REPORT

Assessing the Restoration Potential of Altered Rangeland Ecosystems in the Interior Columbia Basin

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Workshop participants agree on a long-term, landscape-scale restoration plan for the Interior Columbia Basin.

The Interior Columbia Basin (or Basin) is a diverse region that includes the United States' portion of the Columbia River watershed between the crest of the Cascade Range and the Continental Divide, and portions of the Klamath River Basin and the Great Basin to the south (Figure 1). The Basin encompasses nearly 144.3 million acres (58.4 million ha), of which nearly 53 percent is managed by the U.S. Department of Agriculture (USDA) Forest Service (FS) and the U.S. Department of the Interior (USDI) Bureau of Land Management (BLM) (Quigley and Arbelbide 1997).

In 1994, the chief of the U.S. Forest Service and the director of the BLM established the Interior Columbia Basin Ecosystem Management Project (ICBEMP) (Quigley and Arbelbide 1997). The project's primary objective was to develop specific products that would lead to the adoption of a scientifically sound, ecosystem-based strategy for managing FS- and BLM-administered lands in the Basin. The project organizers took an interagency approach to natural resource issues because such a method recognized the geographic differences, the complexity of resources and issues, and the multiple jurisdictions within the Basin. As part of the project, scientists conducted an assessment of the ecological and socioeconomic conditions, historical and future trends, risks and opportunities, as well as the consequences of implementing several management options within the Basin. Land managers used this information to develop broad-scale management strategies, which are outlined and analyzed in a Draft Environmental Impact Statement (DEIS), Supplemental EIS, and Final EIS for the Basin. Major policy questions that were considered included concerns about outcomes of current levels of activities on ecological and human systems, maintenance of long-term productivity, mimicking disturbance on the landscape, sustainability, biological diversity, rural communities, old-growth ecosystems, ecological health, adaptive management, and the viability of endangered and other species (Quigley and Arbelbide 1997). Although a record of decision was not completed for the project area, FS and BLM field units plan to use this wealth of scientific information and the content of the Final EIS to revise their existing land use plans over the next decade.

The authors of a recent landscape-scale assessment of the Basin (Quigley and Arbelbide 1997) found that numerous factors had altered many of the region's ecological components and processes. The most intensive alteration—agricultural development—has affected 17 percent of the land. Meanwhile, less intensive, but

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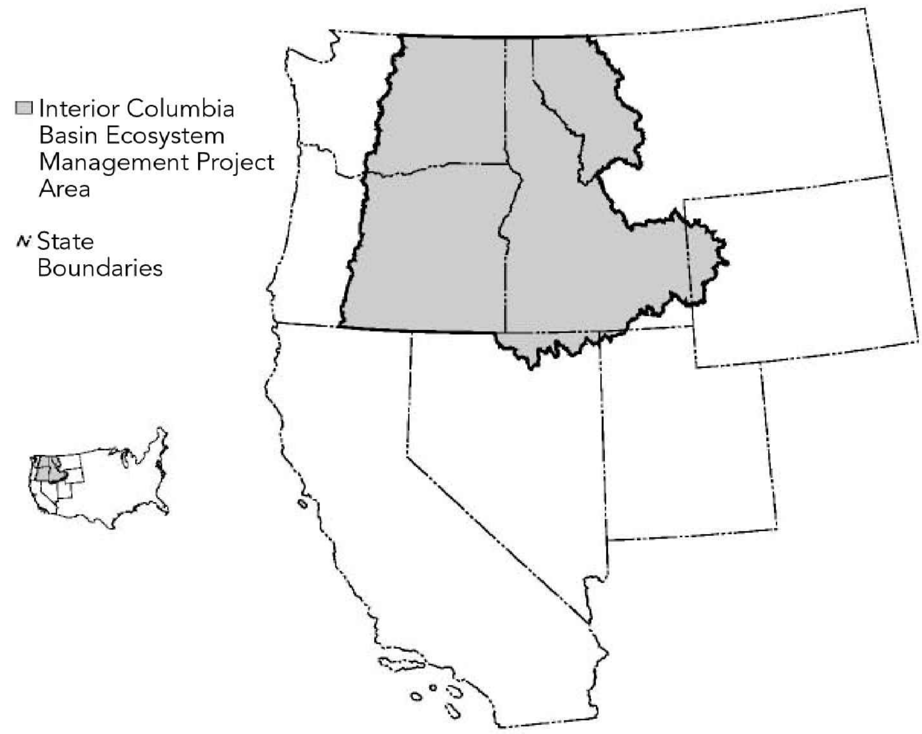

Figure 1. The Interior Columbia Basin Ecosystem Management Project Area includes large areas of Washington and Oregon, nearly all of Idaho, and smaller sections of Montana, Nevada, and Wyoming. *Courtesy of authors*

more extensive, alterations have occurred because of livestock grazing, changes in fire regimes, and invasive species. Altered fire regimes, for example, have resulted in greater fire severity and decreased fire frequency throughout the Basin. Meanwhile, invasive species have altered ecosystem processes across nearly half of the region, and livestock grazing has affected much of the Basin's rangeland and dry forest vegetation types.

This article provides an overview of the current condition of several vegetation types within the Basin and their prognosis for restoration and recovery. The information presented here is the result of a facilitated three-day Interior Columbia Basin Rangeland Issues Workshop held in Spokane, Washington in August 2000. The participants discussed the projected environmental consequences for FS- and BLM-managed rangelands and their associated animal species as expressed in the Supplemental Draft Environmental Impact Statement (SDEIS) for ICBEMP. The need for a survey and workshop originated from concerns about projected environmental consequences for rangelands and associated animal species expressed in the SDEIS for the Interior Columbia Basin Ecosystem Management Project.

Interior Columbia Basin Rangeland Issues Workshop Process

The ICBEMP Science Advisory Group invited 30 individuals from universities, private institutions, and federal and state agencies to participate in the three-day, facilitated workshop. Participants had expertise in both rangeland and wildlife ecology, and land management. In order to organize and facilitate discussion during the workshop, the ICBEMP Science Advisory Group posed four questions for the attendees to consider. The four questions were 1) What are the most likely causes for altered ecosystems on rangelands? 2) Which specific rangeland potential vegetation types (PVTs) are altered to the extent that restoration to their historical or natural conditions is unlikely? 3) What management options exist to restore potential vegetation communities, stabilize conditions, or prevent further alteration? and 4) If the objective is to improve conditions for greater sage-grouse (*Centrocercus urophasianus*), what options should be considered for prioritizing areas for conservation and restoration, and what techniques should be used?

For purposes of discussion, altered ecosystems were defined as any system that had been disturbed to the extent that ecosystem processes had changed or where long-term loss or displacement of native community types and components had occurred. Altered ecosystem processes included permanent changes in succession rates, creation of new disturbance pathways, changes in species composition, and permanent loss of productivity. The historical range of conditions that were in place for a century or more prior to Euro-American settlement (Hann and others 1997) were used as the agreed-upon reference point for change. Potential vegetation type was used as a representation of the biophysical properties of an area of land that is described by a late-seral homogeneous community. Coarse-scale PVTs, for example, are usually groups of similar habitat types or plant associations (Keane and others 1996).

Workshop participants discussed each of the 17 rangeland PVTs found within the Basin with regard to its importance and degree of alteration. All members at the workshop were asked to designate the four most-altered PVTs from their individual perspectives. The most-altered PVTs were then selected through a plurality of votes process. A discussion followed that focused on the prevalent causes of alteration for each of the most-altered PVTs. The workshop participants then discussed the potential methods and feasibility for restoration of each of the most-altered PVTs. Responses to the above questions varied considerably depending on the specific environments within the selected PVTs. Consequently, discussions focused on restoration opportunities, rather than identifying where restoration was not possible. Participants reached agreement on the feasibility of restoration through a group consensus process.

A draft summary of the workshop was developed from notes taken throughout the entire workshop. Each of the members was then asked to comment on the content of the conclusions reached for final summary. We developed this article from the final summary.

Most Prevalent Causes of Alteration

Of the many causes of alteration of rangeland vegetation in the Basin, the members of the workshop agreed on five causes considered most significant in terms of severity of effect and total area of the Basin affected. The five most important causes of alteration are: 1) introduction and spread of invasive species, 2) livestock grazing, 3) modified fire regimes, 4) climatic change, and 5) human presence (urbanization, agriculture, road development). The relative importance of these causes varies locally. For example, agriculture has had a major effect on the Snake River Plain and central Washington, but a minor effect on eastern Oregon and northern Nevada. The majority of workshop participants cited livestock grazing as the most common cause of rangeland alteration, followed by change in fire regime and the introduction of exotic plants and animals.

The five causes for PVT alteration generally occur in synergistic feedback loops, which are magnified by climatic changes and strongly interrelated in their alteration of rangeland vegetation. For example, the introduction of invasive species potentially alters the competitive relationships between species and other ecosystem processes (Vitousek and others 1996, Sakai and others 2001), and it frequently alters the fire regime, particularly when the invasive species are annual grasses (Pellant 1990, Whisenant 1990). Livestock grazing may alter the competitive relationship between species (Augustine and McNaughton 1998, Milchunas and others 1998). It may also increase the spread of invasive species (Mack 1986) and alter the fire regime (Bunting and others 1987, Miller and Wigand 1994). Given these interactions, it is usually impossible to identify a single or even a primary cause of vegetation alteration.

Characterizing Significantly Altered Potential Vegetation Types

Of the 17 dry grass, dry shrub, and cool grass PVTs identified in the Basin (Keane and others 1996), workshop participants identified six that have been significantly altered, have a high restoration priority, and that significantly influence management of federal lands (Figure 2, Table 1). These include: salt desert shrub, Wyoming big sage warm, basin big sage steppe, mountain big sage mesic west, mountain big sage mesic west with juniper, and *Agropyron* steppe.

Salt Desert Shrub

The salt desert shrub PVT (Figure 2a) is often dominated by one or more species of shrubs or sub-shrubs in the Chenopodiaceae and Asteraceae families. Although a large number of species occur in the salt desert shrub communities, a relatively simple composition exists on any given site because species distributions vary in relation to gradients of salinity and aridity (Knight 1994). Herbaceous plant coverage is sparse. Extensive areas have been affected by livestock grazing, particularly during the first half of the twentieth century, often followed by the introduction and subsequent spread of exotic plant species. During years with above average precipitation, annual grasses may be capable of supporting wildfires (Pellant and Reichert 1984). However, once burned, these sites become dominated by annual grasses resulting in higher fire frequency that may preclude re-establishment of the native shrub component.

Wyoming Big Sage Warm

The Wyoming big sage warm PVT (Figure 2b) includes primarily Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*) vegetation with minor amounts of other sagebrush species. Grass species typically include bluebunch wheatgrass (*Agropyron spicatum*), Sandberg bluegrass (*Poa secunda*) and Thurber needlegrass (*Stipa thurberiana*). This PVT has been severely affected by livestock grazing, agriculture, and invasive annual grasses, particularly cheatgrass (*Bromus tectorum*) and medusahead (*Elymus caput-medusae*). These introduced annual grasses produce abundant, highly flammable fuel. The result has been frequent fires, enhanced annual grass dominance, and near elimination of sagebrush species in many locations (Pellant 1990). Extensive areas have also been planted to introduced perennial wheatgrasses (*Agropyron* spp.).

Basin Big Sage Steppe

The basin big sage steppe PVT (Figure 2c) is dominated by basin big sagebrush (*Artemisia tridentata* subsp. *tridentata*). Native understory grass species typically include basin wildrye (*Elymus cinereus*) and bluebunch wheatgrass. Most sites have been affected by livestock grazing and invasive species or converted to agriculture. When surrounded or dominated by annual grass, they are subject to frequent fires that often eliminate sagebrush.

Mountain Big Sage Mesic West

The mountain big sage mesic west PVT (Figure 2d) is typically dominated by mountain big sagebrush (*Artemisia tridentata* subsp. *vaseyana*) and may include other shrubs and a variety of species such as Sandberg bluegrass, bluebunch wheatgrass, Idaho fescue (*Festuca idahoensis*), and arrowleaf balsamroot (*Balsamorhiza sagittata*). While invasive annual grasses occur within this PVT, they seldom dominate unless the site has been severely affected by livestock grazing or other disturbances. Much of this PVT had a shorter fire return interval during historic times (Houston 1973, Bunting and others 1987). Some changes in composition reflect this decrease in fire occurrence due to reduction of fine fuels by livestock grazing and active fire suppression.

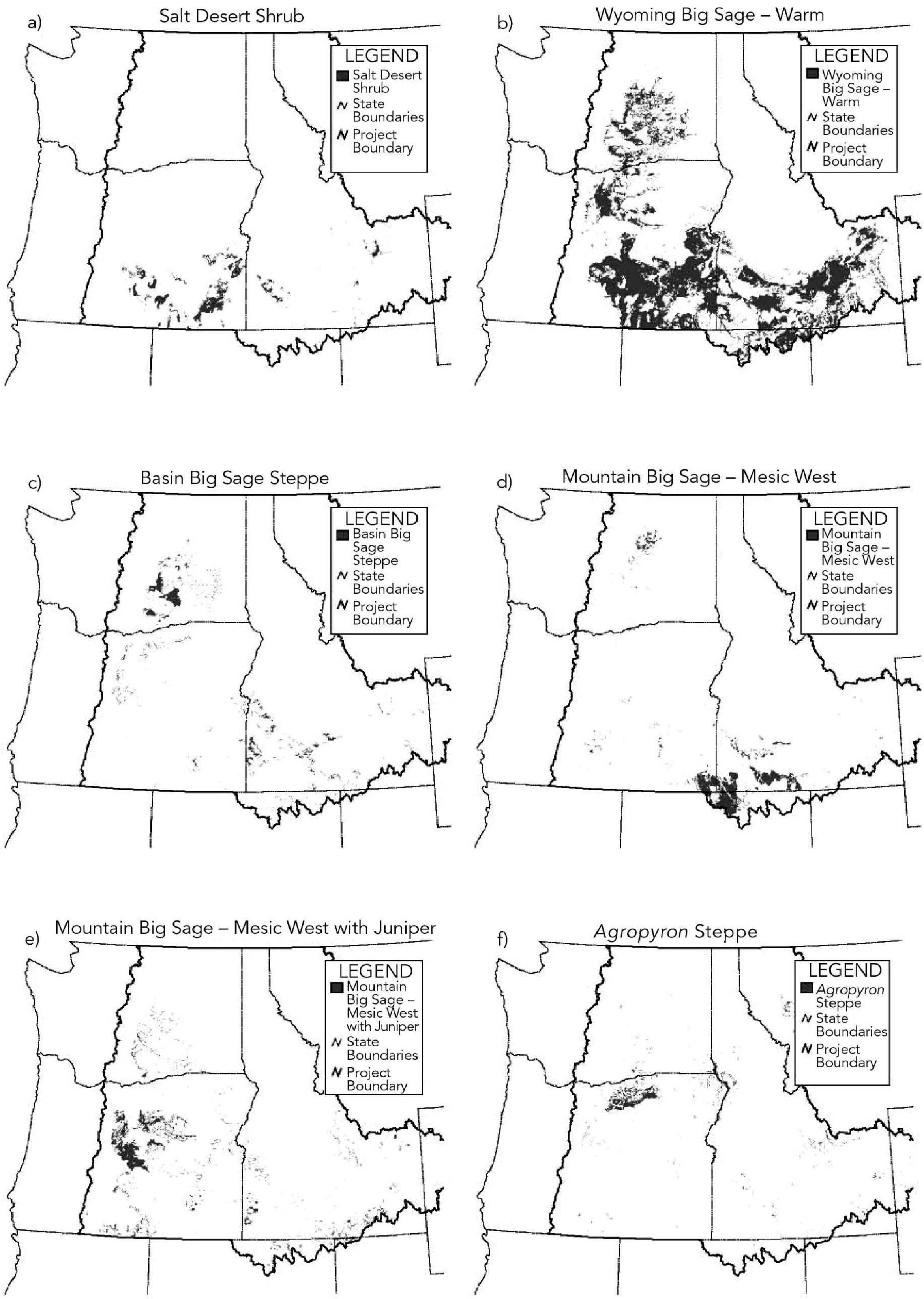

Figure 2. The location of the six most significantly altered potential vegetation types in the Interior Columbia Basin. They are mapped at a 1-km² scale. *Courtesy of ICBEMP*

Table 1. General site characteristics of selected potential vegetation types found within the Interior Columbia Basin (all lands).

Potential Vegetation Type (PVT)	General site characteristics (Areal extent within the Basin in million acres)[1]
Salt desert shrub	Typically occurs on poorly drained flats or basins with saline soils in a mosaic with slopes and ridges containing Wyoming big sagebrush- warm PVT or as a zone that receives less than 12 inches (30 cm) precipitation; typically less than 6,560 ft (2,000 m) elevation. Less extensive areas also occur on upland soils derived from marine or other highly saline sediments. (2.10)
Wyoming big sage warm	Encompasses the lower elevation and more arid portion of the Wyoming big sagebrush zone, typically less than 6,560 ft (2,000 m) elevation and receiving less than 12 inches (30 cm) of precipitation. Common on semiarid valley bottoms and lower mountain slopes. A dominant PVT of Snake River Plain, southeastern Oregon and central Washington. (23.70)
Basin big sage steppe	Generally occurs on lower elevation deep soils within the Basin. Due to the potential productivity of these soils, much of the original area has been converted to agricultural use. Remaining areas are typically smaller patches surrounded by Wyoming big sage warm PVT sites with more shallow soils. This PVT produces structures that are 3 to 10 ft (1 to 3 m) in height, depending on age of sagebrush and soil productivity. (1.80)
Mountain big sage mesic west	Common on mid to upper mountain slopes in central Oregon to southwest and south-central Idaho. Often occurring between the Wyoming big sage warm PVT or on opposing north facing more moist slopes and the coniferous zone; typically at elevations greater than 3,280 ft (1,000 m). (2.99)
Mountain big sage mesic west with juniper	Similar in composition to the mountain big sage mesic west PVT and occurs at the contact between the sagebrush steppe and juniper woodland zones in the Basin; typically greater than 3,280 ft (1,000 m) elevation. Juniper woodland is the late seral stage of this PVT. Common in central Oregon east to southwest and south-central Idaho. (3.21)
Agropyron steppe	Once extensive on canyon and lower valley slopes throughout the central portions of the Basin. Additional areas known as the Palouse Grassland were found in southeastern Washington, northeastern Oregon and northern Idaho, but these have largely been converted to agricultural use. (1.61)

[1] Area of selected PVTs is from unpublished ICBEMP data

Mountain Big Sage Mesic West with Juniper

The mountain big sage mesic west with juniper PVT (Figure 2e) has many shrub and herbaceous species in common with the mountain big sage mesic west PVT. Woodland vegetation dominates the late seral stages, which have increased greatly following Euro-American settlement. Utah juniper (*Juniperus osteosperma*) and singleleaf pinyon (*Pinus monophylla*) to the south, dominate woodlands in southeastern Idaho and adjacent Wyoming. Western juniper (*J. occidentalis*), without pinyon, dominates southwestern Idaho and eastern Oregon. Substantial changes in understory vegetation accompany succession from sagebrush steppe to juniper woodland (Miller and Wigand 1994, Miller and others 2000). Reduction in fire frequency has been commonly credited as the cause of woodland expansion, but livestock grazing, active fire suppression and climatic change have also been important contributing factors (Burkhardt and Tisdale 1976, Miller and Wigand 1994, Miller and Rose 1999).

Agropyron Steppe

Bluebunch wheatgrass and Sandberg bluegrass dominated the *Agropyron* steppe PVT (Figure 2f) under historical conditions. Much of that original area has since been converted to agricultural use, while livestock grazing and invasive species have severely altered the remainder. In the early twentieth century, cheatgrass and medusahead were introduced. More recently, common crupina (*Crupina vulgaris*), yellow starthistle (*Centaurea solstitialis*), and several species of knapweed (*Centaurea* spp.) have been introduced, and are displacing native species and earlier invaders on many sites. Wildfire is common and, while not essential, can aid in the conversion from native to the dominance of invasive species.

Management Options for Restoration

Workshop participants agreed that many PVTs will require active and/or passive restoration, although appropriate restoration techniques depend on the PVT and its condition. Particular sites within a PVT may vary along a continuum from only slightly altered to highly altered. Sites with slightly altered conditions typically contain low levels of invasive species, have been minimally affected by livestock grazing, and other human impacts, and have fire regimes that have not been significantly changed. Sites with highly altered conditions exhibit high levels of invasive species, livestock grazing, and other impacts. Fire may contribute to altered conditions by occurring either more or less frequently than it did prior to Euro-American settlement, depending on relative effects of herbivory, invasive species, human activity, and direct suppression. Restoration of slightly altered conditions may often be readily achieved by changing management of the causative factor(s)—for example, changing management of invasive species, livestock, and/or fire. Allen (1995) refers to this technique as passive restoration management. Severely altered conditions often include extirpation of natural species and their seed sources, loss of soil, and changes in the physical environment. Restoration of highly altered sites requires much more active management of the environmental conditions and intensive application of restoration techniques.

Salt Desert Shrub PVT

Slightly altered salt desert shrub sites usually have relatively intact shrub components. Invasive annuals often are present in low amounts. Restoration efforts should be focused on management of livestock grazing regimes and invasive species to prevent additional loss of native species and further increases in invasive species. In addition, fire should be actively suppressed. These sites are not likely to burn naturally due to low levels of fine fuels, except following periods of above average precipitation (Pellant and Reichert 1984, Knight 1994). However, once fire occurs, invasive annuals increase, which in turn increases the probability of subsequent fires. The salt desert shrub PVT often occurs in a mosaic with the Wyoming big sage warm PVT, which produces more biomass and has a greater fire potential. Fire must be controlled in surrounding vegetation of this type because when an intense fire starts in more flammable surrounding vegetation it may spread into adjacent salt desert shrub communities.

Severely altered salt desert shrub sites typically have lost shrub and subshrub components and have become dominated by invasive annual grasses and forbs. Restoration of native species usually requires control of non-native vegetation through mechanical means or herbicide treatments. Desired species are then established through seeding or transplanting of container or bare-root stock (Luke and Monsen 1984). Rehabilitation efforts in the past have often failed due to severe site conditions (Bleak and others 1965, Blaisdell and Holmgren 1984). It is critical to match plant species used in restoration to the soil type and precipitation regime.

Wyoming Big Sage Warm PVT

Slightly altered sites in this PVT typically have an intact shrub overstory of Wyoming big sagebrush and an understory modified by livestock grazing and invasive plants. Most native herbaceous plants are represented and soil surface cryptogams are present, generally under mature shrubs. The most common invasive grasses are cheatgrass on moderate- to light-textured soils and medusahead on heavier-textured soils. Invasive forbs include diffuse knapweed (*Centaurea diffusa*), spotted knapweed (*C. maculosa*), and skeletonweed (*Chondrilla juncea*). Restoration strategies in this PVT primarily include livestock management to prevent further depletion of the understory and fire suppression to prevent loss of the shrub component. Fire suppression may be difficult because these communities are often surrounded by stands of annual grasses that are prone to fire. Vegetation management treatments may be necessary to prevent further spread by invasive forbs.

Severely altered sites in this PVT present one of the greatest restoration challenges in the Basin due to the large area involved and the difficulty in controlling wildfires. Areas now dominated by invasive annual grasses currently burn once every five years compared to the historical fire return interval of 50-100 years (Whisenant 1990). Frequent fire has often depleted seed sources of sagebrush as well as fire-sensitive herb and grass species (such as Thurber needlegrass and Idaho fescue), and soils have often been eroded or modified. Restoration usually requires 1) fire suppression, 2) control of invasive plant competition, 3) planting of native seeds or transplants, and 4) changes in livestock management to encourage native plant recruitment. Efforts that do not provide for all four components are likely to fail.

Many severely altered sites in this PVT have been previously planted with introduced perennial wheatgrasses because of limited restoration technology and few alternative native seed sources. These perennial grasses protect sites from further invasion by exotic plant species and additional soil erosion. However, they are effective competitors that prevent the establishment of many native herbaceous plants and may actually impede restoration of species diversity on the site.

Basin Big Sage Steppe PVT

Few extensive areas of basin big sage steppe PVT remain except in central Washington (Figure 2c). Most occur in a mosaic with the Wyoming big sage warm PVT and have had similar histories as that PVT. The restoration options for the Wyoming big sage warm PVT apply equally to the basin big sage steppe PVT. Care must be taken to match sagebrush subspecies to site conditions. Once Wyoming big sagebrush becomes established, it may preclude or slow the development of basin big sagebrush. Relatively deep soils typical in this PVT may permit altered sites to respond more rapidly to management changes than in the Wyoming big sage warm PVT. When managed within a mosaic of Wyoming big sagebrush, more consideration must be given to livestock management because these sites are found on less steep terrain and closer to water, which also encourages livestock use.

Mountain Big Sage Mesic West PVT

The presence of invasive species and increased density of mountain big sagebrush characterize slightly altered conditions in this PVT. Dense mountain big sagebrush primarily reflects fire suppression. However, most native species are generally present. Slightly altered sites can respond rapidly to changes in the season of livestock use, grazing intensity, and fire management.

Severely altered sites within this PVT most frequently result from improper livestock management and lack of fire. Early seral native and invasive species typically dominant the understory. Mid- and late seral understory species often are substantially reduced. Seeding to replace depleted native herbaceous species may be necessary because rest from livestock grazing alone may not be effective (Holmgren 1976). Sagebrush density can be reduced by mechanical and fire treatments. Mountain big sagebrush rapidly becomes reestablished if a seed-producing population is present (Bunting and others 1987). Native herbaceous plants will increase on burned sites if there are adequate on-site seed sources.

Mountain Big Sage Mesic West with Juniper PVT

This PVT occurs in a mosaic with juniper or pinyon-juniper woodlands. Juniper often encroaches following alteration of the fire regime (Miller and Rose 1999). Slightly altered sites generally include small juniper and most native sagebrush steppe plant species. Restoration can be readily achieved by reintroducing fire. The livestock grazing regime must be altered at least temporarily, prior to burning, to permit adequate fuels to accumulate. Livestock grazing after burning must allow plant recovery, seed production, and recruitment.

Severely altered sites are typically woodlands. Woodland development normally results in a reduction of fine fuels, making these sites more difficult to burn. It also causes a depletion of sagebrush steppe species, increasing recovery time. Higher rates of erosion further increase recovery time (Davenport and others 1998). Some sites with substantial soil erosion may no longer be capable of supporting sagebrush steppe vegetation. Reduction of juniper overstory has been effectively achieved through cutting or other mechanical methods that may significantly reduce restoration costs.

Agropyron Steppe PVT

Slightly altered sites usually include a number of invasive species such as cheatgrass, Japanese brome (*Bromus japonicus*), medusahead, and yellow starthistle. It is virtually impossible to completely eliminate these well-adapted invasive species (Tisdale 1986). However, aggressive plant control measures and changes in season of livestock use and grazing intensity may prevent increasing dominance of invasive plants and additional displacement of native species. Perennial grass communities respond well to changes in livestock management. However, little is known about the restoration potential of perennial native forbs.

Invasive species dominate severely altered sites with few remaining native species. Aggressive, active measures are needed for restoration, including control of invasive species and seeding of native species. The steep topography and rocky soils of the few areas that have not been converted to agriculture often impede restoration measures that use ground machines.

Potential for Increasing Greater Sage-Grouse Populations

The Wyoming big sage warm, basin big sage steppe, mountain big sage mesic west, and mountain big sage mesic west with juniper PVTs are particularly important habitats for greater sage-grouse. Alteration of these PVTs has, at least in part, contributed to the Basin-wide decline of greater sage-grouse. Although greater sage-grouse were historically distributed throughout most of the Basin, most evidence indicates that their densities varied by season and habitat (Schroeder and others 1999). This variation has been exacerbated by long-term habitat loss and degradation (Connelly and others 2000). These changes in habitat quantity and quality have produced dramatic and widespread declines in the distribution and abundance of sage grouse (Connelly and Braun 1997, Braun 1998).

Historical evidence indicates that sage grouse heavily used all big sagebrush-dominated habitats during both the nesting and brood-rearing seasons (Table 2). Greater sage-grouse appear to prefer sagebrush habitats with a substantial herbaceous component (Fischer 1994, Apa 1998, Sveum and others 1998). This characteristic can be found to varying degrees in the Wyoming big sage warm, basin big sage steppe, mountain big sage mesic west, and mountain big sage mesic west with juniper PVTs. These big sagebrush-dominated PVTs differ in their likelihood of conversion to unsuitable habitat conditions and resilience to long-term degradation (Table 3). However, the authors of a recent study of the Basin (Wisdom and others 2002a) have predicted that more highly altered PVTs would be associated with local extirpation of greater sage-grouse.

Although populations of greater sage-grouse appear to have declined throughout their range, declines appear to be smallest in the relatively unaltered mountain big sagebrush mesic west PVT (Table 2). The mountain big sage mesic west PVT appears to have a high probability for successful restoration, primarily due to low levels of conversion of the type and the continued presence of native grasses and forbs (Table 4). The restoration of this PVT offers distinct opportunities to enhance and protect current populations of greater sage-grouse as well.

Unfortunately, restoration of the mountain big sage mesic west PVT may not be sufficient to ensure the long-term viability of grouse populations. This uncertainty is due to the patchiness and island-like nature of these relatively high-elevation habitats. It is also the result of the decline of habitat in lower-elevation Wyoming big sage warm and basin big sage steppe PVTs, large areas of which are connected to the higher-elevation mountain big sage mesic west PVT. Greater sage-grouse tend to use lower-elevation, sage-dominated habitats more during the winter—feeding on sagebrush leaves and buds (Remington and Braun 1985, Welch and others 1991) and escaping the snow in higher elevations (Hupp and Braun 1989). However, the sustainability of these lower-elevation PVTs, especially Wyoming big sage warm, has declined dramatically. Braun (1998) suggests that this decline in habitat quality is the clearest explanation for the historic declines in greater sage-grouse populations in North America. Regrettably, the significant degree of alteration in the Wyoming big sage warm PVT (Table 3) suggests that it will be difficult to restore this vegetation

Table 2. Historical and current use by sage grouse of several potential vegetation types within the Interior Columbia Basin analysis area. The descriptions in bold type represent declines in relative usage between historical and current.

	Historical seasonal use			Current seasonal use			Potential to increase population levels
Potential Vegetation Type	Nesting	Brood-rearing	Winter	Nesting	Brood-rearing	Winter	with restoration
Salt desert shrub	Low	Low	Low	Low	Low	Low	Low
Wyoming big sage warm	High	High	High	Moderate	Moderate	Moderate	High
Basin big sage steppe	High	High	High	Low	Low	Moderate	Moderate
Mountain big sage mesic west	High	High	Moderate	High	High	Moderate	Moderate
Mountain big sage mesic west with juniper	High	High	Moderate	Low	Low	Low	High
Agropyron steppe	Low	Low	Absent	Low	Low	Absent	Low

Table 3. Estimated continued changes in site characteristics without restoration intervention for each potential vegetation type.

	Potential vegetation type					
Characteristic	Salt desert shrub	Wyoming big sage warm	Big sage steppe	Mountain big sage mesic west	Mountain big sage mesic west with juniper	*Agropyron* steppe
Composition changed	Moderately high	High	High	Moderate	Moderately high	Moderately high
Physical processes changed	Low	High	High	Low	High	High
Degree of stability	Moderately high	Low	Moderately high	Low	Low	Low
Risk of continued decline	Moderately high	Moderately high	High	Moderately high	Moderately high	Moderately high
Predictability	High	High	High	High	High	High

Table 4. Feasibility and response time for restoration options in selected severely altered potential vegetation types within the Interior Columbia Basin.

	Response to restoration options			
Potential vegetation type	Ecological feasibility	Time required for response	Probability of success	Economic feasibility
Salt desert shrub	Low	Long	Low	Low to moderate
Wyoming big sage warm	Moderate	Moderate	Moderate	Moderate
Basin big sage steppe	Moderate	Moderate	Moderate	Moderate
Mountain big sage mesic west	High	Rapid	High	High
Mountain big sage mesic west with juniper	Moderate	Moderate	High	Moderate
Agropyron steppe	Low	Long	Low	Low

type (Table 4). Nevertheless, its restoration may be the best way to realistically ensure the viability of greater sage-grouse in the Basin (Hemstrom and others 2002, Wisdom and others 2002b).

Summary

Of the 17 PVTs in the Interior Columbia Basin described by ICBEMP, the workshop participants identified the previously described six PVTs as being the most altered as well as the most critical to rangeland plant and animal species on FS- and BLM- administered lands. Workshop participants agreed that the degree of alteration in these six potential vegetation communities varied considerably, but that mountain big sage mesic west has been altered the least. Salt desert shrub, *Agropyron* steppe, and mountain big sage mesic west with juniper have been moderately altered, and the basin big sage steppe and Wyoming big sage warm PVTs have been most altered.

The mountain big sage mesic west PVT offers the greatest probability of restoration success for greater sage-grouse and Columbian sharp-tailed grouse due to the continued presence of native grasses and forbs and relatively rapid response to active restoration practices. The probability for success in other PVTs is lower.

Successful restoration of greater sage-grouse will require special emphasis on the spatial distribution of habitats, encompassing the mosaics in which key habitats are embedded, together with their fragmentation and connectivity.

One of the greatest challenges to restoring critical rangeland environments within the Interior Columbia Basin is the need to sustain restoration activities over long time periods. In many cases, managers should expect long time lags (in excess of 15 years) before vegetation responds. Populations of vertebrates associated with rangelands may require at least as long to respond to vegetation restoration.

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