts.

Fire Regime Recommendations

Increase the research and application of mechanical treatments to replicate historic fire regimes.

Safety and property-loss concerns will limit the use of fire as a management tool in areas of increased human development. This trend is likely to continue as Wyoming's population continues to grow. Additionally, some climate models for Wyoming predict a rise in temperature and the frequency and severity of drought, which may lead to more fires (Christensen et al. 2007). Under these circumstances, funding directed for climate-change adaptation should be made available for research and projects to duplicate the ecological effects of fire.

Increase fire-management budgets.

Prescribed burns can be expensive in terms of planning, treatment, and post-fire monitoring

and management. Long-term cost reductions through reducing future expenses in fighting catastrophic fires and associated property loss should be factored into budgeting for prescribed fires.

Herbivory Regime Recommendations

Working in cooperation with Wyoming livestock producers and federal and state agencies who issue, authorize, and manage grazing permits will be critical to implementing the following recommendations.

Management often needs to occur at a landscape level in order to replicate historic grazing regimes.

Individual pastures and grazing allotments are often not sufficiently large to replicate the historic mosaic of varying grazing intensities under which many native wildlife species evolved. Where practical, investigations should be conducted about managing multiple public grazing allotments to achieve the needed management scale. With adequate incentives, private lands could also be incorporated into these efforts. It should be noted that grazing strategies cannot be universally applied, but rather should be outcome and habitat specific. Additionally, the establishment of grazing strategies focused on duplicating past disturbance regimes may be limited in sites where there is insufficient knowledge of historic regimes and ecological processes, and wildlife species' responses.

Use livestock grazing and associated management as a tool to improve wildlife habitat and maintain native plant communities.

Livestock grazing and livestock grazing management practices can be used as an effective tool for improving wildlife habitat. Some research suggests that livestock grazing can be managed to benefit grassland bird species (Derner et al. 2009, Toombs et al. 2010) and improve forage quality on elk winter range (Clark et al. 2000). The use of livestock grazing to meet habitat objectives should be considered. In addition, it is possible that livestock grazing

disturbances before fire may decrease cheatgrass invasions (Davies et al. 2009).

The number of grassbanks should be increased to provide flexibility in applying range management practices.

Grassbanks or forage reserves refer to scenarios where forage is reserved for use and subsequently provided in exchange for management or conservation actions on another property. Such areas can also serve as relief valves or areas for grazing when wild fires remove forage from surrounding areas. Grassbanks have been a component of habitat treatments, such as prescribed fire, where grazing must be reduced or deferred. Both public and private lands⁶ have been used for grassbanks. Grassbanks can increase habitat treatment options for both land management agencies and private landowners.

Maintain hunter access to keep game herds within range capacity and evenly distribute grazing pressure.

Hunter harvest is often needed to keep big game herd populations within established herd objectives and within the carrying capacity of the land. Big game animals tend to congregate in areas where there is little hunting pressure or where hunting is prohibited, diminishing overall hunter harvest. Riparian and aspen habitats, two of Wyoming's most ecologically diverse habitats, can be locally impacted by overuse by big game animals, particularly elk. Sagebrush, mountain shrub, and some grassland communities have been degraded by overuse by big game in some areas. Efforts should continue to ensure adequate hunter access is maintained to ensure the health and productivity of these habitats.

⁶ Grassbanks on private land have often been owned by conservation groups such as The Nature Conservancy.

Evaluating/monitoring Success

Benchmarks should be developed to evaluate the success of habitat treatments based on desired ecological outcomes.

Currently, the success of management actions is often quantified by the extent of treatments, such as number of acres burned. More appropriately, success should be evaluated by the ability to achieve post-treatment vegetation goals. The development of new benchmarks would require additional monitoring and research to document multiple effects of management actions. Frequently, additional resources will be needed to allow for adequate post-treatment monitoring.

Monitor the landscape changes in vegetation-distribution patterns to help guide habitat management actions to support or replicate the effects of historic disturbance regimes.

Technology, including remote sensing analysis, is useful in tracking the size and distribution of vegetation communities, which can reflect the frequency and intensity of historic disturbances such as fire and, to a lesser extent, grazing. Evaluation of vegetation patterns can assist in both determining deviations from historic disturbance regimes and directing where habitat management actions should be administered and where natural disturbance should be allowed to proceed. This technique will require the further development of monitoring protocols and the identification of sample sites. Monitoring should be conducted in relation to the possible effects of climate change.

Increase the development and accessibility of the WGFD's fish passage database.

The WGFD has established a database to track the location, type, extent, and physical characteristics of fish passage barriers on Wyoming waters. The database can be used to prioritize passage improvement efforts within and across drainages. There are 1,174 total entries in the fish passage database as of January 3, 2017. Since 2012, there have been 342 entries into the fish passage database. These

entries have helped prioritize fish passage improvement projects, future field work, and allocating the fish passage grant money.

The potential effects of climate change should be monitored to determine alterations to historic disturbance regimes and appropriate management responses.

Warmer and drier conditions, which have been predicted for Wyoming (Christensen et al. 2007), will fundamentally alter historic disturbance regimes, especially in regards to their frequency and intensity. Greater habitat diversity associated with integrating disturbance regime principles into management practices will increase ecosystem resilience to climate change (Joyce et al. 2000). Research and habitat monitoring data related to climate change should continually be reviewed and adaptive management principles applied to disturbance regime management practices.

Continue to monitor water flows through USGS streamflow monitoring stations.

USGS streamflow monitoring stations and their value to monitoring streamflow and water quality is described on page II – 5 – 13.

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Additional Resources

USDA – Agricultural Research Service
High Plains Grasslands Research Station
8408 Hildreth Road
Cheyenne, WY 82009

Bureau of Land Management –
Wyoming State Office
5353 Yellowstone Road
Cheyenne, WY 82009
P.O. Box 1828,
Cheyenne, WY 82003-1828
Phone: (307) 775-6256
<http://www.blm.gov/wy/st/en.html>

Bureau of Reclamation
Wyoming Area Office
P.O. Box 1630
Casper, WY 82644
Phone: (307) 261-5671
<http://www.usbr.gov/gp/wyao/>

Natural Resources Conservation Services –
Wyoming State Office
100 East B Street, 3rd Floor
Casper, WY 82602-5011
P.O. Box 33124
Casper, WY 33124
Phone: (307) 233-6750
<http://www.wy.nrcs.usda.gov/>

The Nature Conservancy in Wyoming
258 Main Street, Suite 200
Lander, WY 82520
Phone: (307) 332-2971
<http://www.nature.org/wherewework/northamerica/states/wyoming/>

Trout Unlimited –Wyoming
250 North 1st Street
Lander, WY 82520
P.O. Box 64
Lander, WY 82520
Phone: (307) 332-6700
<http://wyomingtu.org/>

University of Wyoming Extension Cooperative
Service
Dept 3354
100 East University Avenue
Laramie, WY 82071
Phone: (307) 766-5124
<http://www.uwyo.edu/uwe/>

U.S. Fish and Wildlife Service
Wyoming Field Office
5353 Yellowstone Road, Suite 308A
Cheyenne, WY 82009
Phone: (307) 772-2374

U.S. Forest Service R2/R4
Wyoming Capitol City Coordinator
Herschler Building 3 West, Room 3603
122 West 25th St.
Cheyenne, WY 82002-0600
Phone: (307) 777-60870

United States Geological Survey
2617 East Lincolnway, Suite B
Cheyenne, WY 82001
Phone: (307) 778-2931
<http://www.usgs.gov/>

Wyoming Association of Conservation Districts
517 East 19th Street
Cheyenne, WY 82001
Phone: (307) 632-5716
<http://www.conservewy.com/index.htm>

Wyoming Department of Agriculture
2219 Carey Ave
Cheyenne, WY 82002
Phone: (307) 777-7321
<http://wyagric.state.wy.us/>

Wyoming Game and Fish Department
5400 Bishop Boulevard
Cheyenne, WY 82006
<http://wgfcms.wyo.gov/>

Fish Division
Phone: (307) 777-4559
Terrestrial Habitat Division
Phone: (307) 777-4565

Wyoming State Engineer's Office
4th Floor East
122 West 25th Street
Cheyenne, WY 82002
Phone: (307) 777-7354
<http://seo.state.wy.us/index.aspx>

Office of State Lands and Investments
Herschler Building, 3rd Floor West
122 West 25th St.
Cheyenne, WY 82001
Phone: (307) 777-7331
<http://lands.wyo.gov/>

Wyoming State Forestry Division
1100 West 22nd Street
Cheyenne, WY 82002
Phone: 307-777-7586
<http://wsfd.wyo.gov/>

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002
Phone: 307-777-7626
<http://wwdc.state.wy.us/>