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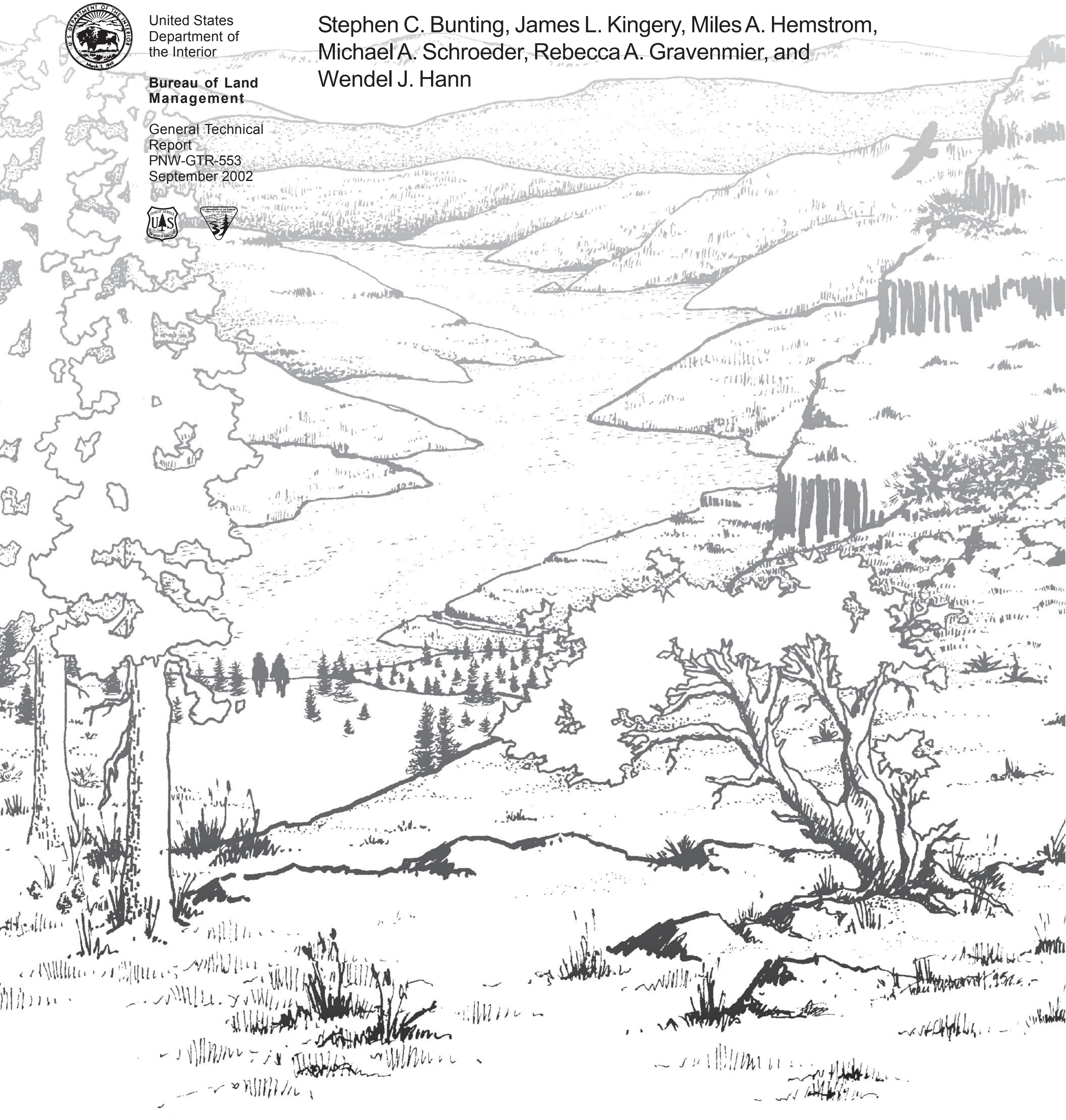

Authors

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Interior Columbia Basin Ecosystem Management Project: Scientific Assessment

Thomas M. Quigley, Editor

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Interior Columbia Basin Ecosystem Management Project

Executive Summary

A workshop was held to address specific questions related to altered rangeland ecosystems within the Interior Columbia basin (hereafter referred to as the basin). Focus was primarily on lands administered by the Forest Service (FS) and Bureau of Land Management (BLM). Altered ecosystems were considered to be those where human-induced or natural disturbances are of sufficient magnitude to change ecosystem processes. Long-term loss or displacement of native community types and reduction of productive potential makes it difficult or impossible to restore these ecosystems to historical conditions. Seventeen rangeland potential vegetation types (PVTs) that are found within the basin are briefly described. Descriptions of riparian or woodland vegetation are not included.

The major factors that have altered the 17 rangeland PVTs are discussed. The most common factors that have affected the PVTs found in the basin include livestock grazing, invasive species, and changes in fire regime. Climatic change has probably been an important factor, but it is difficult to identify the specific influences. Agricultural development has been an important factor on private lands, and in some cases, these influences have spread to adjacent BLM- and FS-managed lands.

Six rangeland PVTs were identified as the most seriously affected in the basin. Selection of these PVTs was related to the degree of alteration, areal extent of the PVT, and the overall importance to the basin as a whole. These include salt desert shrub, Wyoming big sagebrush–warm, basin big sagebrush, mountain big sagebrush–mesic west, mountain big sagebrush–mesic west with juniper, and wheatgrass grassland.

Many altered ecosystems may be restorable, but success of these efforts is variable and untested for many restoration methods. Options exist to restore some altered rangeland ecosystems by restoring native plant communities, stabilizing ecosystem processes, reducing the spread of invasive species, or conserving existing biota. In some altered conditions, these options have a relatively high probability of success over the short term with low to moderate cost at the site scale. However, in other altered conditions, restoration options are expensive, have a low probability of success, and require long timeframes. Failure to restore the most severely altered PVTs will affect the future stability of these areas.

The PVTs differed considerably in the extent to which vegetation composition had changed. The feasibility of restoration of the six most severely altered PVTs in the basin was discussed by the workshop participants from four perspectives. The overall feasibility of restoration of the mountain big sagebrush–mesic west was high. Restoration could primarily be accomplished through changes in the management of fire and livestock grazing. Potential recruitment of native species was high where seed sources were present and alteration by invasive species was low. These management changes could be enacted relatively inexpensively, and the vegetation would respond rapidly to the changes. Restoration of salt desert shrub and wheatgrass grassland PVTs was thought to be the least feasible. Restoration of these PVTs would in most cases require control of invasive species and seeding of native species. In addition, soil and topographic features limit many types of restoration practices. Recruitment rates of native species are low owing to severe environmental conditions such as low rainfall. Consequently, restoration would require a long time. Altered portions of the salt desert shrub are often dominated by annual grasses that greatly increase wildfire occurrence. Wildfires would need to be suppressed for many years to enable recruitment of the native shrubs in this PVT.

Restoration of those sites within the mountain big sagebrush–mesic west with juniper in the early stages of woodland development was highly feasible. The response would be similar to that of the mountain big sagebrush–mesic west. However, restoration of those sites that had advanced through succession to later woodland stages was less feasible. Juniper may have to be removed by using methods other than fire, such as cutting or other mechanical means. In many cases shrub and herbaceous species have been severely reduced on these sites. Shrubs and native perennial grasses have been successfully established through seeding, but little is known about the establishment of many of the native forbs associated with this PVT.

Altered sites in the Wyoming big sagebrush–warm and basin big sagebrush PVTs have a moderate restoration feasibility because of the presence of invasive species and subsequent reduction of recruitment of species native to these PVTs. Many areas are also subject to frequent wildfire that prevents sagebrush recruitment. Severely altered sites require seeding of native species. Availability of seed sources is limited, and the establishment requirements for seedlings for many of these species is not well understood.

Greater sage grouse (*Centrocercus urophasianus*) and Columbian sharp-tailed grouse (*Tympanuchus phasianellus*) are extremely important species within the basin because of their widespread historical distribution, declining status, and potential use of most of the PVTs. Sage grouse densities vary by season and PVT because of seasonal movements and their dependence on sagebrush leaves during winter, shrub and herbaceous cover during spring, and forbs during summer. This natural variation has been exacerbated by differences in quantity, quality, and configuration of the PVTs. Of the six PVTs evaluated by workshop participants, only Wyoming big sagebrush–warm, basin big sagebrush, mountain big sagebrush–mesic west, and mountain big sagebrush–mesic west with juniper were considered to be primary habitats for greater sage grouse. The mountain big sagebrush PVTs were believed to be relatively intact, thus offering the best opportunities for restoration. Unfortunately, these PVTs tend to be at relatively high elevations and somewhat isolated by vast areas of alternate habitats less suitable for sage grouse. The Wyoming and basin big sagebrush PVTs were believed to offer the greatest restoration challenge because of their dramatically altered characteristics. Nevertheless, their restoration may be the best way to realistically ensure the viability of greater sage grouse in the region, because of their immense size and the connections they provide between the smaller and more isolated PVTs. It is clear from this workshop that habitat management and restoration for greater sage grouse will require planning and action over a vast landscape.

Similar to densities of greater sage grouse, densities of Columbian sharp-tailed grouse also vary by season and PVT. Sharp-tailed grouse tend to depend on herbaceous cover during spring, forbs during summer, and deciduous shrubs and trees during winter. Of the six PVTs evaluated by workshop participants, only mountain big sagebrush–mesic west, mountain big sagebrush–mesic west with juniper, and wheatgrass grassland are likely to be primary habitats for sharp-tailed grouse. Although other PVTs also can be used by sharp-tailed grouse, their usage is often dependent on their proximity to a primary PVT. The mountain big sagebrush PVTs seem to be relatively intact, thus offering excellent opportunities for restoration. In contrast, the wheatgrass grassland has largely been eliminated by conversion to cropland. Among all 17 PVTs in the basin, the relatively high-elevation PVTs appear to be the most important for sharp-tailed grouse. These include Wyoming big sagebrush–cool, threetip sagebrush, mountain big sagebrush (four types), wheatgrass grassland, mountain shrub, and fescue grassland (two types). Because many of these habitats are small, isolated, and long distances from existing populations of sharp-tailed grouse, it is likely that restoration should be focused in specific areas where there are opportunities to expand or connect existing populations. As with greater sage grouse, management and restoration of Columbian sharp-tailed grouse will require planning and action over a vast landscape.

Abstract

Bunting, Stephen C.; Kingery, James L.; Hemstrom, Miles A.; Schroeder, Michael A.; Gravenmier, Rebecca A.; Hann, Wendel J. 2002. Altered rangeland ecosystems in the interior Columbia basin. Gen. Tech. Rep. PNW-GTR-553. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 71 p. (Quigley, Thomas M., ed.; Interior Columbia Basin Ecosystem Management Project: scientific assessment).

A workshop was held to address specific questions related to altered rangeland ecosystems within the interior Columbia basin. Focus was primarily on public lands administered by the Forest Service and Bureau of Land Management. Altered ecosystems were considered to be those where human-induced or natural disturbances are of sufficient magnitude to affect ecosystem processes, causing long-term loss or displacement of native community types and loss of productivity, making it difficult or impossible to restore these ecosystems to historical conditions. Seventeen rangeland potential vegetation types (PVT) were identified by the Interior Columbia Basin Ecosystem Management Project and briefly described. Reasons that rangeland ecosystems are altered include presence of invasive species, uncharacteristic grazing effects, climatic change, change in fire regime, and other factors related to human presence. However, primary causes of alteration and restoration potential differ among PVTs. Some altered rangeland ecosystems may be restored by stabilizing ecosystem processes, restoring native plant communities, reducing the spread of invasive species, or conserving existing biota. In some altered conditions, these options have a relatively high probability of success over the short term with low to moderate cost at the site scale. However, in other altered areas, restoration options are expensive, have a low probability of success, and require long timeframes. Restoration of rangeland PVTs is also necessary for the survival of some animal species whose populations are in decline such as the Columbian sharp-tailed grouse and greater sage grouse.

Keywords: Altered rangelands, Columbia sharp-tailed grouse, greater sage grouse, restoration, potential vegetation types, rangeland ecosystems.

Contents

Introduction

The interior Columbia basin (hereafter referred to as the basin) is a diverse region including that portion of the Columbia River drainage within the United States between the crest of the Cascade Range on the west to the Continental Divide on the east (fig. 1). In addition, it includes a portion of the Klamath River basin and the Great Basin to the south. It encompasses 58.4 million ha nearly 53 percent of which is managed by the USDA Forest Service (FS) and USDI Bureau of Land Management (BLM) (Quigley and Arbelbide 1997). A recent landscape assessment of the basin provided detailed information on the broad-scale current conditions and trends within the basin (Hann et al. 1997). The assessment found that numerous factors had altered many ecological components and processes. The most intensive alteration, agricultural development, had affected 17 percent of the area. Other factors that were less intensive but more extensive had affected large portions of the basin. Fire regimes had been altered, resulting in greater fire severity and decreased fire frequency. Invasive species had altered ecosystem characteristics across nearly 47 percent of the basin. Improper livestock grazing had affected much of the rangeland and dry forest vegetation types. Improper grazing is defined as the degree of use of the current year's growth that results in the reduction of the long-term productivity of the site and failure of the site to meet the land management objectives. Improper use may result from one or a combination of factors including season of grazing use, duration of use, or numbers of animals. Hemstrom et al. (in press) and Wisdom et al. (in press) examined the conditions and likely future trends of rangelands and associated species in the basin, concluding that further deterioration is likely in the future. The landscape assessment and rangeland projections were the impetus for a workshop to specifically address altered rangelands within the basin.

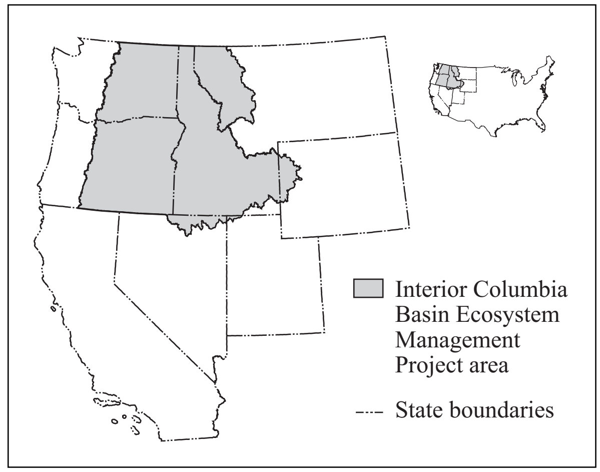

Figure 1—Interior Columbia Basin Ecosystem Management Project area.

Methods

The following is a summary of a collaborative survey of vegetation and vertebrate ecologists concerning altered rangeland communities within the basin. Conducted during a 3-day workshop held August 28–30, 2000, the survey represents the collective assessment of those attending the workshop. The workshop was attended by 31 individuals affiliated with federal, state, and private organizations from throughout the basin (app. 1). These people represented various disciplines related to plant and animal ecology. They had expertise in both research and land management on the various ecosystems found within the basin. The need for a survey and workshop originated from concerns on projected environmental consequences for rangelands and associated animal species considered in the Interior Columbia Basin Ecosystem Management Project (ICBEMP) Supplemental Draft Environmental Impact Statement (SDEIS). The primary focus was conditions of rangelands administered by the FS and BLM.

Information on historical and current rangeland vegetation was based on prior modeling by Hemstrom et al. (in press) and Hann et al. (1997). The foundation for this modeling was the vegetation information developed by Hann et al. (1997) that described 17 rangeland potential vegetation types (PVTs) in the basin and more than 50 cover type-structural stage combinations that are nested within these PVTs. A "potential vegetation type" (PVT) is defined as the representation of the biophysical properties of a portion of land that is described by the successional

Figure 2—Upper Salmon River Valley north of Stanley, Idaho, consisting of a mosaic of mountain big sagebrush–mesic east, riparian, and conifer PVTs. The riparian vegetation in the center will not be indicated on a vegetation map at the 1-km scale, and the area will be classified into a "dominant" PVT. (Photo by Stephen Bunting.)

convergence to a homogenous vegetation community. The concept is similar to that of a "potential natural community" (Jacoby 1989), except that the classification is at a coarser scale. Coarse-scale PVTs are usually a group of similar habitat types or plant associations (Keane et al. 1996). Potential vegetation types reflect biophysical conditions, disturbance regimes, and the suite of plant communities that can occupy sites over time (Hann et al. 1997). Menakis et al. (1996) describe the methods used in the development of the PVTs. Wisdom et al. (2000) provide a summary of the estimation methods and associated accuracy of the classification system. Vegetation cover and structure are transient and reflect the vegetation present at any given time. Cover types reflect the dominant species in upper canopy layers, whereas structural stages depict the horizontal and vertical arrangement of vegetative structures (e.g., canopy cover/height class) and are related to temporal vegetation development patterns (Hann et al. 1997). The base vegetation data included 41 cover types and 25 structural stages across the basin mapped at a resolution of 1-km^2 pixels (fig. 2) (Hann et al. 1997, Wisdom et al. 2000).

The reference point for change was the historical range of conditions resulting from 100- and 400-year simulations of conditions prior to Euro-American settlement. Hann et al. (1997) described simulations of the historical range of conditions and summarized late 1800s mapped conditions that were used as baseline. They assumed climatic conditions similar to those that exist at present. In this sense, their historical conditions could be considered expected conditions under current climate given disturbance regimes similar to those that preceded Euro-American settlement. Climatic conditions have not been stable over the last few hundred years (e.g., Tausch and Nowak 2000) and it is difficult to separate the influences of climate change from influences of land use and related changes in disturbances. However, we use the modeled range of variability from Hann et al. (1997) as a baseline from which to estimate those vegetation conditions that may have been altered by excessive livestock grazing and related factors. It is likely that some of the altered conditions we discuss include complex interactions between human uses and climatic change. In addition, future conditions may not be represented in either the simulated historical conditions or the present conditions. More work is needed to determine changes that could be addressed through management versus those occurring because of broader scale climate change.

Current vegetation maps were developed to reflect average conditions from 1985 to 1995, relying on a combination of satellite imagery, aerial photography, sample data, and a map of land-cover characteristics (Hann et al. 1997, Hessburg et al. 1999, Keane et al. 1996, Menakis et al. 1996). Each pixel was assigned one cover type and structural stage that reflected the likely dominant condition. Although each pixel is actually a mosaic of conditions at finer resolutions, the data were insufficient to refine resolution beyond 1 km. Estimates of conditions from these data, while perhaps necessary at the scale of the entire basin, are inherently limited by resolution and other factors. Wisdom et al. (2000) cite several limitations of particular relevance:

1. High variation in number of cover types within the cell. Mapping units composed of 1-km^2 cells typically contain three to five different cover types that occur in patch sizes of about 4 ha or larger. Typically, the cover type with the largest area or greatest biomass dominates the characteristics of the cell. In many cases, the named type only covers 20 to 30 percent of the cell area, but it has the largest area and thus dominates the reflectance shown in the remote-sensed data source.

2. High variation in cover type distribution within cells. Cover types that typically occur in small patches but are distributed abundantly and scattered throughout the cell also may dominate the characteristics of the cell. Accurate mapping of these types is dependent on summary of many cells or grouping of cover types, which again dampens the effect of high variation in type distribution within cells.

3. Small sample size. Cover types that occur in large patches, but that do not occur in many cells, will dominate the characteristics of those cells. Accurate mapping of these types is dependent on grouping of related types, which dampens the effect of small sample size.

4. Cover types with similar characteristics. Two or more cover types that have similar characteristics may dominate the characteristics of many cells. Accurate mapping of these types is dependent on finding accurate correlations with other mapped biophysical and human-caused characteristics. This dampens effects of errors in misclassification to other cover types that have similar prediction characteristics.

The area of each PVT on BLM- and FS-administered lands within the SDEIS planning area was classified into elevation and precipitation categories. Elevation was determined from a 500-m digital elevation model (DEM). Elevation categories were defined as less than 1,000, 1,000 to 2,000, and greater than 2,000 m for the low, moderate, and high classes, respectively. The precipitation categories were defined as less than 30, 30 to 61, and greater than 61 cm for the low, moderate, and high classes, respectively.

Excessive livestock grazing, as we use the term, is related to the degree to which grazing pressure by livestock exceeds that of native ungulates prior to Euro-American settlement. Our usage is similar to "uncharacteristic grazing" as described by Hemstrom et al. (2001). Hemstrom et al. (2001) estimated current excessive grazing levels through a combination of livestock grazing levels (data from FS and BLM field units), current potential vegetation types, cover types, and structural stages. They assumed excessive grazing in rangeland PVTs was indicated by very early seral condition or substantial presence or dominance by exotic plant species. Although ungulate grazing did occur historically, the vegetation of the study area was not generally adapted to high grazing pressure, particularly pressure from bulk-grazers such as cattle (Mack and Thompson 1982, Miller et al. 1994).

Questions Addressed

Workshop participants considered four primary questions related to the alteration and restoration of rangelands in the basin. They discussed each question, after which a majority opinion was developed. To the extent possible, the information presented here represents the majority opinion.

Question 1—What are the most likely causes for altered rangeland ecosystems?

For the workshop, altered ecosystems were defined as areas that have been disturbed to the extent that ecosystem processes have changed or that long-term loss or displacement of native community types and components has occurred. Decline of productive potential may have occurred as well, making restoration to predisturbance conditions through natural processes alone difficult. Altered ecosystem processes include permanent changes in succession rates, creation of new disturbance pathways, changes in species composition, and permanent decline of productive potential. Unfortunately, alteration includes changes owing to both climate and land management. This question focused on changes owing to land management, recognizing that climate change was responsible for some portion of altered conditions as well.

Question 2—Which specific rangeland potential vegetation types are altered to the extent that restoration to their historical or natural conditions is unlikely?

To address this question, participants considered all rangeland PVTs found within the basin and identified those that were most altered and would be difficult or perhaps impossible to restore to prior natural conditions. For example, some PVTs may be so altered owing to the introduction of invasive species that they cannot be restored.

Question 3—What management options exist to restore native communities within each potential vegetation community, to stabilize conditions, or to prevent alteration?

The following points were considered: (1) Which restoration category (restore, stabilize, or prevent alteration) is applicable? (2) Is restoration feasible? (3) Is the relative cost of restoration high, moderate, or low? (4) Will restoration require relatively little time (< 10 years), moderate amounts of time (11 to 49 years), or long-term efforts (> 50 years)? and (5) Is the likelihood of success for restoration efforts relatively low, moderate, or high?

Question 4—If the objective is to improve conditions for greater sage grouse (*Centrocercus urophasianus*) or Columbian sharp-tailed grouse (*Tympanuchus phasianellus*), what options can be considered for prioritizing areas for conservation and restoration? What conservation and restoration techniques can be used for key habitats and what are their values?

Responses to the above questions differed considerably depending on specific environments within the selected PVTs. It was agreed that most environments require active restoration, passive restoration, or both. Consequently, the focus of the discussions was on restoration opportunities, rather than identifying where restoration was not possible.

Rangeland PVTs Found Within the Basin

Seventeen dry grass, dry shrub, and cool shrub PVTs were identified in the basin (Hann et al. 1997, Keane et al. 1996). Menakis et al. (1996) described the process of PVT classification. The PVT descriptions were developed from many sources but particularly from the vegetation classification research of Daubenmire (1970), Hironaka et al. (1983), Johnson (1987), Mueggler and Stewart (1980), Tisdale (1986), Zamora and Tueller (1973) and the work of Knight (1994) (table 1). Workshop participants identified factors related to the importance of each PVT within the basin. Environmental characteristics (table 2) and past land use activities were identified for each

PVT that increased its likelihood of becoming altered. Riparian, woodland, and forest PVTs were not considered in this evaluation. Several rangeland PVTs include the possibility for conifer encroachment, particularly following reduction of fire frequency. We include these in rangelands because they were historically dominated by rangeland vegetation rather than conifers. In addition, these PVTs are generally labeled by their dominant rangeland condition under historical disturbance regimes rather than their tendency for conifer encroachment under current disturbance regimes. The following section provides a general description of the characteristic vegetal and environmental conditions for the 17 rangeland PVTs found within the basin. General management and restoration discussions are provided for 11 PVTs that are not discussed in detail in the "management options and feasibility of restoration" section of this manuscript.

Table 1—Relations between rangeland potential vegetation types found within the interior Columbia basin and previously published habitat type classifications[a]

Potential vegetation type (PVT)	Prior habitat type classifications[b]
Salt desert shrub	Daubenmire (1970) eastern Washington *Sarcobatus vermiculatus/Distichlis stricta* *Grayia spinosa/Poa secunda* *Eurotia lanata/Poa secunda*
	Mueggler and Stewart (1980) western Montana *Sarcobatus vermiculatus/Agropyron smithii* *Sarcobatus vermiculatus/Elymus cinereus*
	Note: Salt desert shrub habitat types have not been adequately described for most of the basin.
Wyoming big sagebrush–warm	Daubenmire (1970) eastern Washington *Artemisia tridentata/Agropyron spicatum*
	Hironaka et al. (1983) southern Idaho *Artemisia tridentata* subsp. *wyomingensis/Poa sandbergii* *Artemisia tridentata* subsp. *wyomingensis/Sitanion hystrix* *Artemisia tridentata* subsp. *wyomingensis/Stipa thurberiana* *Artemisia tridentata* subsp. *wyomingensis/Agropyron spicatum* *Artemisia tridentata* subsp. *wyomingensis/Stipa comata* *Artemisia tridentata* subsp. *xericensis/Agropyron spicatum* *Artemisia tridentata* subsp. *xericensis/Festuca idahoensis*
Wyoming big sagebrush–cool	Daubenmire (1970) eastern Washington *Artemisia tridentata/Festuca idahoensis*
	Mueggler and Stewart (1980) western Montana *Artemisia tridentata /Agropyron spicatum*
	Hironaka et al. (1983) southern Idaho *Artemisia tridentata* subsp. *wyomingensis/Poa sandbergii* *Artemisia tridentata* subsp. *wyomingensis/Sitanion hystrix* *Artemisia tridentata* subsp. *wyomingensis/Stipa thurberiana* *Artemisia tridentata* subsp. *wyomingensis/Agropyron spicatum*

Table 1—Relations between rangeland potential vegetation types found within the interior Columbia basin and previously published habitat type classifications[a] (continued)

Potential vegetation type (PVT)	Prior habitat type classifications[b]
Basin big sagebrush	Daubenmire (1970) eastern Washington *Artemisia tridentata/Agropyron spicatum* Hironaka et al. (1983) southern Idaho *Artemisia tridentata* subsp.*tridentata/Agropyron spicatum* *Artemisia tridentata* subsp.*tridentata/Stipa comata*
Threetip sagebrush	Daubenmire (1970) eastern Washington *Artemisia tripartita/Agropyron spicatum* *Artemisia tripartita/Festuca idahoensis* Mueggler and Stewart (1980) western Montana *Artemisia tripartita/Festuca idahoensis* Hironaka et al. (1983) southern Idaho *Artemisia tripartita/Agropyron spicatum* *Artemisia tripartita/Festuca idahoensis*
Low sagebrush–xeric	Daubenmire (1970) eastern Washington *Eurotia lanata/Poa secunda* Yensen and Smith (1984) southwestern Idaho *Ceratoides lanata/Artemisia tridentata* subsp. *wyomingensis* *Atriplex falcata/Artemisia tridentata* subsp. *wyomingensis* Note: Winterfat and other salt desert shrub habitat types have not been adequately described for most of the basin.
Low sagebrush–mesic	Daubenmire (1970) eastern Washington *Artemisia rigida/Poa secunda* Zamora and Tueller (1973) northern Nevada *Artemisia arbuscula/Stipa thurberiana* *Artemisia arbuscula-Purshia tridentata/Agropyron spicatum* *Artemisia arbuscula/Festuca idahoensis* *Artemisia longiloba/Festuca idahoensis* *Artemisia nova/Agropyron spicatum* *Artemisia nova/Agropyron inerme* *Artemisia nova/Stipa comata* Mueggler and Stewart (1980) western Montana *Artemisia arbuscula/Agropyron spicatum* *Artemisia arbuscula/Festuca idahoensis* Hironaka et al. (1983) southern Idaho *Artemisia arbuscula/Poa sandbergii* *Artemisia arbuscula/Agropyron spicatum* *Artemisia arbuscula/Festuca idahoensis* *Artemisia longiloba/Festuca idahoensis* *Artemisia nova/Agropyron spicatum* *Artemisia nova/Festuca idahoensis* *Artemisia rigida/Poa sandbergii* Johnson (1987) northeastern Oregon *Artemisia rigida/Poa sandbergii*

Table 1—Relations between rangeland potential vegetation types found within the interior Columbia basin and previously published habitat type classifications[a] (continued)

Potential vegetation type (PVT)	Prior habitat type classifications[b]
Low sagebrush–mesic with juniper	Zamora and Tueller (1973) northern Nevada *Artemisia arbuscula/Stipa thurberiana* *Artemisia arbuscula-Purshia tridentata/Agropyron spicatum* *Artemisia arbuscula/Festuca idahoensis* *Artemisia longiloba/Festuca idahoensis* *Artemisia nova/Agropyron spicatum* *Artemisia nova/Agropyron inerme* *Artemisia nova/Stipa comata*
	Hironaka et al. (1983) southern Idaho *Artemisia arbuscula/Poa sandbergii* *Artemisia arbuscula/Agropyron spicatum* *Artemisia arbuscula/Festuca idahoensis* *Artemisia longiloba/Festuca idahoensis*
Mountain big sagebrush–mesic east	Mueggler and Stewart (1980) western Montana *Artemisia tridentata /Festuca idahoensis* *Artemisia tridentata /Festuca scabrella*
	Hironaka et al. (1983) southern Idaho *Artemisia tridentata* subsp. *vaseyana/Agropyron spicatum* *Artemisia tridentata* subsp. *vaseyana/Festuca idahoensis* *Artemisia tridentata* subsp. *vaseyana-Symphoricarpos oreophilus/Agropyron spicatum* *Artemisia tridentata* subsp. *vaseyana-Symphoricarpos oreophilus/Festuca idahoensis*
Mountain big sagebrush–mesic east with conifers	Hironaka et al. (1983) southern Idaho *Artemisia tridentata* subsp. *vaseyana/Agropyron spicatum* *Artemisia tridentata* subsp. *vaseyana/Festuca idahoensis* *Artemisia tridentata* subsp. *vaseyana-Symphoricarpos oreophilus/Agropyron spicatum* *Artemisia tridentata* subsp. *vaseyana-Symphoricarpos oreophilus/Festuca idahoensis*
Mountain big sagebrush–mesic west	Daubenmire (1970) eastern Washington *Artemisia tridentata* subsp. *vaseyana/Festuca idahoensis*
	Hironaka et al. (1983) southern Idaho *Artemisia tridentata subsp. vaseyana/Agropyron spicatum* *Artemisia tridentata subsp. vaseyana/Festuca idahoensis* *Artemisia tridentata subsp. vaseyana-Symphoricarpos oreophilus/Agropyron spicatum* *Artemisia tridentata subsp. vaseyana-Symphoricarpos oreophilus/Festuca idahoensis*
	Johnson (1987) northeastern Oregon *Artemisia tridentata* subsp. *vaseyana/Festuca idahoensis* *Artemisia tridentata* subsp. *vaseyana-Symphoricarpos oreophilus/Bromus carinatus*

Table 1—Relations between rangeland potential vegetation types found within the interior Columbia basin and previously published habitat type classifications[a] (continued)

Potential vegetation type (PVT)	Prior habitat type classifications[b]
Mountain big sagebrush–mesic west with juniper	Hironaka et al. (1983) southern Idaho *Artemisia tridentata* subsp. *vaseyana/Festuca idahoensis* *Artemisia tridentata* subsp. *vaseyana-Symphoricarpos oreophilus/Festuca idahoensis*
Wheatgrass grassland	Daubenmire (1970) eastern Washington *Agropyron spicatum/Poa secunda* *Agropyron spicatum/Festuca idahoensis*
	Mueggler and Stewart (1980) western Montana *Agropyron spicatum/Agropyron smithii* *Agropyron spicatum/Poa sandbergii*
	Tisdale (1986) central Idaho *Apropyron spicatum-Poa sandbergii/Balsamorhiza sagittata* *Agropyron spicatum/Opuntia polyacantha*
	Johnson (1987) northeastern Oregon *Agropyron spicatum/Eriogonum heracleoides* *Agropyron spicatum/Poa sandbergii* *Agropyron spicatum-Poa sandbergii/Scutellaria angustifolia* *Agropyron spicatum-Poa sandbergii/Astragalus cusickii* *Agropyron spicatum-Poa sandbergii/Erigeron pumilus* *Agropyron spicatum-Poa sandbergii/Phlox colubrina* *Agropyron spicatum-Poa sandbergii/Opuntia polyacantha*
Antelope bitterbrush	Daubenmire (1970) eastern Washington *Purshia tridentata/Stipa comata* *Purshia tridentata/Agropyron spicatum* *Purshia tridentata/Festuca idahoensis*
	Mueggler and Stewart (1980) western Montana *Purshia tridentata/Agropyron spicatum* *Purshia tridentata/Festuca idahoensis* *Purshia tridentata/Festuca scabrella*
	Hironaka et al. (1983) southern Idaho *Purshia tridentata/Stipa comata* *Purshia tridentata/Agropyron spicatum*
	Johnson (1987) northeastern Oregon *Purshia tridentata/Festuca idahoensis-Agropyron spicatum* *Purshia tridentata/Agropyron spicatum*
Mountain shrub	Mountain shrub habitat types have not been described for the basin.
Fescue grassland	Daubenmire (1970) eastern Washington *Festuca idahoensis/Symphoricarpos albus* *Festuca idahoensis/Rosa nutkana*

Table 1—Relations between rangeland potential vegetation types found within the interior Columbia basin and previously published habitat type classifications[a] (continued)

Potential vegetation type (PVT)	Prior habitat type classifications[b]
Fescue grassland (continued)	Mueggler and Stewart (1980) western Montana
	Festuca scabrella/Festuca idahoensis
	Festuca idahoensis/Agropyron spicatum
	Festuca idahoensis/Carex filifolia
	Festuca idahoensis/Stipa richardsonii
	Festuca idahoensis/Deschampsia caespitosa
	Tisdale (1986) central Idaho
	Festuca idahoensis/Agropyron spicatum
	Festuca idahoensis/Koeleria cristata
	Carex hoodii/Festuca idahoensis
	Johnson (1987) northeastern Oregon
	Festuca viridula/Lupinus laxiflorus
	Festuca idahoensis/Koeleria cristata
	Festuca idahoensis/Agropyron spicatum
	Festuca idahoensis-Agropyron spicatum/Lupinus sericeus
	Festuca idahoensis-Agroptron spicatum/Balsamorhiza sagittata
	Festuca idahoensis-Agropyron spicatum/Phlox colubrina
	Festuca idahoensis/Carex hoodii
Fescue grassland with conifers	Mueggler and Stewart (1980) western Montana
	Festuca scabrella/Festuca idahoensis
	Festuca idahoensis/Agropyron spicatum
	Festuca idahoensis/Carex filifolia
	Festuca idahoensis/Stipa richardsonii
	Festuca idahoensis/Deschampsia caespitosa
	Tisdale (1986) central Idaho
	Festuca idahoensis/Agropyron spicatum
	Festuca idahoensis/Koeleria cristata
	Festuca viridula/Lupinus laxiflorus
	Johnson (1987) northeastern Oregon
	Festuca viridula/Lupinus laxiflorus
	Festuca idahoensis/Koeleria cristata
	Festuca idahoensis/Agropyron spicatum
	Festuca idahoensis-Agropyron spicatum/Lupinus sericeus
	Festuca idahoensis-Agroptron spicatum/Balsamorhiza sagittata
	Festuca idahoensis-Agropyron spicatum/Phlox colubrina
	Festuca idahoensis/Carex hoodii

[a] Johnson (1987) classified vegetation into “plant associations” rather than the landscape into “habitat types.”

[b] Habitat type names included are those used by the authors. Plant nomenclature can be updated with the USDA NRCS plants database.

Table 2—General site characteristics of 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 ha)[a]
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 30 cm precipitation; typically <2000 m elevation. Less extensive areas also occur on upland soils derived from marine or other highly saline sediments. (0.86)
Wyoming big sagebrush–warm	Encompasses the lower elevation (<2000 m) and more arid portion of the Wyoming big sagebrush zone, typically <2000 m elevation and receiving less than 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. (9.59)
Wyoming big sagebrush–cool	Encompasses the higher elevation (>1000 m) and colder portion of the Wyoming big sagebrush zone. This PVT has a more continental climatic regime and colder winter temperatures that limit influence of annual grasses more than in the Wyoming big sagebrush–warm PVT. Common in valley bottoms and lower slopes of cental Oregon, northern Nevada, eastern Idaho, and southwestern Montana. (0.66)
Basin big sagebrush	Generally occurs on lower elevation deep soils within the basin. Because of 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 sagebrush–warm PVT sites with shallower soils. This PVT produces structures that are 1 to 3 m tall, depending on age of sagebrush and soil productivity. (0.73)
Threetip sagebrush	Widespread geographically throughout sagebrush-dominated portion of the basin but seldom locally abundant. Found intermixed with Wyoming big sagebrush vegetation but typically on north or east slopes. This PVT is most prevalent in southeastern Idaho and southwestern Montana where summer precipitation is not as limiting. This sagebrush species resprouts after fire, but this varies widely locally. (0.18)
Low sagebrush–xeric	Dominated by winterfat that occurs in a mosaic with Wyoming big sagebrush communities. The mosaic is determined primarily by the salinity of the sediment-derived soils. Understory includes Gardner's or sickle saltbush and Sandberg bluegrass. Sites often are dominated by cheatgrass after fire. (0.36)
Low sagebrush–mesic	Sites dominated by one of several species of dwarf sagebrushes including low, stiff, black, Owyhee, and little sagebrush. Low sagebrush is the most extensive in the basin. This PVT generally occurs on distinctive soils that differentiate the sites from those supporting the surrounding big-sagebrush-dominated PVTs. Stiff sagebrush also occurs in association with wheatgrass grassland and dry forest PVTs. Herbaceous coverage and production are less than in surrounding PVTs. (0.74)
Low sagebrush–mesic with juniper	Sites are similar to low sagebrush–mesic but occur in association with juniper woodlands. (0.05)

Table 2—General site characteristics of potential vegetation types found within the interior Columbia basin (all lands) (continued)

Potential vegetation type (PVT)	General site characteristics (areal extent within the basin in million ha)[a]
Mountain big sagebrush–mesic east	Typically dominated by mountain big sagebrush, other shrubs species, and a variety of herbaceous species. Occurs primarily in valley bottoms and mountain slopes in southwestern Montana and eastern Idaho. Much of this PVT had a shorter fire return interval during historical times, and changes in composition such as increased sagebrush coverage and decreased herbaceous species coverage reflect this decrease in fire occurrence. Invasive annual grasses are present but have not affected the dynamics of disturbance and composition to the extent of many other sagebrush steppe vegetation types. (1.92)
Mountain big sagebrush–mesic east with conifers	Composition and geographical range is similar to that of the mountain big sagebrush–mesic east PVT except having a greater conifer component. Historically this PVT probably occurred as a mosaic of mature conifer stands interspersed with grassland, mountain big sagebrush steppe, young developing conifer, and mature conifer communities. Decreased fire occurrence has resulted in more continuous conifer overstory development and conifer expansion into adjacent sagebrush-dominated communities. (0.09)
Mountain big sagebrush–mesic west	Common on mid to upper mountain slopes from central Oregon to southwest and south-central Idaho. Often occurring within the Wyoming big sagebrush–warm PVT or on opposing north-facing more moist slopes and the coniferous zone; typically at elevations >1000 m. (1.18)
Mountain big sagebrush–mesic west with juniper	Similar in composition to the mountain big sagebrush–mesic west PVT and occurs at the contact between the sagebrush steppe and juniper woodland zones in the basin; typically >1000 m elevation. Juniper woodland is the late seral stage of this PVT. Common from central Oregon east to southwest and south-central Idaho. (1.31)
Wheatgrass grassland	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. (0.63)
Antelope bitterbrush	Typically found in a mosaic of dry forest and mountain big sagebrush–mesic west PVTs in north-central Washington and southern Oregon. Usually located on coarse-textured soils and dry aspects. Herbaceous understory often is altered by past livestock grazing and invasive species. (0.18)
Mountain shrub	Occurs at the transition between the upper shrub steppe and dry forest PVTs and includes a variety of shrub species common to these communities. May also occur as stringers of shrub-dominated vegetation in the draws of upper watersheds. (0.03)
Fescue grassland	Occurs at transition between wheatgrass grassland and coniferous forest PVTs in northern Montana, central Idaho, and northeastern Oregon. Composition is usually dominated by rough fescue, Idaho fescue, and bluebunch wheatgrass. (0.29)

Table 2—General site characteristics of potential vegetation types found within the interior Columbia basin (all lands) (continued)

Potential vegetation type (PVT)	General site characteristics (areal extent within the basin in million ha)[a]
Fescue grassland with conifers	Herbaceous composition similar to fescue grassland PVT but occurring in a mosaic of coniferous forest PVTs. Often contains sparse overstory of conifers such as Douglas-fir and lodgepole pine. Most common in western Montana, and northeastern Oregon. (1.39)

[a] Area of PVTs is from unpublished ICBEMP data on file with: USDA Forest Service, Pacific Northwest Research Station, P.O. Box 3890, Portland, OR 97208.

Salt Desert Shrub PVT

The salt desert shrub PVT is often dominated by one or more species of shrubs or half-shrubs in the Chenopodiaceae and Asteraceae families (Blaisdell and Holmgren 1984) (figs. 3 and 4). A large number of species occur in the salt desert shrub communities. However, in any given site, a relatively simple composition exists because the species distributions vary in relation to gradients of salinity and aridity (Knight 1994, West 1988). Common plant community dominants occurring in this PVT include black greasewood,[1] fourwing saltbush, winterfat, shadscale, and budsage. As salinity increases, the site is dominated by winterfat, shadscale, Gardner's saltbush and finally black greasewood. Greasewood also occupies the less arid sites. Herbaceous plant coverage is sparse.

Biological soil crusts are a critical component of salt desert shrub vegetation, providing soil stability and nutrient input into the ecosystem (Mayland et al. 1966, West and Skujins 1977). They appear to be more resilient to livestock use when wet during spring than later in the year when they become more susceptible to mechanical damage (Anderson et al. 1982a, 1982b). Johansen et al. (1984) found that wildfire severely reduced biological soil crusts in a shadscale-greasewood community. Moss and algal coverage recovered within 5 years postburn. Lichen coverage, however, was less than 50 percent of the unburned sites after 5 years.

Livestock and feral horse grazing has affected extensive areas, particularly during the first half of the 20th century. Subsequently, invasive species have entered many areas of this PVT. During years with above-average precipitation, annual grasses may develop herbaceous biomass capable of supporting unwanted wildland fire (wildfires) (Pellant and Reichert 1984). Fire occurrence further favors communities dominated by annual grasses.

Slightly altered salt desert shrub sites usually have relatively intact shrub components. Invasive annuals are often present in low amounts. These sites are unlikely to burn because they have little fine fuel except after periods of above-average precipitation (Knight 1994, Pellant and Reichert 1984). Once fire occurs, however, invasive annuals increase greatly, increasing the probability of subsequent fires. The salt desert shrub PVT often occurs in a mosaic with the Wyoming big sagebrush–warm PVT, which has greater biomass production and fire potential. Fire often starts in this PVT and spreads to salt desert shrub communities.

Severely altered salt desert shrub sites typically have lost shrub and half-shrub components and have become dominated by invasive annual grasses and forbs. Natural recruitment of native species is inhibited by competition from annual species, lack of seed sources, recurrent fires, and herbivory. Once burned, these sites often become dominated by annual grasses, increasing the risk of subsequent fire occurrence. Frequent fires may preclude reestablishment of the native shrub component and increase the extent of the disturbed area.

[1] Plant taxonomy nomenclature follows that used by the USDA Natural Resources Conservation Service (USDA NRCS 2001; see app. 2).

End of Part A. Click here for Part B.

Part B — continued from Part A

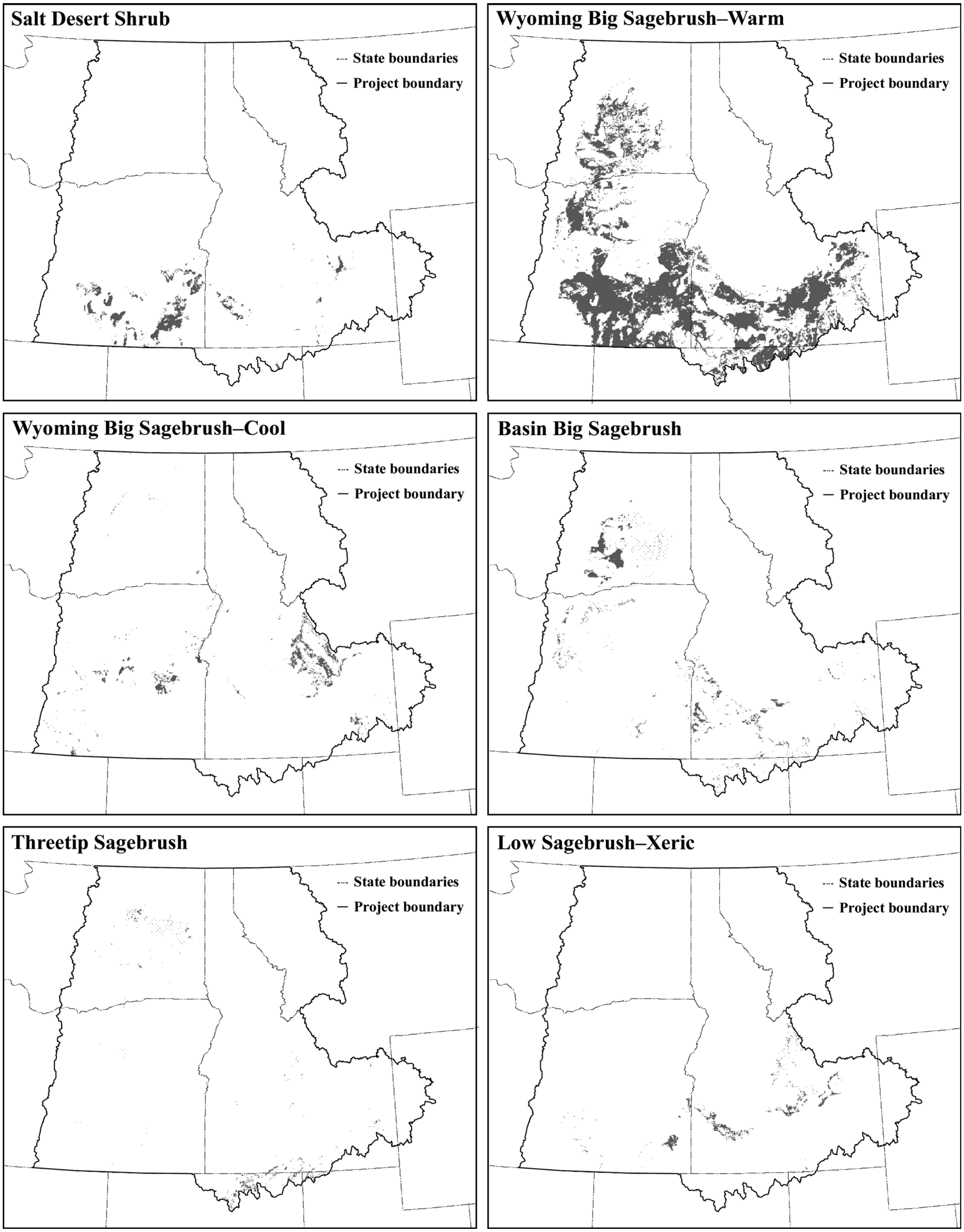

Figure 3—Area included in the salt desert shrub, Wyoming big sagebrush–warm, Wyoming big sagebrush–cool, basin big sagebrush, threetip sagebrush, and low sagebrush–xeric potential vegetation types within the interior Columbia basin as mapped at the 1-km scale. ICBEMP data on file with: USDA Forest Service, Pacific Northwest Research Station, P.O. Box 3890, Portland OR 97208.

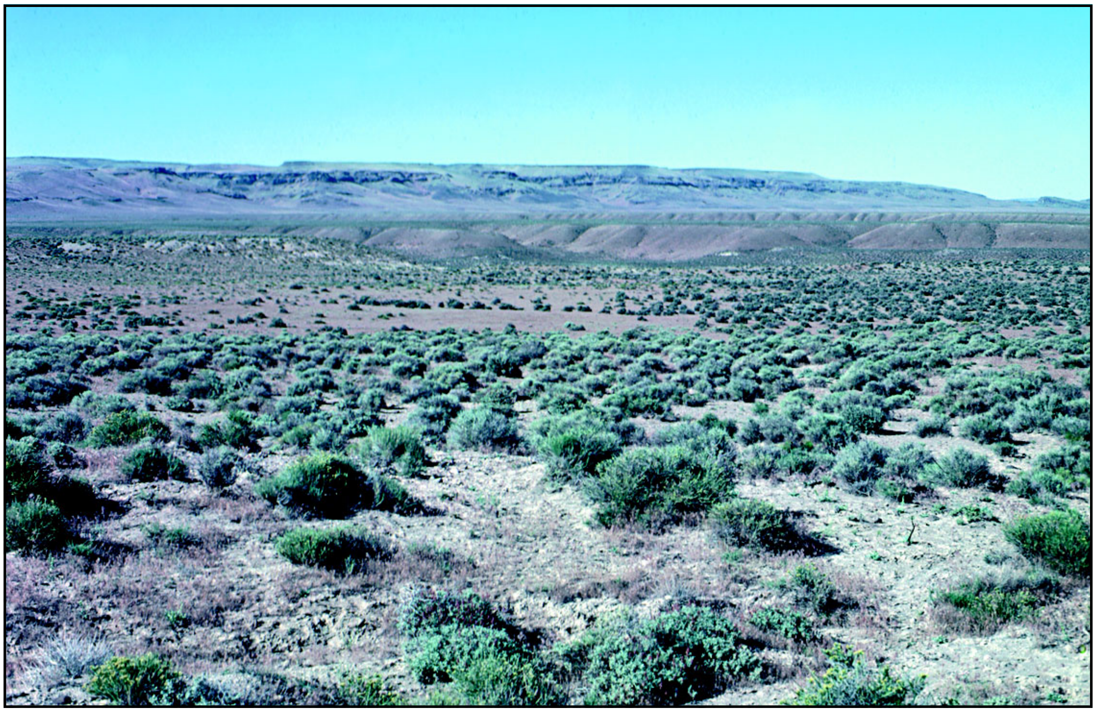

Figure 4—The salt desert shrub PVT usually occurs on saline soils. Vegetal coverage is typically sparse, and plant interspaces are frequently occupied by biological soil crusts. This community near Grand View, Idaho, is dominated by shadscale and budsage. (Photo by Stephen Bunting.)

Within the basin BLM and FS lands, this PVT is located primarily in south-central and southeastern Oregon with lesser extents in southwestern Idaho and small scattered patches in eastern Washington and north-central Oregon (Hann et al. 1997; ICBEMP source data, Pacific Northwest Research Station, P.O. Box 3890, Portland, OR 97208). Most of this type occurs within intermontane basin, plateau, and plains landforms at moderate elevations (table 3) and within the low precipitation zone (table 4).

Wyoming Big Sagebrush–Warm PVT

The Wyoming big sagebrush–warm PVT includes vegetation dominated primarily by Wyoming big sagebrush with minor amounts of other sagebrush species (fig. 3). Foothills sagebrush, primarily found in the lower Weiser and Payette River drainages of Idaho and adjacent Oregon, also was included within this PVT. Herbaceous species typically include bluebunch wheatgrass, bottlebrush squirreltail, Sandberg bluegrass, and Thurber's needlegrass. Livestock grazing, agriculture, and invasive annual grasses, particularly cheatgrass and medusahead, have severely affected this PVT (figs. 5a and 5b). Annual grasses produce abundant, highly flammable fuel. The result has been frequent fire, enhanced annual grass dominance, and near elimination of sagebrush species in many locations (Pellant 1990). Sagebrush moth (*Aroga websteri* Clarke) may cause local centers of mortality (Passey and Hugie 1962). Extensive areas have been planted with introduced perennial wheatgrasses.

Biological soil crusts, including cyanobacteria, lichens, algae, and mosses, occur commonly on or near the soil surface in many sites within this PVT, increasing soil stability in the plant interspaces (Belnap et al. 1994, Belnap and Gardner 1993, Evans and Ehleringer 1993). They also may provide for nitrogen (Mayland et al. 1966, West and Skujins 1977) and carbon (Lange et al. 1997) input into the soil, and enhance availability of essential minerals for higher plants (Harper and Pendleton 1993). Biological soil crusts are susceptible to disturbances such as fire (Johansen

Table 3—Percentage and area by elevation class for each of 17 rangeland potential vegetation types on BLM- and FS-administered lands within the environmental impact statement planning area

Potential vegetation type (PVT)	Elevation	Percentage of PVT	Area	
			Hectares	*Acres*
Salt desert shrub	Low	9	59 000	145,800
	Moderate	91	623 700	1,541,200
	High	0	300	700
	Total	100	683 000	1,687,700
Wyoming big sagebrush–warm	Low	6	349 800	864,400
	Moderate	92	4 976 900	12,298,200
	High	1	71 700	177,200
	Total	99	5 398 400	13,339,800
Wyoming big sagebrush–cool	Low	4	17 700	43,700
	Moderate	71	334 900	827,600
	High	26	121 800	301,000
	Total	101	474 400	1,172,300
Basin big sagebrush	Low	33	58 500	144,600
	Moderate	64	113 800	281,200
	High	3	4 600	11,400
	Total	100	176 900	437,200
Threetip sagebrush	Low	3	1 000	2,500
	Moderate	72	21 700	53,600
	High	25	7 700	19,000
	Total	100	30 400	75,100
Low sagebrush–xeric	Low	36	66 900	165,300
	Moderate	59	109 200	269,800
	High	5	10 300	25,500
	Total	100	186 400	460,600
Low sagebrush–mesic	Low	1	4 900	12,100
	Moderate	96	469 600	1,160,400
	High	3	17 000	42,000
	Total	100	491 500	1,214,500
Low sagebrush–mesic with juniper	Moderate	100	7 800	19,300
	Total	100	7 800	19,300
Mountain big sagebrush–mesic east	Low	7	77 900	192,500
	Moderate	64	739 200	1,826,600
	High	29	336 000	830,300
	Total	100	1 153 100	2,849,400

Table 3—Percentage and area by elevation class for each of 17 rangeland potential vegetation types on BLM- and FS-administered lands within the environmental impact statement planning area (continued)

Potential vegetation type (PVT)	Elevation	Percentage of PVT	Area	
			Hectares	*Acres*
Mountain big sagebrush–mesic east with conifers	Low	0	100	200
	Moderate	97	45 600	112,700
	High	3	1 300	3,200
	Total	100	47 000	116,100
Mountain big sagebrush–mesic west	Low	7	47 000	116,100
	Moderate	93	610 600	1,508,800
	High	0	1 500	3,700
	Total	100	659 100	1,628,600
Mountain big sagebrush–mesic west with juniper	Low	21	111 300	275,000
	Moderate	73	379 300	937,300
	High	6	30 500	75,400
	Total	100	521 100	1,287,700
Wheatgrass grassland	Low	52	64 700	159,900
	Moderate	31	38 800	95,900
	High	17	21 400	52,900
	Total	100	124 900	308,700
Antelope bitterbrush	Low	16	4 200	10,400
	Moderate	83	21 300	52,600
	High	1	300	700
	Total	100	25 800	63,700
Mountain shrub	Moderate	41	1 400	3,500
	High	59	2 000	4,900
Total		100	3 400	8,400
Fescue grassland	Low	6	5 700	14,100
	Moderate	48	46 500	114,900
	High	46	44 000	108,700
	Total	100	96 200	237,700
Fescue grassland with conifer	Low	10	65 700	162,300
	Moderate	50	320 800	792,700
	High	40	258 900	639,800
	Total	100	645 400	1,594,800
Grand total			10 724 800	26,501,600

Note: Elevation classified from 0.5-km Digital Elevation Model (DEM): Low ≤1000 m; moderate >1000 m and ≤2000 m; high >2000 m. (Source: ICBEMP data available at http://www.icbemp.gov/spatial; theme number: 426; theme abbreviation: PHYSDEM50)

Table 4—Percentage and area by precipitation zone for each of 17 rangeland potential vegetation types on BLM- and FS-administered lands within the environmental impact statement planning area

Potential vegetation type (PVT)	Precipitation	Percentage of PVT	Area	
			Hectares	*Acres*
Salt desert shrub	Low	89	605 000	1,495,000
	Moderate	11	78 000	192,700
	Total	100	683 000	1,687,700
Wyoming big sagebrush–warm	Low	70	3 785 400	9,353,900
	Moderate	29	1 561 200	3,857,800
	High	1	51 800	128,000
	Total	100	5 398 400	13,339,700
Wyoming big sagebrush–cool	Low	72	342 200	845,600
	Moderate	27	126 100	311,600
	High	1	6 100	15,100
	Total	100	474 400	1,172,300
Basin big sagebrush	Low	55	97 100	239,900
	Moderate	40	70 500	174,200
	High	5	9 300	23,000
	Total	100	176 900	437,100
Threetip sagebrush	Low	15	4 600	11,400
	Moderate	60	18 300	45,200
	High	25	7 500	18,500
	Total	100	30 400	75,100
Low sagebrush–xeric	Low	88	163 100	403,000
	Moderate	12	23 200	57,300
	High	0	100	200
	Total	100	186 400	460,500
Low sagebrush–mesic	Low	43	209 100	516,700
	Moderate	57	279 400	690,400
	High	1	3 000	7,400
	Total	101	491 500	1,214,500
Low sagebrush–mesic with juniper	Low	3	200	500
	Moderate	88	6 900	17,100
	High	9	700	1,700
	Total	100	7 800	19,300
Mountain big sagebrush–mesic east	Low	33	374 000	924,200
	Moderate	59	682 300	1,686,000
	High	8	96 800	239,200
	Total	100	1 153 100	2,849,400

Table 4—Percentage and area by precipitation zone for each of 17 rangeland potential vegetation types on BLM- and FS-administered lands within the environmental impact statement planning area (continued)

Potential vegetation type (PVT)	Precipitation	Percentage of PVT	Area	
			Hectares	*Acres*
Mountain big sagebrush– mesic east with conifer	Low	2	1 000	2,500
	Moderate	76	35 500	87,700
	High	22	10 500	25,900
	Total	100	47 000	116,100
Mountain big sagebrush– mesic west	Low	40	263 300	650,600
	Moderate	60	393 000	971,100
	High	0	2 800	6,900
	Total	100	659 100	1,628,600
Mountain big sagebrush– mesic west with juniper	Low	60	315 100	778,600
	Moderate	38	197 300	487,500
	High	2	8 700	21,500
	Total	100	521 100	1,287,600
Wheatgrass grassland	Low	42	52 700	130,200
	Moderate	47	58 200	143,800
	High	11	14 000	34,600
	Total	100	124 900	308,600
Antelope bitterbrush	Low	19	4 800	11,900
	Moderate	73	18 800	46,500
	High	9	2 200	5,400
	Total	101	25 800	63,800
Mountain shrub	Low	32	1 100	2,700
	Moderate	65	2 200	5,400
	High	3	100	200
	Total	100	3 400	8,300
Fescue grassland	Low	2	2 400	5,900
	Moderate	52	50 200	124,000
	High	45	43 600	107,700
	Total	99	96 200	237,600
Fescue grassland with conifers	Low	11	72 400	178,900
	Moderate	56	359 300	887,800
	High	33	213 700	528,100
	Total	100	645 400	1,594,800
Grand total			10 724 800	26,501,000

Note: Precipitation classified using PRISM Model: Low ≤30 cm; moderate >30 cm and ≤61 cm; high >61 cm. (Source: ICBEMP data available at http://www.icbemp.gov/spatial; theme: 741; theme abbreviation: ATMPRISM)

Figure 5A—Slightly altered community within the Wyoming big sagebrush–warm PVT located near Vantage, Washington. The community is dominated by Wyoming big sagebrush with an understory of bluebunch wheatgrass. (Photo by Stephen Bunting.)

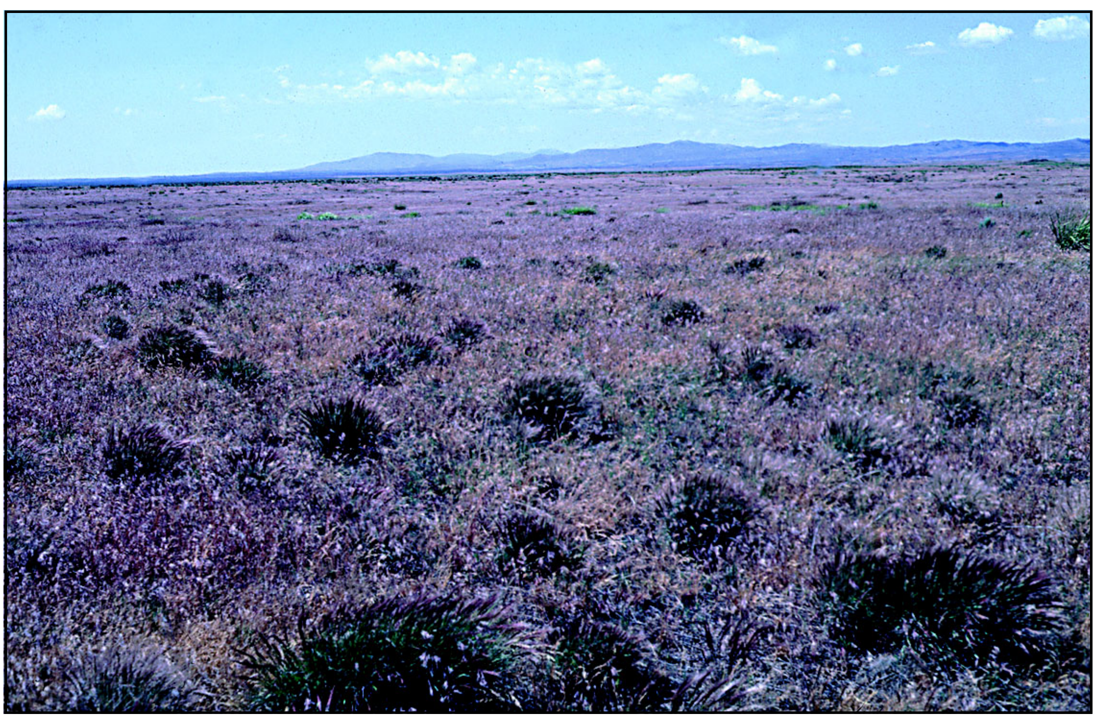

Figure 5B—Severely altered community within the Wyoming big sagebrush–warm PVT near Boise, Idaho. The community is dominated by invasive species, primarily cheatgrass. Perennial grass in the photo is bottlebrush squirreltail. (Photo by Stephen Bunting.)

et al. 1982, 1993) and mechanical damage from large herbivores (Beymer and Klopatek 1992, Kleiner and Harper 1972, Marble and Harper 1989). Recovery of biological soil crusts may be slow after disturbance, particularly for the lichens. The time required for full recovery has been estimated at 20 to 85 years (Anderson et al. 1982b, Belnap and Gardner 1993). Johansen et al. (1993) found, however, that soil algae may recover within 2 to 5 years postburn.

Slightly altered sites 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 biological soil crusts and tortula (*Tortula ruralis* (Hedw.) Gaerten., Meyer and Scherb.) are present, at least under mature shrubs (Hironaka et al. 1983). The most common invasive grasses are cheatgrass on moderate to light textured soils and medusahead on heavier textured soils (Dahl and Tisdale 1975). Invasive forbs include diffuse knapweed, spotted knapweed and rush skeletonweed.

Severely altered sites in this PVT present one of the greatest restoration challenges in the basin because of the large area involved, the difficulty in controlling wildfires, and the difficulty in establishing perennial species. Some areas currently burn once every 5 years compared to the historical fire return interval of 50 to 100 years (Whisenant 1990). Frequent fire has, in many places, depleted sagebrush and fire-sensitive herb and grass species (e.g., Thurber's needlegrass and Idaho fescue) seed sources. Soils have eroded or been modified in many cases. Some researchers consider these changes irreversible (Young et al. 1979). Many severely altered sites have been planted previously with introduced perennial wheatgrasses. The introduced perennial grasses protect sites from further invasion by invasive plant species and additional soil erosion. They are, however, effective competitors that prevent the establishment of many native herbaceous plants and reduce the rate of increase in species diversity on the site.

Within the basin BLM and FS lands, this PVT is located in a band across the southern portion of Oregon and Idaho with scattered patches in northern Oregon and central Washington (Hann et al. 1997, ICBEMP source data). Most of this type occurs within intermontane basin, plateau, and plains landforms at moderate elevations (table 3), with most in the low precipitation zone (table 4) and much of the remaining in the moderate zone associated with warm aspects and droughty soils.

Wyoming Big Sagebrush–Cool PVT

The Wyoming big sagebrush–cool PVT is found primarily in valley bottoms in eastern Idaho, southwestern Montana, and the west slopes of the Blue Mountains in Oregon (fig. 3). The herbaceous component is similar to the Wyoming big sagebrush–warm PVT. Climatic differences such as a greater proportion of summer precipitation and colder winters have resulted in this PVT not being as affected by invasive annual grasses as the Wyoming big sagebrush–warm PVT. Consequently, wildfire occurrence has not increased as greatly from past conditions for most of this PVT.

Slightly altered sites usually have an intact sagebrush overstory with a slightly to moderately altered understory composition. Invasive species are present but have not disrupted the natural processes to the extent they have in some other PVTs. Sites respond to changes in management (Eckert and Spencer 1986, Wambolt and Payne 1986, Yeo et al. 1990), but increases in perennial species may be slow. Restoration strategies primarily include livestock management to prevent further depletion of the understory and fire suppression to prevent loss of the shrub component.

An understory depleted of native perennial species usually characterizes severely altered sites. Wildfires are uncommon because there is minimal fine fuel production. When fire does occur, it results in an early seral community of native and invasive species. Reestablishment of sagebrush and perennial herbaceous species is slow, and recovery may take many decades (Eckert and Spencer 1986, Harniss and Murray 1973). Seeding of introduced wheatgrasses has been used successfully as a rehabilitation practice in some areas.

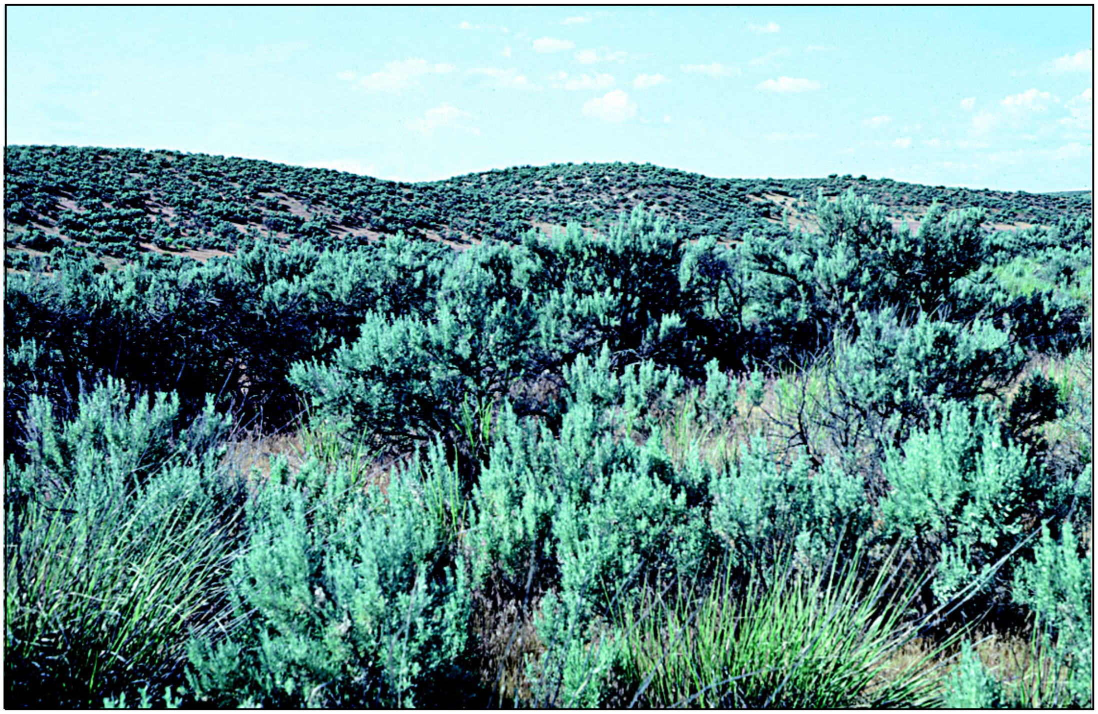

Figure 6—Most of the historical area of the basin big sagebrush PVT within the basin has been converted to intensive agriculture. What remains is mostly in small areas within other PVTs, such as this example found north of Mountain Home, Idaho. Vegetation in background is primarily Wyoming big sagebrush–warm PVT. (Photo by Stephen Bunting.)

Within the basin BLM and FS lands, this PVT is scattered diagonally from southwestern Oregon to northeastern Oregon and in a relatively large zone in east-central Idaho with scattered patches in southeastern Idaho (Hann et al. 1997). Most of this PVT type occurs in intermontane basins and draws of foothills and mountains at moderate elevations (table 3) within the low precipitation zone. Most of the remaining is in the moderate zone (table 4) but on warm aspects and droughty soils.

Basin Big Sagebrush PVT

Basin big sagebrush with a native understory of basin wildrye and bluebunch wheatgrass dominates the basin big sagebrush PVT (figs. 3 and 6). Livestock grazing and invasive species have affected most sites. When surrounded by sites dominated by annual grass, they are subject to frequent fires that often eliminate sagebrush.

Most of this PVT has been converted to intensive agriculture (Hironaka et al. 1983). Few extensive areas of basin big sagebrush PVT remain except in central Washington (fig. 3). Most occur in a mosaic with the Wyoming big sagebrush–warm PVT and have suffered similar histories. Annual grasses and frequent fire have heavily affected those that remain (Daubenmire 1975b). The restoration options for the Wyoming big sagebrush–warm PVT apply equally to the basin big sagebrush 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 sites in the Wyoming big sagebrush–warm PVT. When managed within a mosaic of Wyoming big sagebrush–warm vegetation, livestock management must be closely monitored because these sites are found on less steep terrain and closer to water, which tends to encourage livestock use.

Within the basin BLM and FS lands, this PVT is thinly scattered through central Washington and Oregon and across southeastern Oregon and southern Idaho (Hann et al. 1997, ICBEMP source data). Most of this PVT occurs in intermontane basins, plains, and plateaus at low elevations and moderate elevations (table 3) within the low and moderate precipitation zones (table 4), typically on droughty soils.

Threetip Sagebrush PVT

An overstory of threetip sagebrush, one of the few species of sagebrush that resprouts after fire, dominates the threetip sagebrush PVT (Bunting et al. 1987, Tisdale and Hironaka 1981) (fig. 3). Common native herbaceous species include bluebunch wheatgrass, Idaho fescue, arrowleaf balsamroot, and several species of lupine. Environmentally this PVT occurs between the more xeric Wyoming big sagebrush–warm PVT and the more mesic mountain big sagebrush PVTs. Threetip sagebrush is more resistant to fire than most other sagebrush species in the basin (Beetle 1960, Morris et al. 1976), and may increase after fire (Bunting et al. 1987). Threetip sagebrush may occur as a seral community in the mountain big sagebrush PVTs after repeated fires because of its resprouting capability. Whereas this PVT is widespread geographically within the basin, it normally occurs in small patches intermixed with other sagebrush-dominated PVTs on the landscape, and thus only a minor area was included in the ICBEMP broad-scale map. The most extensive areas of threetip sagebrush PVT are found primarily on the Snake River plain and adjacent valleys, most often in a mosaic with the Wyoming big sagebrush PVTs.

Slightly altered sites of threetip sagebrush steppe have an intact shrub overstory and an herbaceous understory composition dominated by native perennials. Most are found within the environmental range of Idaho fescue (table 1), where greater precipitation has made them more resistant to alteration. The primary disturbance factor has been livestock grazing, and this PVT often responds well to changes in management. Because threetip sagebrush resprouts, recovery after fire is more rapid than many other sagebrush steppe PVTs.

Most threetip sagebrush steppe sites that have been severely altered are in the bluebunch wheatgrass zone (table 2). The shrub overstory component is generally intact, but the perennial understory species have usually been depleted. Cheatgrass is not usually invasive in this PVT as it is in Wyoming big sagebrush steppe vegetation (Hironaka et al. 1983). However, this PVT is susceptible to frequent fires that often occur where annual grasses have invaded.

Within the basin BLM and FS lands, this PVT is scattered in a few areas of eastern Washington, Oregon, and southern Idaho with a concentration in south-central Idaho (Hann et al. 1997, ICBEMP source data). Most of this type occurs in intermontane basin, plateau, and plains landforms at moderate elevations with some on warmer aspects at higher elevations (table 3). Most occurs in the moderate precipitation zone, but some also occurs in the high precipitation zone on the warmer aspects and droughty soils (table 4).

Low Sagebrush–Xeric PVT

The low sagebrush–xeric PVT occurs as a fine-scale mosaic of distinct vegetation types that include communities dominated by Wyoming big sagebrush, winterfat, and Nuttall saltbush (Yensen and Smith 1984) (fig. 3). The soils, which are usually derived from sediments within the basin, are similar to those supporting sagebrush steppe vegetation except for greater salinity. These communities are restricted by high soil salinity typical of soil supporting communities in the salt desert shrub PVT (Blaisdell and Holmgren 1984, West 1982). The distributions of many species within the PVT are defined environmentally by minor changes in soil salinity as well (Knight 1994). Other common native species include Sandberg bluegrass, bottlebrush squirreltail, sixweeks fescue, budsage, and spiny hop-sage. These areas have long been used by sheep and more recently by cattle as winter range (Blaisdell and Holmgren 1984).

Slightly altered communities have a relatively intact shrub overstory. Some reduction in winterfat, Nuttall saltbush, and biological soil crusts has resulted from past livestock use. Invasive species such as cheatgrass, tumblemustard, and tansy mustard are present in small amounts. As livestock use increases, winterfat decreases (Blaisdell and Holmgren 1984); cheatgrass increases as the shrub cover decreases. Normally winterfat-dominated sites do not contain adequate fuels to carry a wildfire readily (Pellant and Reichert 1984). However, after more than 1 year with above-average precipitation, fine fuels may build to a level that is sufficient to carry a fire when cheatgrass is present. Although Nuttall saltbush readily resprouts after fire, winterfat mortality after wildfire is high. Pellant and Reichert (1984) reported 95 percent mortality of winterfat following an intense wildfire in southern Idaho. Once an initial fire has occurred, cheatgrass can dominate the site, and the probability of subsequent fires increases. Several fires can extirpate winterfat and Wyoming big sagebrush from the site. Severely altered sites are primarily dominated by invasive annual species such as cheatgrass, tumblemustard, and tansy mustard.

Within the basin BLM and FS lands, this PVT was mapped at a 1-km resolution where large patches occur (Hann et al. 1997, ICBEMP source data). These large patches appear to be concentrated in areas of southeastern Oregon, and southwestern and south-central Idaho on shallow soils of plains and plateau landforms. They are typically dominated by winterfat-saltbush species of the salt desert with some intermingled Wyoming big sagebrush and low sagebrush. However, based on plot data, historical and current oblique landscape photography, and mid-scale photo interpretation, it is apparent that much of this PVT actually occurs in small patches not mapped at 1-km resolution, on shallow soils intermingled within large patches of the Wyoming big sagebrush–warm PVT (Hann et al. 1997, Hessburg et al. 1999). This portion of the low sagebrush–xeric PVT appears to be dominated by scattered Wyoming big sagebrush with a short growth form and has been included in the area estimate for the Wyoming big sagebrush–warm PVT. It is estimated that because of the mapping scale used, the low sagebrush–xeric PVT may account for as much as 10 percent of the Wyoming big sagebrush–warm PVT area estimate.

Most of this type occurs in intermontane basin, plateau, and plains landforms at moderate elevations with some at lower elevations (table 3). Most occurs in the low precipitation zone (table 4).

Low Sagebrush–Mesic PVT

The low sagebrush–mesic PVT is dominated by dwarf sagebrush species such as low, stiff, and little sagebrush. Low sagebrush is the most prevalent of the sagebrush species included in this PVT and is one of the most abundant in the basin (Tisdale and Hironaka 1981) (fig. 7). Low sagebrush occurs over a wide range of annual precipitation (15 to 50 cm) and probably includes at least two ecotypes (Hironaka et al. 1983). This PVT includes the most xeric portions of the sites occupied by low sagebrush and occurs at the lower elevations and on shallow poorly developed lithic soils (Passey and Hugie 1962, Tisdale and Hironaka 1981, Zamora and Tueller 1973). Low sagebrush vegetation often occurs on soils that have an impermeable B horizon within 33 cm of the surface (Tisdale and Hironaka 1981), which results in a waterlogged condition for a portion of the year. Understory species commonly include Sandberg bluegrass, western needlegrass, Idaho fescue, onespike oatgrass, yampah, lupines, and several species of biscuitroot. Apart from its edaphic relations, little has been published on low sagebrush and other dwarf sagebrushes or the vegetation types (Tisdale and Hironaka 1981). Sparse herbaceous cover and production limits fire in this PVT, but sagebrush recovery is slow when fire does occur. Low sagebrush is susceptible to the sagebrush moth (*Aroga websteri* Clarke) that causes small patches of high mortality (Furniss and Barr 1975). Extensive portions of sites dominated by stiff sagebrush have been invaded by cheatgrass.

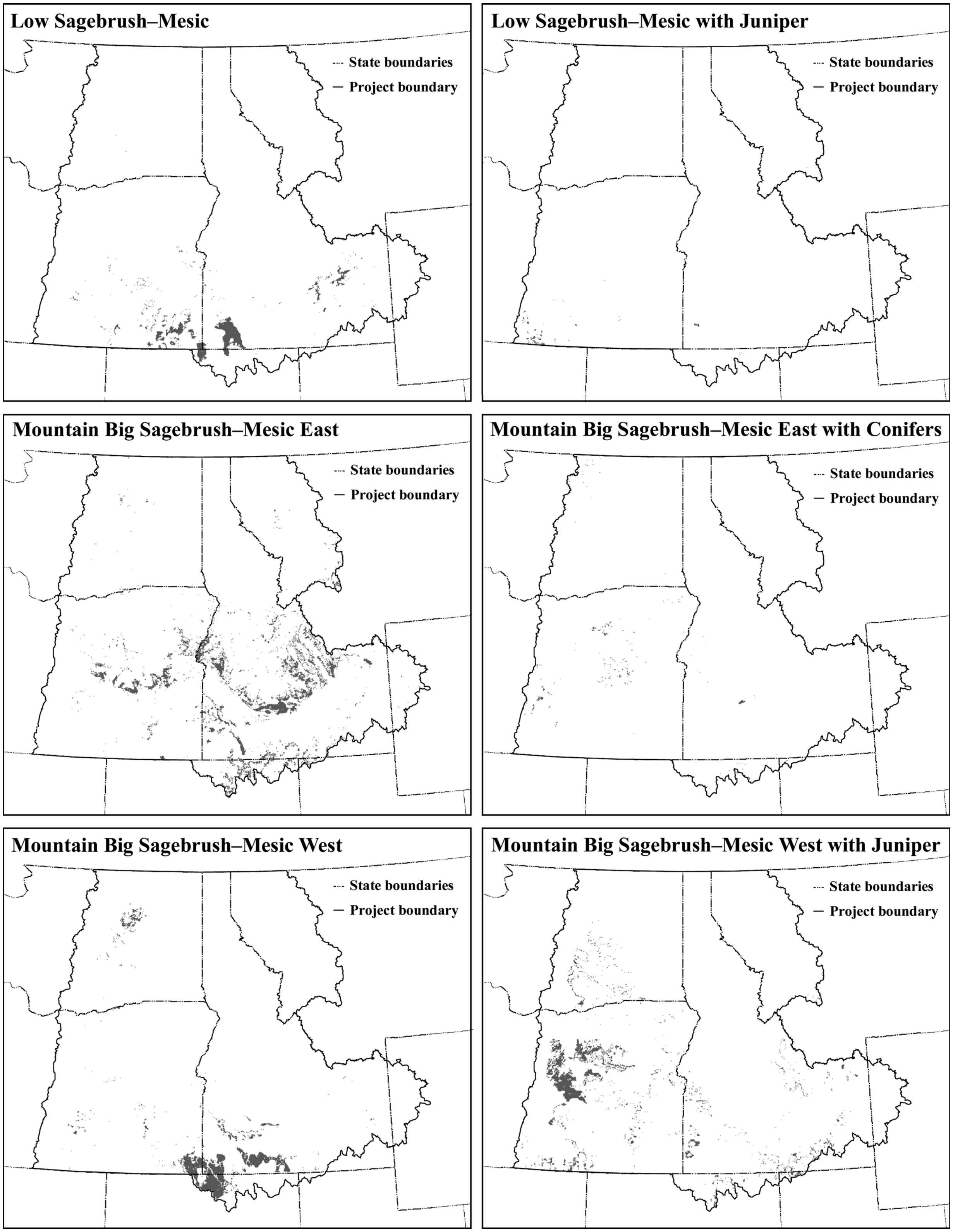

Figure 7—Area included in the low sagebrush–mesic, low sagebrush–mesic with juniper, mountain big sagebrush–mesic east, mountain big sagebrush–mesic east with conifers, mountain big sagebrush–mesic west, and mountain big sagebrush–mesic west with juniper potential vegetation types within the interior Columbia basin as mapped at the 1-km scale. ICBEMP data on file with: USDA Forest Service, Pacific Northwest Research Station, P.O. Box 3890, Portland, OR 97208.

Because the low sagebrush–mesic PVT occurs over a wide range of precipitation, the potential herbaceous production varies accordingly. Fire occurrence is normally less than in the adjacent sagebrush steppe vegetation owing to low sagebrush coverage and lower herbaceous productivity (Bunting et al. 1987). This variation affects its historical and present fire regime. Fires often spread from surrounding vegetation into low sagebrush steppe. At the drier end of the PVT's precipitation range, it is often surrounded by Wyoming big sagebrush vegetation that has been invaded by annual grasses. Consequently, fire occurrence is high, and many low sagebrush sites have burned, resulting in an increase of invasive species. At the upper end of its precipitation range, low sagebrush steppe is often in a mosaic of mountain big sagebrush steppe that increases fire occurrence. Because the site retains soil moisture in the A horizon, it may be susceptible to soil displacement by large-animal herbivory in spring.

Slightly altered sites have been affected by improper grazing strategies that have reduced the herbaceous species and caused mechanical plant displacement. The PVT responds relatively quickly to changes in management when seed sources are available on site. Severely altered sites have greatly reduced native perennial herbaceous coverage. Invasive species have increased on some sites. Low fine-fuel production makes wildfire occurrence less probable than in surrounding vegetation. Management-ignited wildland fire (prescribed fire) is difficult to implement (Blaisdell et al. 1982) and is seldom used in this PVT.

Within the basin BLM and FS lands, this PVT was mapped at a 1-km scale, and thus only large patches were detected (Hann et al. 1997, ICBEMP source data). These large patches appear to be concentrated in areas of south-central and southeastern Oregon, and south-western and southeastern Idaho. Some of the low sagebrush–mesic PVT appears to have been included in the area estimate for the Wyoming big sagebrush–warm PVT. It is estimated that because of the mapping scale used, the low sagebrush–mesic PVT may account for as much as 20 percent of the Wyoming big sagebrush–warm PVT area estimate.

Most of this type occurs within plateau and plains landforms at moderate elevations (table 3). Nearly equal amounts occur in the moderate precipitation and low precipitation areas (table 4).

Low Sagebrush–Mesic with Juniper PVT

The low sagebrush–mesic with juniper PVT is similar in composition to the low sagebrush–mesic PVT but occurs in a mosaic with western juniper woodlands (fig. 7). Juniper historically occurred as a sparse overstory (less than 5 percent coverage). Fires, although historically infrequent, maintained the savannah-like physiognomy of this PVT. Juniper establishment and growth are slow on these sites but have been increasing in the past 150 years (Miller and Rose 1999, Miller and Wigand 1994). Active fire suppression and use of fine fuels by livestock have been effective in reducing fire occurrence in this PVT.

Sites slightly altered by improper grazing strategies have a reduced herbaceous component resulting from herbivory and mechanical plant displacement. The PVT responds relatively quickly to changes in management when seed sources are available on site. Severely altered sites exhibit greatly reduced native perennial herbaceous coverage, increased western juniper coverage, or both. Low fine-fuel production makes wildfire occurrence unlikely and management ignited wildland fire use (prescribed fire) difficult (Blaisdell et al. 1982).

Within the basin BLM and FS lands, this PVT was mapped at a 1-km resolution where a few large patches occur (Hann et al. 1997, ICBEMP source data). These large patches occur primarily in south-central Oregon and southwestern Idaho. However, based on plot data, historical and current oblique landscape photography, and midscale photo interpretation, some of this PVT actually occurs in small undetectable (at 1-km mapping scale) patches intermingled within large patches of the mountain big sagebrush–mesic west with juniper and within Wyoming big sagebrush–warm PVT (Hann et al. 1997, Hessburg et al. 1999). Because of the limitations of the mapping scale used, this PVT may actually have a greater geographic range and as much as 20 percent more area than shown on the maps. All of this type occurs within plateau, plains, foothill, and mountain landforms at moderate elevations (table 3) with most in the moderate precipitation zone (table 4).

Mountain Big Sagebrush–Mesic East PVT

The mountain big sagebrush–mesic east PVT is typically dominated by mountain big sagebrush and may include other shrubs such as rabbitbrush, antelope bitterbrush, and snowberry, and various herbaceous species such as Sandberg bluegrass, bluebunch wheatgrass, Idaho fescue, lupine, wild buckwheat, and arrowleaf balsamroot. This PVT occurs primarily in valley bottoms and mountain slopes in southwestern Montana and eastern Idaho (fig. 7). That portion east of the Bitterroot Mountains in the basin often includes species typical of the shortgrass prairie such as bluegrama and western wheatgrass. Common invasive species are leafy spurge and knapweed species (Dunn 1979, Rinella et al. 2001). Invasive annual grasses occur within this PVT on sites that have been severely affected by livestock grazing or other disturbance. Much of this PVT had a shorter fire-return interval during historical times (Arno and Gruell 1983, Bunting et al. 1987, Houston 1973). Some changes in composition, such as increased sagebrush coverage, reflect this decrease in fire occurrence resulting from reduction of fine fuels by livestock grazing and active fire suppression.

Alteration of this PVT has largely resulted from historical livestock grazing and decreased fire occurrence. Both have resulted in greater sagebrush coverage and a decreased herbaceous coverage on these sites. The composition of the slightly altered communities responds readily to changes in grazing and fire management. Invasive annual grasses are present but have not affected the dynamics of disturbance and composition to the extent they have in many other sagebrush steppe vegetation types. The native herbaceous species are commonly reduced on severely altered communities. Changes in fire and grazing management may not be adequate to restore these sites. Additional active restoration measures such as seeding may be necessary to reestablish these herbaceous species.

Within the basin BLM and FS lands, this PVT was a dominant type with many large patches when mapped at a 1-km scale (Hann et al. 1997, ICBEMP source data). These large patches are distributed throughout the foothills and mountains of central Oregon and central and southern Idaho. Much of this type occurs at moderate elevations and in the moderate precipitation zone, with a lesser amount occurring at high elevations and in low and high precipitation areas (tables 3 and 4).

Mountain Big Sagebrush–Mesic East with Conifers PVT

The mountain big sagebrush–mesic east with conifers PVT is common throughout the eastern portion of the basin but occurs in small patches that were not mapped at the 1-km resolution. Most of the mapped areas of the PVT are found in central Oregon (fig. 7). Composition is similar to the mountain big sagebrush–mesic east PVT except having a greater conifer component, particularly Douglas-fir and Rocky Mountain juniper. Historically this PVT probably occurred as a mosaic of mature conifer stands interspersed with grassland, mountain big sagebrush steppe, and young developing conifer communities. Decreased fire occurrence has resulted in more continuous conifer overstory development and conifer expansion into adjacent sagebrush-dominated communities (Arno and Gruell 1983). Increased conifer overstory has diminished the grassland and shrub-steppe herbaceous and shrub species and facilitated changes in understory composition to species more adapted to forest environments, such as pinegrass, Idaho fescue, western snowberry, and heartleaf arnica (Arno and Gruell 1986, Ferguson 2001, Sindelar 1971).

End of Part B. Click here for Part C.

Part C — continued from Part B

Slightly altered sites have an abundant understory of herbaceous species associated with sagebrush steppe and moderate levels of conifer overstory. These sites usually respond quickly to changes in livestock grazing and fire management. Severely altered sites contain lower amounts of herbaceous species associated with sagebrush steppe as a result of intense grazing regimes or greater conifer overstory coverage. Recovery of sagebrush is rapid owing to efficient seed transport (Bunting et al. 1987, Ferguson 2001). Once the local seed sources of herbaceous species have been lost, however, recovery of this type after change in grazing management or conifer removal is slow.

Within the basin BLM- and FS-administered lands, this PVT only occurs as a few large patches when mapped at 1-km resolution (Hann et al. 1997, ICBEMP source data). These large patches are scattered and infrequent across central and southern Idaho and central Oregon. However, based on plot data, historical and current oblique landscape photography, and midscale photo interpretation, much of this PVT actually occurs in small undetectable (at 1-km mapping resolution) patches. On moist aspects or high elevations, it is intermingled with large patches of the mountain big sagebrush–mesic east, mountain big sagebrush–west, and mountain big sagebrush–mesic west with juniper PVTs; on the drier aspects of the dry and cold forest types throughout the foothills and mountains of Idaho, western Montana, eastern Washington, and Oregon (Hann et al. 1997, Hessburg et al. 1999). Although this PVT is more prevalent in the eastern portion of the basin, the mountain big sagebrush–mesic east with conifer PVT can be found throughout the basin where this environment occurs. It is estimated that because of the limitations of the mapping resolution, this PVT may actually occur with a greater geographic range and an area increased by as much as 50 percent.

Most of this type occurs at moderate elevations (table 3) in the moderate precipitation zone (table 4).

Mountain Big Sagebrush–Mesic West PVT

Mountain big sagebrush typically dominates the mountain big sagebrush–mesic west PVT, which is found west of the Bitterroot Mountains (figs. 7 and 8). Other common shrubs include yellow rabbitbrush and antelope bitterbrush. Herbaceous species are similar to those found in the mountain big sagebrush–mesic east PVT, but this type lacks species typical of the shortgrass prairie. Although invasive annual grasses occur within this PVT, they seldom dominate unless livestock grazing or other disturbance has severely impacted the site. Spotted and diffuse knapweed have increased in some localities. Much of this PVT had a shorter fire-return interval during historical times (Bunting et al. 1987, Houston 1973, Miller and Rose 1999, Miller and Wigand 1994), and some changes in composition reflect this decrease in fire occurrence resulting from active fire suppression and reduction of fine fuels by livestock grazing. Cold winters with little snow coverage may result in widespread sagebrush foliage mortality (Hansen et al. 1982).

The presence of invasive species and increased mountain big sagebrush density 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 respond rapidly to changes in livestock 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 dominate the understory. Mid- and late-seral understory species are often substantially reduced.

Within the basin BLM- and FS-administered lands, this PVT was a dominant type with many large patches when mapped at a 1-km resolution (Hann et al. 1997, ICBEMP source data). These large patches occur throughout the mountains, plateaus, and plains of southeastern Oregon and

Figure 8—This example of the mountain big sagebrush–mesic west PVT, located near Fairfield, Idaho, is dominated by mountain big sagebrush and antelope bitterbrush. (Photo by Stephen Bunting.)

southwestern Idaho. Most of this type occurs at moderate elevations (table 3) in the moderate and low precipitation areas (table 4).

Mountain Big Sagebrush–Mesic West with Juniper PVT

The mountain big sagebrush–mesic west with juniper PVT has many shrub and herbaceous species in common with the mountain big sagebrush–mesic west PVT. Woodland vegetation dominates late-seral stages, which have increased greatly following Euro-American settlement. Utah juniper dominates woodlands in southeastern Idaho and adjacent Wyoming (figs. 7 and 9). Singleleaf pinyon also may be present in southeastern Idaho. Western juniper, without pinyon, dominates southwestern Idaho and eastern Oregon. Portions of this PVT also can contain stands of curlleaf mountain-mahogany. Substantial changes in understory vegetation accompany succession from sagebrush steppe to juniper woodland (Miller et al. 2000, Miller and Wigand 1994). Reduction in fire frequency has been commonly credited as the cause of woodland expansion, but livestock grazing and climatic change have been important interacting factors (Burkhardt and Tisdale 1976, Miller and Rose 1999, Miller and Wigand 1994).

This PVT occurs in a mosaic with juniper or locally pinyon-juniper woodlands. Plant species composition is similar to the mountain big sagebrush–mesic west PVT. Juniper often encroaches after alteration of the fire regime (Burkhardt and Tisdale 1976, Miller and Rose 1999, Miller and Wigand 1994). Seed dispersal into the sagebrush steppe is facilitated by animal consumption of the juniper fruits (Chambers et al. 1999a, 1999b). Slightly altered sites generally include small juniper and most native sagebrush steppe plant species. These sites respond rapidly to changes in fire management to achieve restoration.

Severely altered sites have typically developed into woodlands. Woodland development normally results in a reduction of fine fuels, making sites more difficult to burn. The resulting loss of sagebrush steppe species increases the recovery time

Figure 9—Example of mountain big sagebrush–mesic west with juniper PVT in an early stage of western juniper encroachment located south of Jordan Valley, Oregon. (Photo by Stephen Bunting.)

after fire (Bunting et al. 1999). Woodland development often results in increased soil erosion further increasing recovery time (Davenport et al. 1998). Some sites with substantial soil erosion may no longer be capable of supporting sagebrush steppe vegetation.

Within the basin BLM- and FS-administered lands, this PVT was a dominant type with many large patches when mapped at a 1-km resolution (Hann et al. 1997, ICBEMP source data). Although the modal type occurs extensively in central Oregon, this type has a range across all the foothills and mountains of eastern Oregon and southern Idaho. Most of this type occurs at moderate and low elevations (table 3). Most occurs in the low precipitation zone, with a lesser amount (38 percent) in the moderate precipitation areas (table 4).

Wheatgrass Grassland PVT

The wheatgrass grassland PVT was typically dominated by bluebunch wheatgrass and Sandberg bluegrass under historical conditions (figs. 10 and 11). Much of the original area has been converted to agricultural use. The remaining area has been severely altered by excessive livestock grazing and invasive species. Cheatgrass and medusahead were introduced early in the 20th century. More recently, common crupina, yellow starthistle, and several species of knapweed have been introduced and are displacing native species and earlier invaders on many sites. Wildfire is common and aids the conversion from native to invasive species dominance. However, fire is not essential in the conversion to invasive species.

Slightly altered sites usually include many invasive species such as cheatgrass, Japanese brome, medusahead, and yellow starthistle (Daubenmire 1975a, Roché and Roché 1988). It is virtually impossible to completely eliminate these well-adapted invasive species (Tisdale 1986). However, aggressive weed control measures and changes in livestock management may prevent increasing invasive plant dominance and additional displacement of native species. Perennial grass

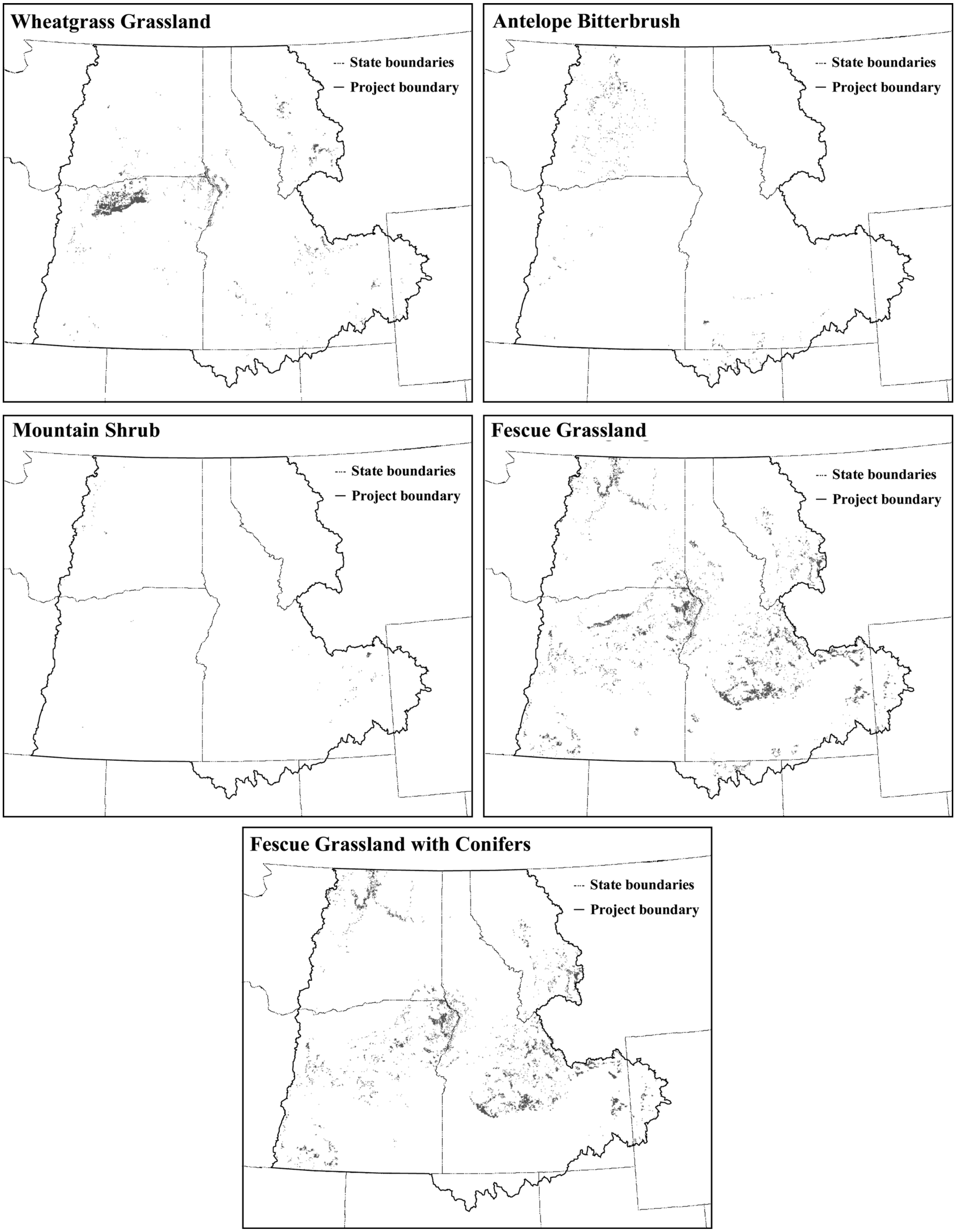

Figure 10—Area included in the wheatgrass grassland, antelope bitterbrush, mountain shrub, fescue grassland, and fescue grassland with conifers potential vegetation types within the interior Columbia basin as mapped at the 1-km scale. ICBEMP data on file with: USDA Forest Service, Pacific Northwest Research Station, P.O. Box 3890, Portland OR 97208.

Figure 11—Remaining wheatgrass grassland PVT vegetation is often located in steep canyon country associated with the Snake, Salmon, Clearwater, Grande Ronde, and Imnaha Rivers. This example is from Corral Creek, a tributary of the Snake River, Hells Canyon, Idaho. (Photo by Sandra Robins.)

communities respond well to changes in livestock management, but little is known about the restoration of perennial native forbs.

Invasive species dominate severely altered sites, and few native species may remain. To restore these areas, aggressive, active restoration measures are needed, which may include control of invasive species and seeding of native species.

Within the basin BLM- and FS-administered lands, large patches of this PVT detectable at 1-km resolution mapping are thinly scattered across northern Oregon, southern Washington, central Idaho, and western Montana (Hann et al. 1997, ICBEMP source data). However, based on plot data, historical and current oblique landscape photography, and midscale photo interpretation, much of this PVT actually occurs in small, undetectable (at 1-km mapping resolution) patches on dry aspects of rugged river breaks and foothill terrain intermingled with dry and cold forests and with mountain big sagebrush PVTs, or in rugged terrain intermingled with agricultural lands. Most of this type occurs at low and moderate elevations (table 3). Almost equal amounts occur in low and moderate precipitation zones (table 4).

Antelope Bitterbrush PVT

The antelope bitterbrush PVT is most extensive in the basin in central Washington (fig. 10). It is dominated by bitterbrush and has a perennial herbaceous understory dominated by one or more grasses including bluebunch wheatgrass, Idaho fescue, rough fescue and needle-and-thread (Daubenmire 1970, Mueggler and Stewart 1980, Youtie et al. 1988). On less steep slopes with sandy soils, needle-and-thread dominated the understory but has often been replaced by cheatgrass (Daubenmire 1970, Youtie et al. 1988). The PVT often occurs on coarse-textured soils that permit greater rates of recruitment for bitterbrush than sites with heavier textured soils (Nord 1965). These communities are important as a source of landscape diversity and for providing forage for wild ungulates (Griffith and Peek 1989, Ngugi et al. 1992). Periodic high populations of the western tent caterpillar (*Malacosoma californicum* Packard) may cause extensive damage and mortality to bitterbrush if the defoliation persists for 2 years (Clark 1956, Furniss and Barr 1975, Nord 1965, Tisdale and Hironaka 1981).

Invasive annual grasses and secondary invasive weedy species such as knapweed have severely altered much of this PVT. Invasive annual grasses also have fueled increased fire occurrence, and this has reduced the abundance of bitterbrush in many areas. Some areas currently with dense stands of bitterbrush are vulnerable because the stands are becoming extremely old and recruitment rates are low.

Within the basin BLM and FS lands, few large patches of this PVT were detectable at 1-km resolution mapping (Hann et al. 1997, ICBEMP source data). However, based on plot data, historical and current oblique landscape photography, and midscale photo interpretation, much of this PVT actually occurs in small undetectable (at 1-km mapping resolution) patches on foothill and mountain slopes, ridges, and benches as inclusions in dry forests and in mountain big sagebrush or fescue grassland PVTs. Most of this type occurs at moderate elevations (table 3) and in the moderate precipitation zone (table 4).

Mountain Shrub PVT

The mountain shrub PVT is usually located in the transition between shrub steppe and conifer forest vegetation (fig. 10). The vegetation is often regarded as a stable community, but at least some stands are probably seral to many coniferous forest types (Christensen 1964). Little information is available on this PVT. It is dominated by a variety of shrubs often associated with mesic shrub steppe and dry conifer communities such as mountain big sagebrush, antelope bitterbrush, Utah serviceberry, Saskatoon serviceberry, shinyleaf ceanothus, ninebark, curlleaf mountain-mahogany, common choke-cherry, and bitter cherry (Major and Rejmanek 1991). On some sites, small quaking aspen may be common. This PVT occurs as relatively small patches interspersed with other PVTs, and, consequently, its area is often underestimated. The mountain shrub PVT also may occur as stringers of shrub-dominated vegetation in draws. These stringer communities may be particularly important to vertebrates such as mountain quail (*Oreortyx pictus*) because of the proximity of water and tall dense shrub overstory (Brennan et al. 1987) that provides added structure to the landscape. Mountain shrub communities also provide valuable browse for large ungulates. Therefore the PVT is more important than its areal extent indicates. The mountain shrub communities are often surrounded by vegetation such as sagebrush steppe that frequently burns and therefore is susceptible to fire. However, most shrub species exhibit moderate to high resprouting potential and recover quickly (Cook et al. 1994, Gartner and Thompson 1973, Leege 1979, Leege and Hickey 1971, Morgan and Neuenschwander 1988, Noste et al. 1989, Young 1983).

Within the basin BLM- and FS-administered lands, few large patches of this PVT were detectable at 1-km resolution mapping (Hann et al. 1997, ICBEMP source data). However, based on plot data, historical and current oblique landscape photography, and midscale photo interpretation, much of this PVT actually occurs in small patches on foothills, mountain slopes, and draws as inclusions in dry and cold forests and in mountain big sagebrush or fescue grassland PVTs, or in rugged terrain intermingled with agricultural lands. These patches are detectable with finer resolution mapping. Much of this type occurs at high and moderate elevations (table 3). Most occurs in the moderate and low precipitation zones (table 4).

Fescue Grassland PVT

The fescue grassland PVT is found in western Montana where it is dominated by rough fescue or Idaho fescue (Mueggler and Stewart 1980), in central Idaho where it is dominated by Idaho fescue, and in northeastern Oregon where the dominants are Idaho or green fescue (Johnson 1987) (fig. 10). Other common codominant grass species include bluebunch wheatgrass, Hood's sedge, western needlegrass, and prairie junegrass. Common forbs include lupine, geranium, and arrowleaf balsamroot. Fescue grasslands form on a variety of site conditions from subalpine ridges to lower forest-grassland transitions where sagebrush species do not occur.

The most prevalent cause of alteration is improper past grazing. Slightly altered sites often show a reduction in the fescue species and bluebunch wheatgrass and an increase in the shallow-rooted, less productive grasses (Dormaar and Willms 1990, Johnson 1987, Reid et al. 1991). Sites that are more severely altered may be totally dominated by short-lived weedy forbs (Revel 1993). Looman (1969) estimated that more than 90 percent of the Canadian fescue grasslands had been moderately to severely altered. These sites deteriorate rapidly under improper grazing and may require more than 20 years to recover after management changes (Dormaar and Willms 1990, Reid et al. 1991). Leafy spurge and knapweed are common invasive species in portions of this PVT (Best et al. 1980, Olsen and Wallander 1998, Tyser and Key 1988).

Within the basin BLM and FS lands, the large patches of this PVT detectable at 1-km resolution mapping are scattered across northern Oregon, southern Washington, central Idaho, and western Montana (Hann et al. 1997, ICBEMP source data). However, based on plot data, historical and current oblique landscape photography, and midscale photo interpretation, much of this PVT actually occurs in small patches of rugged river breaks and foothill terrain intermingled with dry and cold forests and with mountain big sagebrush PVTs; such patches are detectable with finer resolution mapping. This type occurs at both moderate and high elevations (table 3). Most of the type is found within the moderate and high precipitation zones (table 4).

Fescue Grassland with Conifer PVT

The fescue grassland with conifer PVT has a geographic distribution and herbaceous composition similar to that of the fescue grassland PVT (fig. 10). However, it occurs in a mosaic of conifer PVTs and may have a scattered overstory of Douglas-fir, lodgepole pine, subalpine fir, or other conifers. Response of grazing is similar to that of the fescue grassland PVT. In the absence of fire, conifers tend to increase on this PVT, and the understory species composition changes from grassland species to one more similar to dry conifer vegetation.

Within the basin BLM and FS lands, the large patches of this PVT detectable at 1-km scale mapping are widely spread across northern Oregon, southern Washington, central Idaho, and western Montana (Hann et al. 1997, ICBEMP source data). However, based on plot data, historical and current oblique landscape photography, and midscale photo interpretation, additional portions of this PVT also may occur in patches intermingled with dry and cold forests and with mountain big sagebrush PVTs; such patches are detectable with finer resolution mapping. This type occurs primarily at both moderate and high elevations (table 3). Most is found within the moderate and high precipitation zones (table 4).

Primary Causes of PVT Alteration

Workshop participants identified the causes that were most significant in altering the composition and function of rangeland vegetation in the basin (table 5). Identification of the causes allows managers to better develop strategies for restoration. Of the many causes of alteration of rangeland vegetation in the basin, five were considered most significant in terms of severity of effect and total area of the basin affected: (1) introduction of invasive species, (2) livestock grazing, (3) modified fire regimes, (4) climatic change, and (5) activities related to human presence (urbanization, agriculture, road development, etc.). It was recognized that perhaps native ungulates also altered vegetation, but the areal extent of these sites is not known. The relative importance of the causes of alteration differs with location. 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.

All five causes often occur in synergistic feedback loops, are magnified by climatic changes, and are strongly interrelated in their effect on

Table 5—Primary factors contributing to and severity of alteration of each of 17 rangeland potential types found within the interior Columbia basin

Potential vegetation type (PVT)	Primary factors	Votes for most highly altered [a]
Salt desert shrub	Past livestock grazing, invasive species, increased fire occurrence	11[b]
Wyoming big sagebrush–warm	Past livestock grazing, invasive species, increased fire occurrence	16[b]
Wyoming big sagebrush–cool	Past livestock grazing, invasive species	2
Basin big sagebrush	Agricultural development, past livestock grazing, invasive species, increased fire occurrence	7[b]
Threetip sagebrush	Past livestock grazing, invasive species, increased fire occurrence	0
Low sagebrush–xeric	Past livestock grazing, invasive species	2
Low sagebrush–mesic	Past livestock grazing, invasive species	1
Low sagebrush–mesic with juniper	Decreased fire occurrence	1
Mountain big sagebrush–mesic east	Decreased fire occurrence, invasive species	2
Mountain big sagebrush–mesic east with conifers	Decreased fire occurrence, invasive species	0
Mountain big sagebrush–mesic west	Decreased fire occurrence, past livestock grazing	9[b]
Mountain big sagebrush–mesic west with juniper	Decreased fire occurrence, past livestock grazing	14[b]
Wheatgrass grassland	Invasive species, past livestock grazing	10[b]
Antelope bitterbrush	Invasive species, past livestock grazing, increased fire occurrence	2
Mountain shrub	Decreased fire occurrence	5
Fescue grassland	Invasive species, past livestock grazing	0
Fescue grassland with conifers	Decreased fire occurrence, invasive species, past livestock grazing	2

[a] A low number does not indicate that alteration has not occurred within a PVT; rather, it indicates the degree or extent of alteration is low relative to other PVTs found in the basin.
[b] Considered among the most highly altered PVTs and having high priority for restoration practices.

vegetation. For example, invasive annual grasses affect both the fire regime and competition. More frequent wildfire occurrence increases the dominance by invasive annual grasses (Pellant 1990, Peters and Bunting 1994, Whisenant 1990). The introduction of invasive species also alters the competitive relation among species (Harris 1967, Klemmedson and Smith 1964) and other ecosystem processes (Vitousek et al. 1996). Livestock grazing potentially alters the competitive relations among species as well. It also may increase the spread of invasive species (Mack 1986) and alter the fire regime (Bunting et al. 1987). Thus, it is usually impossible to identify a single or even a primary cause of vegetation alteration.

Other factors also were noted as important influences for some areas in the basin. Agricultural development fragments many landscapes (Harms et al. 1987, Knick and Rottenberry 1997) and resulted in the initial introduction of many invasive species (Mack 1986). Climatic variation (Blaisdell 1958, Sauer and Uresk 1976), climatic change (Hu et al. 1999, Miller and Wigand 1994, Steig 1999, Tausch 1999a, Tausch and Nowak 2000, Whitlock and Bartlein 1997), and type conversion efforts such as seeding, herbicidal control of sagebrush (Blaisdell et al. 1982, Blaisdell and Mueggler 1956), and mechanical control of juniper and sagebrush (Blaisdell et al. 1982, Evans 1988) also were cited as important factors in some areas of the basin. Feral horse populations, which were greatest in the 19th century (Ryden 1978, Thomas 1979, Wagner 1983), remain locally important factors and may have great impact on those areas (Beever 1999, Beever and Brussard 2000).

Participants were asked to identify the primary and secondary causes of alteration for each of the basin's PVTs (table 6). Some participants did not think that they were adequately familiar with the vegetation of the entire basin and did not complete this exercise. Participants did not agree as to which factors were most important for the different PVTs. Livestock grazing (past and current) (Daubenmire 1940, Miller et al. 1994, Tisdale 1986), invasive species (Kindschy 1994, Mack 1981, Melgoza and Nowak 1991, Tausch et al. 1994, Tisdale 1986), and changes in fire occurrence (Bunting et al. 1987, Miller and Wigand 1994, Pellant 1990, Whisenant 1990) were most often cited as the primary factors that have affected extensive areas within the basin, but the relative importance of these differed between PVTs (table 6).

Of the 17 dry grass, dry shrub, and cool shrub PVTs identified in the basin, workshop participants identified the PVTs that most significantly influence management of federal lands at the broad scale (table 7). This selection was based on the degree of alteration, aerial extent of the PVT, and the importance of the PVT to the overall ecological function of the basin. Considering the basin-wide scale, these six PVTs have a high priority for restoration. At the local scale, however, others may deserve greater priority for restoration activities. Knowing the causal factors related to alteration is important when planning restoration methods. Participants identified the primary and secondary factors contributing to the alteration of the six PVTs (table 6). Livestock grazing was most often cited as the primary or secondary cause of altered PVTs, followed by invasive species and change in fire regime. The effects of past and current livestock grazing were separated.

The ramifications of not restoring the PVTs are expected to be significant to the future stability of these areas, but the magnitude of change differed across the six PVTs considered (table 7), such as the extent to which vegetation community composition had changed. Mountain big sagebrush–mesic west was predicted to change the least, whereas the other five PVTs showed moderately high or high levels of vegetation composition change. Two PVTs showed low levels of predicted change in physical processes, whereas the remaining four PVTs displayed moderately high to high levels of change. Four PVTs showed low degrees of system stability with the remaining two rated as having moderately high degrees of stability. The basin big sagebrush PVT had the highest predicted risk of continued decline. All

Table 6—Number of participants ranking cause as primary and secondary in alteration of six rangeland potential vegetation types (PVT) in the interior Columbia basin

Priority potential vegetation type (PVT)	Ranking	Causes of alteration: Change in fire regime	Climate change	Invasive species	Livestock grazing	Other human-related factors	Other causes
Salt desert shrub	Primary	0	0	3	10	1	
	Secondary	4	2	5	0	0	
	Unranked						3
Wyoming big sage-brush–warm	Primary	1	0	1	10	1	
	Secondary	2	0	7	0	0	
	Unranked						2
Basin big sagebrush	Primary	0	0	1	8	2	
	Secondary	4	0	4	2	2	
	Unranked						4
Mountain big sage-brush–mesic west	Primary	4	0	0	3	1	
	Secondary	2	0	0	5	0	
	Unranked						4
Mountain big sage-brush–mesic west with juniper	Primary	7	0	0	2	1	
	Secondary	2	0	0	3	4	
	Unranked						5
Wheatgrass grassland	Primary	0	0	3	8	3	
	Secondary	0	6	6	1	2	
	Unranked						3

other PVTs showed moderately high risk. All six PVTs were considered to be generally predictable in the direction of future trend for these ecosystem characteristics. The following discussion of the options for restoration will focus on the six most altered PVTs previously identified.

Management Options and Feasibility for Restoration

Appropriate restoration technique depends on vegetal and environmental conditions, and degree of alteration. As previously discussed, particular sites in a PVT differ along a continuum from only slightly altered to extremely altered. 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, although changed from the historical period, have not resulted in significant alteration of vegetation composition and function. Extremely altered conditions often exhibit high levels of invasive species, livestock grazing, and other impacts. Fire may contribute to altered conditions by either occurring more or less frequently than it did prior to Euro-American settlement because fire occurrence is affected by herbivory, invasive species, human activity, and direct fire suppression.

Restoration of slightly altered conditions often may be readily achieved by changing management of the causative factor(s); i.e., changing management of invasive species, livestock, or fire. This has been referred to as passive restoration management (Allen 1995). Severely altered conditions often include extirpation of natural

Table 7—Degree of change in site characteristics expected with no restoration intervention for severely altered potential vegetation types in the interior Columbia basin

	Potential vegetation type					
Characteristic	**Salt desert shrub**	**Wyoming big sage-brush–warm**	**Basin big sagebrush**	**Mountain big sage-brush–mesic west**	**Mountain big sage-brush–mesic with juniper**	**Wheatgrass grassland**
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

species and their seed sources, loss of soil, and changes in the physical environment. Restoration of such sites requires management that is much more active, such as seeding of native or other desirable species or the use of prescribed fire.

Restoration also was considered to have one of three primary objectives. First, it may be done to prevent future alteration. An example of this situation may be the application of prescribed fire or natural ignition wildland fire use in an ecosystem that is currently within the historical range of variability (HRV), but in which the trend in vegetation change is moving outside the HRV owing to the lack of fire occurrence. The HRV has been defined as the ecological conditions of an ecosystem, and the spatial and temporal variation of these conditions, that occur when the ecosystem is relatively unaffected by people (Landres et al. 1999, Morgan et al. 1994). Second, restoration may be done to stabilize an ecosystem that is currently altered but still contains all the essential ecosystem elements. These sites can be restored through passive restoration activities. Third, restoration may require active and sometimes substantial management effort to restore a poorly functioning ecosystem. These are obviously the most difficult sites to restore and may require management activities that are not ecologically or economically feasible on a broad scale.

The feasibility of restoration, related to four criteria of the six most severely altered PVTs in the basin, was discussed by the workshop participants (table 8). When rating "ecological feasibility," consideration was given to whether or not irreversible changes had occurred in portions of a PVT that precluded the possibility of restoration. These included factors such as changes in soil characteristics or invasive species that had become a permanent part of the site's flora. When considering the "time required for response," it was recognized that the response time for restoration would be highly variable within a PVT because it is dependent on the degree of alteration. Time estimates reflecting the most typical situation within a given PVT were categorized as short (≤10 years), moderate (11 to 49 years), and long (≥50 years). The "probability of success" criterion incorporated probable climatic variation and other stochastic factors as they influence the

Table 8—Feasibility and response time for restoration options in severely altered potential vegetation types within the interior Columbia basin

	Response to restoration options			
Potential vegetation type	**Ecological feasibility**	**Time required for response[a]**	**Probability of success**	**Economic feasibility**
Salt desert shrub	Low	Long	Low	Low to moderate
Wyoming big sagebrush–warm	Moderate	Moderate	Moderate	Moderate
Basin big sagebrush	Moderate	Moderate	Moderate	Moderate
Mountain big sagebrush–mesic west	High	Short	High	High
Mountain big sagebrush–mesic west with juniper	Moderate	Moderate	High	Moderate
Wheatgrass grassland	Low	Long	Low	Low

[a] Time required for response: Short <10, moderate 11–49, and long >50 years.

success of restoration activities. For example, when reseeding native species is necessary in the more arid PVTs, several years of above-average precipitation are needed to assure successful establishment. Because this is an unlikely event that cannot be predicted prior to seeding, establishment from a single seeding in PVTs like the salt desert shrub has a low probability of success. Possible restoration activities were evaluated for "economic feasibility" as low, moderate, or high, but the data to develop monetary values were not available. Thus, the economic feasibility categories assigned to PVTs in table 8 are relative among the six PVTs considered.

The potential restorations of the six most altered PVTs in the basin are discussed below as considered at the basin-wide scale. Local conditions and objectives must be included when planning any restoration program, and these often will include factors not discussed here.

Salt Desert Shrub PVT

Restoration of the salt desert shrub PVT is challenging because of the harsh environment. Low precipitation and saline soils are especially challenging (Blaisdell and Holmgren 1984, Bleak et al. 1965) in their effects on seed germination and growth (Roundy et al. 1984). Individual sites are often highly fragmented and embedded in a mosaic of sagebrush steppe vegetation that further isolates them from natural seed sources. Even when seedling establishment is achieved, populations of shrubs and grasses often decline within 10 to 12 years (Blaisdell and Holmgren 1984, Hull 1963). However, West (1979) found that most seedlings persisted for long periods if they survived the second year after establishment. Common causes of failure include poor seed germination, unadapted species or ecotypes, improper seedbed preparation or planting techniques, competition, climatic variation, and frequent wildfires on the more altered sites. Rehabilitation efforts in the past often have failed owing to severe site conditions and lack of attention given to high ecotypic variation that is common within this PVT (Blaisdell and Holmgren 1984, Bleak et al. 1965). It is critical to match plant species used in restoration to the soil type. Indigenous animals cause a significant loss of seedlings through herbivory but also may be important in the natural recruitment of some species (Longland 1995).

In general, three restoration scenarios exist within the salt desert shrub PVT. The first scenario includes communities that have been slightly altered and where there has been little change in the native perennial shrub and herbaceous plant cover. The second scenario describes sites where the vegetation has been moderately altered, generally to the extent that the perennial herbaceous component has been reduced or eliminated and often replaced by annual grasses. The third scenario describes the most altered state where the perennial shrubs and herbaceous plants have been replaced primarily by annual grasses.

Recovery of slightly altered sites generally can occur under passive management and proper livestock grazing (Blaisdell and Holmgren 1984, Holmgren and Hutchings 1972). Livestock grazing management must be flexible, however, to accommodate the extreme environmental variation from one year to the next. Winter use by domestic animals is most feasible (Cook and Stoddart 1963). Winter livestock grazing when the soil is frozen or snow covered is recommended when managing for biological soil crusts (Belnap et al. 2001).

Sites within the salt desert shrub PVT that have been slightly to moderately altered can be restored through proper livestock management, fire prevention, and aggressive management of invasive species (Blaisdell and Holmgren 1984). However, recruitment of native species on moderately altered sites may require long periods. Consequently, restoration of many sites will require artificial establishment of native species. Knowledge of the agronomic requirements of some shrub species such as fourwing saltbush, spiny hopsage, and winterfat is available (Clary and Tiedemann 1984, Durrant et al. 1984, Pellant and Reichert 1984, Shaw and Hafercamp 1994, Shaw and Monsen 1984), but little is known about others (budsage and shadscale). Herbaceous species should be seeded without removal of the shrub overstory when possible, to maintain the seed source of the shrub species (Blaisdell and Holmgren 1984). This usually can be accomplished with the rangeland drill. However, establishment of native herbaceous species is difficult at best, and most stands of introduced species decline within 10 to 12 years (Plummer 1966). Forage kochia has been successfully used (Clements et al. 1997, Monsen and Turnipseed 1990, Stevens and Van Epps 1984) but may act as an invasive species. Harrison et al. (2000) found that forage kochia successfully competed with annuals, especially cheatgrass, halogeton, medusahead, and tumblemustard and may spread into disturbed and bare areas. However, they found no evidence that it was an aggressive invader or overcame established perennial plant communities.

The sites within the salt desert shrub PVT that offer the greatest challenge for restoration are those that have been severely altered, are dominated by annual grasses, and where wildfires occur frequently. Restoration of native species usually requires controlling competing vegetation through mechanical or herbicidal means and restricting wildfire. Desired species can then be established through seeding or transplanting of container or bareroot stock (Luke and Monsen 1984). The inability to control competition and wildfire in the past has resulted in failure to adequately restore many of these sites to predisturbance conditions. As such, the feasibility for restoration on sites altered the most severely was generally considered to be quite low and in some situations not possible.

Wyoming Big Sagebrush–Warm PVT

The restoration needs in the Wyoming big sagebrush–warm PVT are staggering owing to the immense area involved. This PVT covers more than 9 million ha in the basin (table 2) and an extensive additional area outside the basin. Much of the area has been altered by past livestock use, invasive species, agricultural development, and changed fire regimes. Seed sources for sagebrush and many perennial herbaceous species have been extirpated from many sites in central Washington and the Snake River plain. Frequent disturbance also potentially alters the nitrogen cycle of these sites (Bolton et al. 1990). Wildfires repeatedly burn large areas of annual-dominated steppe and create additional annual-grass-dominated areas each year throughout the basin (Pellant 1990, Whisenant 1990). Restoration usually requires (1) fire suppression, (2) control of invasive plant competition, (3) input of native plant seeds or transplants, and (4) changes in livestock management to encourage plant recruitment. Efforts that do not provide for all four components are likely to fail. Establishment of native species has been difficult because of low summer precipitation (Hironaka et al. 1983), inadequate restoration technology, and limited seed sources.

Perhaps the most feasible action is to prevent further alteration of those areas that are at risk but only slightly to moderately altered through changes in management of fire, invasive species, and grazing. Recovery through natural recruitment processes is possible but occurs slowly, and full restoration may take a long time (Eckert and Spencer 1986, Wambolt and Payne 1986). Cheatgrass and other invasive species likely will remain as a component of this vegetation, regardless of the level of restoration achieved (Kindschy 1994, Tisdale and Hironaka 1981). Restoration strategies primarily include changes in livestock management necessary 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 often are surrounded by stands of annual grasses that are prone to fire. Weed management may be necessary to prevent further invasion by invasive forbs.

Although establishment of introduced perennial grasses through direct seeding has proven successful (Hull 1974, Keller 1979, Mueggler and Blaisdell 1955), establishment of native species has been problematic in this PVT (Blaisdell 1958, Miller et al. 1986). Interseeding and transplanting into annual and introduced perennial grass communities have been used successfully to diversify species composition and establish native species (Stevens 1994). Annual grass competition inhibits the recruitment of most native herbaceous species with the exception of bottlebrush squirreltail (Harris 1967, Hironaka 1994). It is evident that competition from annual grasses must be controlled prior to seeding with either introduced or native species (Miller et al. 1986). This has been accomplished with varying success by livestock grazing, burning, mechanical treatments, and herbicide applications (Hull and Holmgren 1964, Ogg 1994, Pellant et al. 1999, Vallentine and Stevens 1994). Other factors contributing to the failure of native perennial species recruitment include availability of adapted species or ecotypes (Meyer 1994, Meyer and Monsen 1992), poor seedbed conditions (Call and Roundy 1991, Roundy 1994), climatic variation (Meyer 1994, Millar 1997, Miller et al. 1986, Tausch 1996), altered small-herbivore populations (Hardegree 1994), and altered soil conditions (Allen 1995, Stahl et al. 1998). In recent years, greater research emphasis has focused on the establishment of native perennial species.

Highly altered sites exist over a wide continuum of conditions, but three categories of conditions frequently occur. Firstly, the shrub overstory remains with a depleted herbaceous understory. These most frequently have developed under improper grazing management. In many cases, the coverage of sagebrush has increased on these sites. Mechanical treatments have been successfully used to temporarily reduce sagebrush canopies and increase presence of herbaceous species (Blaisdell et al. 1982, Mueggler and Blaisdell 1958). However, if adequate populations of desirable herbaceous species are not present, seeding will be necessary. Establishment of the shrubs and dominant perennial grasses is feasible, and recruitment requirements of these species have been studied (Blaisdell et al. 1982, Meyer 1994, Meyer and Monsen 1990, Roundy 1994). The recruitment requirements for native perennial forbs in this PVT are not well understood. The feasibility of restoration for all four criteria (table 8) is moderate.

Secondly, both native shrub and herbaceous components are largely absent, and the site is dominated by annual invasive species such as cheatgrass and medusahead, and perennial invasive forbs such as rush skeletonweed. These most often have developed when the first type of site conditions (sagebrush overstory-depleted understory) has burned by wildfire and no post-fire rehabilitation was done or those that were attempted failed (Laycock 1991). Abandoned cropland also has resulted in more areas of annual-grass dominated communities. Sagebrush recruitment occurs when a nearby seed source exists. However, repeated wildfires remove the seed source from extensive areas and may result in modified soil environments making natural sagebrush recruitment less likely (Allen 1995, 1988). Restoration usually includes controlling invasive species competition and seeding of both herbaceous species and sagebrush. Some researchers recommend seeding of sagebrush after the herbaceous species are established to reduce competition between native species. Meyer (1994), however, indicates that herbaceous seedlings may also compete with young sagebrush seedlings. Because sagebrush establishes best when planted at or near the surface, broadcast seeding may be more effective than drill seeding (Meyer 1994). The feasibility of restoration is moderate to low because of (1) moderate to high costs, (2) moderate probability of success, and (3) moderate time for response. The primary objective of these treatments would be to establish a functional shrub steppe ecosystem that would eventually repair itself. The restoration of some components such as biological soil crusts may take a long time.

Thirdly, introduced perennial grasses, such as crested wheatgrass, dominate the site. These have been seeded after wildfire occurrence or mechanical removal of sagebrush. Sagebrush recruitment can occur on these sites when a seed source is available and other conditions are favorable, but what makes these conditions favorable is not understood. Restoration of sites seeded to introduced-perennial species has not been widely studied but appears to be feasible if competition by the introduced perennial grasses can be reduced (Bakker et al. 1997, Sheley and Larson 1997). Because the introduced species keep less-desirable species out of the community through competition, these may have a lower priority for restoration than those more subject to further degradation.

Basin Big Sagebrush PVT

Considerations and feasibility for restoration of the basin big sagebrush PVT are similar to those of the Wyoming big sagebrush–warm PVT. Many severely altered sites occur as one of the three categories mentioned previously: (1) sagebrush overstory-depleted understory, (2) invasive annual grass dominated, and (3) introduced perennial grass seedings. Many remaining areas not under intensive agriculture often are embedded in a mosaic of other vegetation types, particularly Wyoming big sagebrush steppe (Hironaka et al. 1983) and may be isolated from other similar sites. These areas are generally small, occurring on the terraces adjacent to water courses, and are not mappable at the 1-km scale. Many of these patches of basin big sagebrush PVT embedded within the Wyoming big sagebrush PVTs (warm and cool) have been severely altered by higher herbaceous productivity, which increases wildfire risk, invasive species problems, and influence of livestock grazing. The more developed deeper soils, as compared to Wyoming big sagebrush steppe, increase the probability of establishment of herbaceous species (Hironaka et al. 1983). This may increase the feasibility of restoration as compared to the Wyoming big sagebrush steppe. Prior to the 1970s, this sagebrush subspecies was not separated taxonomically from Wyoming big sagebrush (Beetle 1960; Winward 1970, 1980; Winward and Tisdale 1977), and the ecology of these subspecies is confounded in the older literature. Little information specific to this PVT related to restoration or management exists. Harniss and McDonough (1976) found greater year-to-year variation in seed germination in basin big sagebrush than in Wyoming big sagebrush. Daubenmire (1975a) stated that sagebrush overstory benefitted the growth of native herbaceous plants and cheatgrass by modifying the microenvironment and enhancing the soil nutrient status from leaf fall.

Mountain Big Sagebrush–Mesic West PVT

Slightly altered sites of the mountain big sagebrush–mesic west PVT usually contain all the elements necessary for recovery following changes in management. This PVT is perhaps the most resilient of those found in the basin and often responds to changes in livestock management (Eckert and Spencer 1986, Yeo et al. 1990). Mountain big sagebrush occurs with greater density and coverage than other sagebrush species (Hironaka et al. 1983), and reduced fire occurrence has resulted in many sites with high shrub coverage. Canopy coverage of mountain big sagebrush rarely exceeds 40 percent (Winward 1970, Bunting et al. 1987). High coverage of sagebrush reduces the abundance of understory species. Fire often is used to reduce the influence of sagebrush in these communities. Mountain big sagebrush rapidly becomes reestablished if a seed-producing population is present and the fire is not severe (Bunting et al. 1987). Seedlings also may rapidly establish from seed in the soil (Hironaka et al. 1983), but germination is enhanced by stratification (McDonough and Harniss 1974) or a heat treatment (Chapin and Winward 1982). Nelle et al. (2000) reported that mountain big sagebrush had developed 8 percent canopy coverage on 6- to 14-year-old burned areas, whereas the nearby unburned areas had 18 percent coverage. On large severely burned areas, it may require more than 30 years for the sagebrush to fully recover (Blaisdell et al. 1982). Antelope bitterbrush is often associated with this PVT and usually recovers rapidly through resprouting and seedling establishment (Bunting et al. 1984). However, resprouting is highly correlated to the season of the fire and to growth form. The greatest resprouting potential is observed on spring burns and from the shorter multiple-stemmed growth forms (Bunting et al. 1984). Mechanical and herbicidal treatments also have been used extensively to reduce sagebrush coverage in the past (Blaisdell et al. 1982, Mueggler and Blaisdell 1958, Wambolt and Payne 1986), but these practices are less common today owing to economic and environmental concerns (Klebenow 1970, Schroeder and Sturges 1975). Because sagebrush establishment occurs rapidly, disturbances that maintain open to mid-density sagebrush must be frequently applied (15- to 30-year intervals).

Most perennial herbaceous species respond positively to fire, but Idaho fescue may be reduced depending on the severity of the burn (Bunting et al. 1987, Harniss and Murray 1973, Hironaka et al. 1983). Native herbaceous plants will increase on burned sites if there are adequate onsite seed sources. This PVT has a diverse perennial forb component, particularly in areas with higher precipitation. Perennial forbs that are enhanced by postfire conditions include arrowleaf balsamroot, lupine, senecio, penstemon, and hawksbeard.

Severely altered conditions are dominated by annual and short-lived forbs and grasses resulting primarily from improper grazing practices. Seeding native herbaceous species on depleted sites may be necessary because rest from livestock grazing alone may not be effective in restoring them (Holmgren 1976). The greater precipitation and cooler climate of this PVT increase the probability of seeding success as compared to many other sagebrush steppe communities. Those sites with a depleted herbaceous component or domination by invasive species may require seeding. Establishment of common grass and shrub species is highly feasible (Blaisdell et al. 1982), but less is known about the establishment requirements of native perennial forbs. Those sites dominated by invasive forb species such as knapweed, yellow starthistle, or leafy spurge may be the most difficult to restore within this PVT. Biological control of these species has shown potential but has not proven to be fully successful at this time (Jacobs et al. 2000, Maddox et al. 1991, Muller-Scharer and Schroeder 1993, Rinella et al. 2001). Grazing by sheep has been shown to be effective in reducing leafy spurge (Bowles and Thomas 1978, Olsen and Wallander 1998).

Restoration of the mountain big sagebrush–mesic west PVT may be the most feasible of the six most altered PVTs found within the basin (table 8). It is one of the most resilient PVTs of the rangeland vegetation types, responding readily to changes in management. The changes in fire regime and livestock grazing were considered about equal as primary causes of alteration (table 6). The response time was considered to be short, and the probability of success high for this PVT (table 8). Prescribed fire and wildland fire use can open sagebrush canopy where it is greater

Figure 12—An example of the mountain big sagebrush–mesic west with juniper PVT in the midstage of western juniper encroachment located on the Owyhee Plateau, Idaho. Advancing succession results in a reduction of the species associated with sagebrush steppe. (Note the skeletons of dead and dying sagebrush and antelope bitterbrush in the juniper interspaces.) (Photo by Stephen Bunting.)

than desired. Prescribed fire was predicted to be moderate in cost, short in response time, and have a high probability of success. Mechanical treatments also have been successfully used in the past, but these treatments are limited by increased economic costs, topography, and soil conditions that reduce their feasibility.

Mountain Big Sagebrush–Mesic West with Juniper PVT

The species compositions of the seral stages of mountain big sagebrush–mesic west with juniper PVT are similar to that of the mountain big sagebrush–mesic west PVT. Many of the restoration considerations for the two PVTs are the same. The primary difference is the presence of adjacent juniper woodlands that expand into this PVT in the absence of fire and dominate the later stages of succession (Miller and Wigand 1994). The woodland-dominated stages of succession have widely different restoration potentials and considerations. Restoration can be readily achieved by reintroducing fire in the early stages of woodland development (Bunting 1987) (fig. 9). The livestock grazing regime must be altered, at least temporarily prior to burning, to permit adequate fuels to accumulate. Postburn livestock grazing strategies must allow for herbaceous plant recovery, seed production, and recruitment.

As the more advanced woodland stages develop, a threshold is crossed (Tausch 1999b) that affects the potential fire behavior and postfire successional pattern. Fine fuel loads decline in the community making prescribed fire more difficult to implement (fig. 12). Community composition becomes dominated by species typical of juniper woodlands, and many species typical of sagebrush steppe decline (Bunting et al. 1999). When fires do occur, they are more intense and severe (Gruell 1999) causing greater mortality of herbaceous species. Plant canopy coverage for site protection takes increasingly longer to redevelop postburn leaving the site more susceptible to further soil erosion. In some portions of the basin,

End of Part C. Click here for Part D.

these severely burned areas become dominated by annual grasses (Svejcar 1999, Tausch 1999a). They are then susceptible to frequent reburning, which further inhibits the establishment of many native perennial species on the site.

Reduction of juniper overstory has been effectively achieved through wood cutting (Bates et al. 1998, 2000) or other mechanical methods (Evans 1988) that may significantly reduce restoration costs. These methods have been shown to restore understory productivity and diversity (Bates et al. 2000). Mechanical reduction of juniper also may be necessary to provide increased herbaceous production to increase fine fuel loading on the site.

Past seeding efforts after removal of juniper by fire or mechanical methods have focused on introduced species (Richards et al. 1998). Recently, more emphasis has been placed on native species, but little data exist on the establishment of native species in this ecosystem, particularly perennial forbs. The need for postfire seeding needs to be evaluated carefully. Many indigenous species are well adapted to fire, and seeding may be unnecessary to restore plant coverage and counterproductive in terms of reducing erosion potential (Ratzlaff and Anderson 1995).

A change in fire regime was considered the most common cause of alteration within this PVT (table 6). The overall feasibility of restoration of slightly altered sites is high by using prescribed fire when the encroachment of juniper is in its early stages of development. Most of the typical sagebrush steppe species usually remain in the community, and these reestablish rapidly after fire. Periodic reburning of these sites will be required after restoration in order to limit juniper recruitment. Overall feasibility declines as the woodland develops because the overstory influence on the understory species results in longer time for response and higher cost of treatment. Mechanical or other treatments that reduce the older juniper may be required. There also was some discussion of the feasibility of chemical treatments for the control of juniper; however, the broad-scale use of chemicals on public lands for this purpose is generally unacceptable and not a realistic alternative. Those sites where advanced woodland development has resulted in soil loss may not be feasible to restore. In some areas, invasive annual grasses also have encroached into the vegetation, and these may dominate the site after fire. This often initiates a frequent wildfire cycle that limits recruitment of native species onto the site. When this situation occurs, the feasibility of restoration is reduced by (1) the added expense of fire control and seeding of native species, (2) increased time of response, and (3) increased uncertainty of treatments.

The second most common cause of alteration of this PVT was thought to be past livestock grazing (table 6). Restoration of slightly to moderately altered sites is highly feasible through changes in the livestock grazing regime. Restoration of severely altered sites is less feasible because of the need for seeding natives into the community. Seeding increases cost, time of response, and uncertainty of success. Information on establishment of the common native grasses and shrubs is available, but little is known about the establishment of many perennial forbs.

Wheatgrass Grassland PVT

The composition of large portions of the wheatgrass grassland PVT was severely altered by livestock grazing in the early 20th century (Daubenmire 1975b, Tisdale 1986). Bluebunch wheatgrass was susceptible to heavy grazing use (Tisdale 1961), particularly in the late spring and early summer (McLean and Wikeem 1985, Mueggler 1975, Pitt 1986). The dominant grasses have largely been replaced by invasive annual species and rubber rabbitbrush on much of the area of this PVT (Daubenmire 1975b). Initially, cheatgrass became dominant but was displaced by other invasive species such as St. Johnswort (Tisdale 1976) and medusahead (Dahl and Tisdale 1975) later in the century. Successful biological control of St. Johnswort did not result in an increase of perennial species but rather a return to annual grass dominance (Tisdale 1976). More recently, invasive species such as yellow starthistle also have partially been reduced by biological control agents (Fornasari et al. 1991, Maddox et al. 1991, Shishkoff and Bruckart 1996) but continue to invade additional areas. Prescribed burning has been successfully used to reduce yellow starthistle density and seed banks (DiTomaso et al. 1999). However, the reduction of yellow starthistle results only in an increase of annual grasses or other invasive species unless a native component is present prior to control. In addition, reduction or complete removal of livestock grazing has not been effective in restoring perennial herbaceous species on severely altered sites in this PVT (Daubenmire 1975b). Sand dropseed is perhaps one of the few native species capable of establishing, when a seed source is available, in the presence of cheatgrass competition (Daubenmire 1975b). Clearly, more active measures including competition control and seeding will be required for restoration.

The wheatgrass grassland PVT was subject to periodic fires during the pre-Euro-American period. Aboriginal people used fire extensively to manipulate vegetation and for other purposes in the basin (Barrett and Arno 1982, Gruell 1985, Shinn 1980). Tisdale (1986) and Horton (1972) both concluded that the occurrence of fire was not particularly ecologically important in these grasslands, in spite of being important to the surrounding forest and shrub-dominated vegetation structure. In the absence of the invasive species present today, most plant species, which are relatively fire tolerant (Johnson 1987, Tisdale 1986), recover rapidly after fire. Daubenmire (1975b) found that fire initially decreased bluebunch wheatgrass and resulted in greater Sandberg bluegrass density. The site had recovered to unburned composition by year 12. Although cheatgrass and other annual grasses were present, they did not dominate the site postburn (Daubenmire 1975b). Since the dominance by annual grasses, fires probably occur more frequently and the perennial herbaceous species recover more slowly, particularly with respect to postburn recruitment.

Past seeding efforts in this PVT have focused on soil stabilization, invasive species control, and forage production and have primarily used introduced perennial grasses such as intermediate, pubescent, and crested wheatgrass. “Secar” wheatgrass, a cultivar of Snake River wheatgrass[2] that is native to this PVT, is commercially available and is now used extensively in seeding programs (Ganskopp et al. 1997, Jones and Neilson 1993). Insufficient moisture and severe competition are the most limiting factors in the establishment of native grasses (Daubenmire 1968, Miller et al. 1986). Many active restoration methods are severely limited by the steep slopes and rocky soils associated with the PVT. Little information is available on the restoration of the wheatgrass grassland PVT.

As this PVT becomes more altered, invasive species become more prevalent, at which time it becomes far more difficult to maintain or restore perennial native forbs and grasses. Of the PVTs discussed, the wheatgrass grassland is perhaps the least understood as to restoration of altered sites. This is evidenced by the scarcity of supporting references and other information about techniques and feasibility of restoring altered sites.

Potential for Increasing Greater Sage Grouse Populations

The greater sage grouse is a species of large landscapes. It uses the leaves of sagebrush for food during winter, the combined cover of shrubs and residual grasses and forbs during the spring nesting season, and a diverse assemblage of forbs and insects during the summer brood-rearing season (Schroeder et al. 1999). Because these habitat attributes differ in quantity, quality, and condition depending on PVT, greater sage grouse may move large distances or elevation gradients to reach acceptable nesting, brood rearing, or foraging habitat. Hence, although sage grouse were historically distributed throughout most of the basin, evidence indicates that their densities differed by season and PVT. This natural variation has been exaggerated by long-term habitat

[2] Snake River wheatgrass (*Elymus wawaiensis* Carlson and Barkworth) has been taxonomically separated from bluebunch wheatgrass (Carlson and Barkworth 1997) but is not currently included in the USDA NRCS (2001) plant database.

loss and degradation (Beck and Mitchell 2000, Connelly et al. 2000). Changes in habitat quantity, quality, and configuration have been dramatic and have resulted in widespread declines in the distribution and abundance of greater sage grouse (Braun 1998, Connelly and Braun 1997).

The PVTs with the strongest potential to support greater sage grouse during all or a portion of their life cycle include (1) Wyoming big sagebrush–warm, (2) Wyoming big sagebrush–cool, (3) basin big sagebrush, (4) threetip sagebrush , (5) low sagebrush–mesic, (6) mountain big sagebrush–mesic east, (7) mountain big sagebrush–mesic east with conifers, (8) mountain big sagebrush–mesic west, and (9) mountain big sagebrush–mesic west with juniper. These PVTs compose about 75 percent of the potential rangeland vegetation in the basin (21.69 million ha). Other PVTs in the basin may be used by greater sage grouse, depending on their quality, configuration, and proximity to the primary habitats. For example, the wheatgrass grassland PVT is normally not considered to be greater sage grouse habitat. However, if wheatgrass grassland is adjacent to the mountain big sagebrush–mesic west PVT, it will probably be used.

Of the nine PVTs listed as primary greater sage grouse habitat, only four were selected for specific evaluation by the workshop participants. Salt desert shrub and wheatgrass grassland were evaluated but were not considered primary sage grouse habitat (table 6). Wyoming big sagebrush–cool, threetip sagebrush, and low sagebrush–mesic do not provide substantial greater sage grouse habitat in the basin, but are important elsewhere. The four PVTs discussed in detail contribute approximately 59 percent of the potential rangeland habitat in the basin (12.83 million ha). They also illustrate the dramatic variation in seasonal suitability for greater sage grouse, habitat condition, and potential for protection and restoration.

Greater sage grouse use the lower elevation sagebrush-dominated habitats (represented by Wyoming big sagebrush–warm and basin big sagebrush) more during winter. This pattern of use occurs because greater sage grouse depend on sagebrush leaves and buds as a winter food source (Remington and Braun 1985, Welch et al. 1991) and because some of the higher elevation habitats are covered by snow during winter (Hupp and Braun 1989). Because the Wyoming big sagebrush–warm and basin big sagebrush PVTs have been affected by dramatic levels of habitat conversion and degradation (table 5), there is substantially less habitat area when compared with historical levels. The enormous overall area of these habitats (10.32 million ha) and the high level of habitat alteration indicate that restoration likely will be difficult.

Historical evidence indicates that greater sage grouse used all big sagebrush-dominated habitats heavily during both the nesting and brood-rearing seasons. Greater sage grouse appear to prefer sagebrush habitats with a substantial herbaceous component (Apa 1998, Fischer 1994, Sveum et al. 1998). This characteristic can be found to varying degrees in Wyoming big sagebrush–warm, basin big sagebrush, mountain big sagebrush–mesic west, and mountain big sagebrush–mesic with juniper. These big sagebrush-dominated PVTs differ in their likelihood of conversion to unsuitable habitat conditions and resilience to long-term degradation (table 2). Although populations of greater sage grouse appear to have declined in every PVT throughout the species range, declines appear to be smallest in the mountain big sagebrush–mesic west PVT, which has been altered less than the other potential habitats. Wisdom et al. (in press b) predicted that the highest probability of local extirpation of greater sage grouse was associated with highly altered landscapes.

The mountain big sagebrush–mesic west PVTs (1.21 million ha combined) offer a high probability of restoration success, primarily owing to the low level of conversion and the continued presence of native grasses and forbs (table 8). Because these habitats are important to greater sage grouse, their protection or restoration offer distinct opportunities to enhance and protect current populations. The protection and restoration of mountain big sagebrush–mesic west PVTs, however, may not be enough to ensure the long-term viability of greater sage grouse populations.

Table 9— Historical and current use by greater sage grouse of several potential vegetation types within the interior Columbia basin

Potential vegetation type	Historical seasonal use			Current seasonal use[a]			Potential to improve population outcomes with management
	Nesting	Brood-rearing	Winter	Nesting	Brood-rearing	Winter	
Salt desert shrub	Low	Low	Low	Low	Low	Low	Low
Wyoming big sagebrush–warm	High	High	High	**Mod.**	**Mod.**	**Mod.**	High
Basin big sagebrush	High	High	High	**Low**	**Low**	**Mod.**	Moderate
Mountain big sagebrush–mesic west	High	High	Mod.	High	High	Mod.	Moderate
Mountain big sagebrush–mesic with juniper	High	High	Mod.	**Low**	**Low**	Low	High
Wheatland grassland	Low	Low	Absent	Low	Low	Absent	Low

[a] The descriptions in bold type represent declines in relative usage between historical and current periods.

This lack of certainty is because of the patchiness and island-like nature of these relatively high-elevation habitats. These patches are connected by relatively large regions of the lower elevation Wyoming big sagebrush–warm PVT. Suitability of greater sage grouse habitat in this low-elevation PVT has declined owing to reduction in both sagebrush and herbaceous cover. This decline in habitat quality is the clearest explanation for the historical declines in greater sage grouse populations in North America (Braun 1998). However, the high degree of alteration in the Wyoming big sagebrush-warm PVT (table 2) suggests that it will be more difficult to restore (table 5). Nevertheless, its restoration may be the best way to realistically ensure the viability of greater sage grouse in the region (Hemstrom et al., in press; Wisdom et al., in press).

Although the workshop participants only evaluated six PVTs (table 9), the same considerations can be applied to all PVTs in the basin. The habitats that currently support the largest populations of greater sage grouse tend to be relatively intact, high-elevation sites. Although these habitats have the highest potential for protection or restoration, their island-like nature is a long-term problem for viability of greater sage grouse populations. Research on population viability suggests that sage grouse populations existing in "islands" of habitat may not be viable (Schroeder 2000). Consequently, the relatively expansive, low-elevation PVTs may be particularly important for providing a habitat connection between the smaller, high-elevation PVTs.

Management recommendations in these PVTs are varied, because of the extreme range in problems. For example, areas that have been converted for the production of crops usually are on private land and are considered too expensive to restore. Nevertheless, the croplands within the basin are characterized by relatively low elevation and deep soil and, hence, they have potential to support certain types of habitats that may not be supportable in the high elevations and shallow soils. The high potential of these converted areas has been illustrated by the Conservation Reserve Program (CRP), which has resulted in the "setting-aside" of vast tracts of cropland in perennial grasses, forbs, and shrubs resulting in benefits to the greater sage grouse in some areas (Schroeder et al. 2000). In addition, the low-elevation sites offer opportunities to connect the relatively intact, but isolated, high-elevation sites.

Altered areas of habitat within the PVTs differ in resiliency and in opportunities for restoration. The relatively high-elevation sites have tended to maintain an intact composition of native species, particularly grasses and forbs. Nevertheless, many sites have been affected by overgrazing and fire management strategies that have increased the relative density of shrubs or invading conifers. Strategies that reduce conifers, create a mosaic of different shrub successional stages, and increase herbaceous cover are recommended. In some areas, these habitats need to be protected rather than restored. Although the intact areas of habitat at lower elevations have been affected by the same problems (Beck and Mitchell 2000), lower precipitation and expansion of invasive species have dramatically complicated the restoration process. Invasive species have altered the fire frequency and reduced the opportunities for reestablishment of native forbs and grasses. In many cases, treatment of invasive species may result in the simultaneous reduction of native species. Although these areas present a difficult restoration challenge, their immense area indicates that their restoration may offer the greatest potential for the improvement of greater sage grouse populations.

Potential for Increasing Columbian Sharp-Tailed Grouse Populations

The Columbian sharp-tailed grouse needs a close configuration of both high-quality and diverse PVTs. It requires the buds of deciduous shrubs and trees during winter, the combined cover of shrubs and residual grasses and forbs during the spring nesting season, and a diverse assemblage of forbs and insects during the summer brood-rearing season (Giesen and Connelly 1993). Although sharp-tailed grouse were historically distributed throughout much of the basin, evidence indicates that their densities varied dramatically by season and PVT. Because of changes in habitat quantity, quality, and configuration, there have been widespread declines in the distribution and abundance of Columbian sharp-tailed grouse (Connelly et al. 1998).

The PVTs with the strongest potential to support Columbian sharp-tailed grouse during all or a portion of their life cycle include (1) Wyoming big sagebrush–cool, (2) threetip sagebrush, (3) mountain big sagebrush–mesic east, (4) mountain big sagebrush–mesic east with conifers, (5) mountain big sagebrush–mesic west, (6) mountain big sagebrush–mesic west with juniper, (7) wheatgrass grassland, (8) mountain shrub, (9) fescue grassland, and (10) fescue grassland with conifers. These PVTs make up approximately 50 percent of the potential rangeland vegetation in the basin (14.42 million ha).

Of the 10 PVTs listed as primary sharp-tailed grouse habitat, 3 were specifically evaluated by the workshop participants. These included mountain big sagebrush–mesic west (two types) and wheatgrass grassland (table 10). Although these three PVTs compose only 11 percent of the potential rangeland habitat in the basin (3.16 million ha), they illustrate the dramatic declines in overall habitat quality. Because these three PVTs are used by Columbian sharp-tailed grouse primarily during the nesting and brood-rearing seasons, the quantity and quality of herbaceous cover are extremely important. In the mountain big sagebrush–mesic PVTs, increases in shrub and juniper cover often have come at the expense of decreases in grass and forb cover. In the wheatgrass grassland PVT, many areas have been converted to croplands.

All of the declines in herbaceous cover have been exacerbated by the declining quantity and quality of critical areas of winter habitat. Columbian sharp-tailed grouse are dependent on the buds, catkins, and fruits of deciduous trees and shrubs, particularly when the ground is covered by snow (Giesen and Connelly 1993). These required PVTs include (1) mountain big sagebrush–mesic east with conifers, (2) mountain big sagebrush–mesic west with juniper, (3) mountain shrub, and (4) fescue grassland with conifers. Although all four of these PVTs have potential to support

Table 10—Historical and current use by Columbian sharp-tailed grouse of several potential vegetation types within the interior Columbia basin

Potential vegetation type	Historical seasonal use			Current seasonal use[a]			Potential to improve population outcomes with management
	Nesting	Brood-rearing	Winter	Nesting	Brood-rearing	Winter	
Salt desert shrub	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Wyoming big sagebrush–warm	Mod.	Mod.	Low	**Low**	**Low**	Low	Low
Basin big sagebrush	Mod.	Mod.	Low	**Low**	**Low**	Low	Low
Mountain big sagebrush–mesic west	High	High	Mod.	**Low**	**Low**	**Low**	Moderate
Mountain big sagebrush–mesic with juniper	High	High	Mod.	**Low**	**Low**	**Low**	Moderate
Wheatland grassland	High	High	Low	**Low**	**Low**	Low	Moderate

[a] The descriptions in bold type represent declines in relative usage between historical and current periods.

many species of trees and shrubs, the necessary winter habitat is often in relatively small and isolated areas.

Because of the required configuration of diverse and high-quality habitat types, the overall distribution of sharp-tailed grouse has been dramatically influenced by relatively small changes in land use. Almost all populations of Columbian sharp-tailed grouse in unconverted portions of the basin have been extirpated. The remaining populations are largely restricted to regions dominated by cropland of which substantial portions have been enrolled in the federal CRP. The CRP habitats that support sharp-tailed grouse tend to be dominated by substantial stands of perennial grasses and forbs, usually near potential winter habitat (Connelly et al. 1998).

The expansion of sharp-tailed grouse in areas dominated by CRP and their declines in areas of native rangeland help illustrate the dramatic declines in herbaceous vegetation associated with native habitat. Consequently, restoration efforts should be focused in areas where there is a high probability of increasing herbaceous cover, such as in the Wyoming big sagebrush–cool, threetip sagebrush, mountain big sagebrush–mesic (four types), wheatgrass grassland, mountain shrub, and fescue grassland (two types) (table 8). As with greater sage grouse, management efforts should consider all available options, including changes in livestock management, control of invasive species, and alteration of fire frequency. In addition, efforts should be strongest where these potential habitats are relatively close (within 20 km) to existing populations of sharp-tailed grouse. This region of focus should include eastern and south-central Idaho (Connelly et al. 1998).

Conclusion

Altered ecosystems were considered to be those where human-induced or natural disturbances are of sufficient magnitude to change ecosystem processes. Long-term loss of or displacement of native community types and reduction of productive potential makes it difficult or impossible to restore these ecosystems to historical conditions. The most common factors that have affected the PVTs found in the basin include livestock grazing, invasive species, and changes in fire regime. In most instances, fire is less common now than during the historical period. However, in some PVTs, such as the Wyoming big sagebrush–warm, and the basin big sagebrush, fire may be more common than under historical conditions. Agricultural development has been an important factor on private lands, and in some cases, these influences have spread to adjacent BLM- and FS-managed lands.

Options exist to restore some altered rangeland ecosystems by restoring native plant communities, stabilizing ecosystem processes, reducing the spread of invasive species, or conserving existing biota. In some altered conditions, these options have a relatively high probability of success over the short term with low to moderate cost at the site scale. However, in other altered conditions, restoration options are expensive, have a low probability of success, and require a long time. Many altered ecosystems may be restorable, but success of these efforts is variable and untested for many restoration methods. Failure to restore the PVTs most altered will affect the future stability of these areas. This is particularly the case for those altered by invasive species, such as cheatgrass and yellow starthistle, or where fire occurrence is more frequent than the historical conditions, as in the Wyoming big sagebrush–warm PVT.

The PVTs differed considerably in the extent to which vegetation composition had changed. The feasibility of restoration of the six most severely altered PVTs in the basin was discussed by the workshop participants from four perspectives (table 9). The overall feasibility of restoration of the mountain big sagebrush–mesic west was high. Restoration could primarily be accomplished through changes in the management of fire and livestock grazing. Potential recruitment of native species was high where seed sources were present and alteration by invasive species was low. These management changes could be enacted relatively inexpensively, and the vegetation would respond rapidly to the changes. Restoration of salt desert shrub and wheatgrass grassland PVTs were thought to be the least feasible. Restoration of these PVTs often would require control of invasive species and seeding of native species. In addition, soil and topographic conditions limit many types of restoration practices. Recruitment rates of native species are low owing to severe environmental conditions such as low rainfall. Consequently, restoration would take a long time. Altered portions of the salt desert shrub often are dominated by annual grasses that greatly increase wildfire occurrence. Wildfires need to be suppressed for many years to enable recruitment of the native shrubs in this PVT. Composition of the wheatgrass grassland PVT has been significantly altered by invasive annual grasses. Currently, invasions by yellow starthistle, common crupina, and other species continue, often displacing the invasive annual grasses. Given the limitations of soil and topography, methods to successfully reestablish perennial species are not tested, and restoration may not be feasible at this time.

Restoration of those sites within the mountain big sagebrush–mesic west with juniper that were in the early stages of woodland development was highly feasible. The response would be similar to that of the mountain big sagebrush–mesic west. However, restoration of those sites that had advanced through succession to later woodland stages was less feasible. Juniper may have to be removed by using methods other than fire, such as cutting or other mechanical means. In many cases, the shrub and herbaceous species have been severely reduced on these sites. Shrubs and native perennial grasses have been successfully established on these sites through seeding, but little is known about the establishment of many of the native forbs associated with this PVT.

The Wyoming big sagebrush–warm PVT is the most abundant rangeland PVT in the basin (table 2), and restoration feasibility is reduced by the immense area involved. Much of the area has been altered by past livestock grazing practices and invasive species. Altered sites in the Wyoming big sagebrush–warm and the basin big sagebrush PVTs have a moderate restoration feasibility because of the presence of invasive species and subsequent reduction of recruitment of species native to these PVTs. Many areas are also subject to frequent wildfire that prevents sagebrush recruitment. Severely altered sites require seeding of native species. Availability of seed sources is limited, and the establishment requirements for seedlings for many of these species is not well understood.

Greater sage grouse and Columbian sharp-tailed grouse are extremely important species within the basin because of their widespread historical distribution, declining status, and potential use of most of the rangeland PVTs. Sage grouse densities vary by season and PVT because of seasonal movements and their dependence on sagebrush leaves during winter, shrub and herbaceous cover during spring, and forbs during summer. This natural variation has been exaggerated by differences in quantity, quality, and configuration of the PVTs. Of the six PVTs evaluated by workshop participants, only Wyoming big sagebrush–warm, basin big sagebrush, mountain big sagebrush–mesic west, and mountain big sagebrush–mesic west with juniper were considered to be primary habitats for greater sage grouse. The mountain big sagebrush PVTs were believed to be relatively intact, thus offering the best opportunities for restoration. These PVTs, however, tend to be relatively high-elevation sites that are somewhat isolated by vast areas of alternate habitats less suitable for sage grouse. The Wyoming and basin big sagebrush PVTs were believed to offer the greatest restoration challenge because of their dramatically altered characteristics. Nevertheless, their restoration may be the best way to realistically ensure the viability of greater sage grouse in the region because of their immense size and because they provide connections between the smaller and more isolated PVTs. It is clear from this workshop that habitat management and restoration for greater sage grouse will require planning and action over a vast landscape.

Similar to greater sage grouse use, use by Columbian sharp-tailed grouse also varies by season and PVT. Sharp-tailed grouse tend to depend on herbaceous cover during spring, forbs during summer, and deciduous shrubs and trees during winter. Of the six PVTs evaluated by workshop participants, only mountain big sagebrush–mesic west, mountain big sagebrush–mesic west with juniper, and wheatgrass grassland are likely to be primary habitats for sharp-tailed grouse. Although other PVTs also can be used by sharp-tailed grouse, their usage often is dependent on their proximity to a primary PVT. The mountain big sagebrush PVTs appear to be relatively intact, thus offering excellent opportunities for restoration. In contrast, the wheatgrass grassland has largely been eliminated by conversion to cropland. Among all 17 PVTs in the basin, the relatively high-elevation rangeland PVTs appear to be the most important for sharp-tailed grouse. These include Wyoming big sagebrush–cool, threetip sagebrush, mountain big sagebrush (four types), wheatgrass grassland, mountain shrub, and fescue grassland (two types). Because many of these habitats are small, isolated, and long distances from existing populations of sharp-tailed grouse, it is likely that restoration should be focused in specific areas where there are opportunities to expand or connect existing populations. As with greater sage grouse, management and restoration of Columbian sharp-tailed grouse will require planning and action over a vast landscape.

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English Equivalents

When you know:	Multiply by:	To find:
Centimeters (cm)	0.39	Inches
Meters (m)	3.28	Feet
Kilometers (km)	0.62	Miles
Square kilometers (km^2)	0.39	Square miles
Hectares (ha)	2.47	Acres

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Appendix 1—Rangeland workshop participants

Affiliation	Name	Location
Federal agencies		
USDA Forest Service		
PNW Research Station–ICBEMP	Miles Hemstrom	Portland, OR
PNW Research Station–ICBEMP	Tom Quigley	La Grande, OR
PNW Research Station–ICBEMP	Mike Wisdom	La Grande, OR
Region 4–ICBEMP	Hal Gibbs	Boise, ID
Region 6	Lisa Croft	Portland, OR
Region 6	Jeff Walter	Portland, OR
Rocky Mountain Research Station	Steve Monsen	Provo, UT
Rocky Mountain Research Station	Robin Tausch	Reno, NV
Washington Office	Larry Bryant	Washington DC
Washington Office	Wendel Hann	Leadville, CO
Washington Office	Richard Holthausen	Flagstaff, AZ
USDI Bureau of Land Management		
Burns District Office	Jeff Rose	Hines, OR
OR/WA State Office–ICBEMP	Jodi Clifford	Long Beach, CA
OR/WA State Office–ICBEMP	Becky Gravenmier	Portland, OR
OR/WA State Office–ICBEMP	Goeff Middaugh	Portland, OR
OR/WA State Office	Judy Nelson	Portland, OR
OR/WA State Office	Hugh Barrett	Portland, OR
OR/WA State Office–ICBEMP	Mary Rowland	La Grande, OR
Prineville District Office	John Swanson	Prineville, OR
Washington Office	Mike “Sherm” Karl	Washington, DC
USDI Geological Survey		
Biological Resources Division	Steve Knick	Boise, ID
Biological Resources Division	Dave Pyke	Corvallis, OR
Biological Resources Division	Erik Beever	Corvallis, OR
State agency		
Washington State Department of Fish and Wildlife	Mike Schroeder	Bridgeport, WA
Universities		
Oregon State University		
Agricultural Science Department	Marty Vavra	Burns, OR
Department of Fisheries and Wildlife	John Crawford	Corvallis, OR
University of Idaho		
Department of Rangeland Ecology and Management	Steve Bunting	Moscow, ID
	Kendall Johnson	Moscow, ID
	Jim Kingery	Moscow, ID
Washington State University		
Department of Natural Resource Sciences	Linda Hardesty	Pullman, WA
Organizations		
Point Reyes Bird Observatory	Aaron Holmes	Stinson Beach, CA
Other		
Facilitator	Susan Hayman	Boise, ID

Appendix 2—Scientific and common names of vascular plants referred to in the text

Common name(s)	Scientific name and authority
Forbs	
Arrowleaf balsamroot	*Balsamorhiza sagittata* (Pursh) Nutt.
Biscuitroot; desertparsley	*Lomatium* Raf. spp.
Bolander's yampah	*Perideridia bolanderi* (Gray) A. Nels. & J.F. Macbr.
Common crupina	*Crupina vulgaris* Cass.
Forage kochia	*Kochia prostrata* (L.) Schrad.
Geranium	*Geranium* L. spp.
Goatweed; St. John's wort	*Hypericum perforatum* L.
Halogeton; saltlover	*Halogeton glomeratus* (Bieb.) C.A. Mey.
Hawksbeard	*Crepis* L. spp.
Heartleaf arnica	*Arnica cordifolia* Hook.
Knapweed	*Centaurea* L. spp.
Leafy spurge	*Euphorbia esula* L.
Lupine	*Lupinus* L. spp.
Penstemon	*Penstemon* Schmidel spp.
Rush skeletonweed; hogbite	*Chondrilla juncea* L.
Senecio, ragwort	*Senecio* L. spp.
Spotted knapweed	*Centaurea biebersteinii* DC. spp.
Sticky purple geranium	*Geranium viscosissimum* Fisch. & C.A. Mey. Ex C.A. Mey.
Tansymustard	*Descurainia* Webb & Berth. spp.
Tumblemustard	*Sisymbrium altissimum* L.
White knapweed; diffuse knapweed	*Centaurea diffusa* Lam.
Wild buckwheat	*Eriogonum* Michx. spp.
Yellow starthistle	*Centaurea solstitialis* L.
Graminoids	
Basin wildrye	*Leymus cinereus* (Scribn. & Merr.) A. Löve
Bluebunch wheatgrass	*Pseudoroegneria spicata* (Pursh) A. Löve
Bluegrama	*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths
Bottlebrush squirreltail	*Elymus elymoides* (Raf.) Swezey
Cheatgrass	*Bromus tectorum* L.
Crested wheatgrass	*Agropyron cristatum* (L.) Gaertn.
Hood's sedge	*Carex hoodii* Boott
Idaho fescue	*Festuca idahoensis* Elmer

Common name(s)	Scientific name and authority
Indian ricegrass	*Achnatherum hymenoides* (Roemer & J.A. Schultes) Barkworth
Intermediate wheatgrass	*Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey
Japanese brome	*Bromus japonicus* Thunb. ex Murr.
Medusahead	*Taeniatherum caput-medusae* (L.) Nevski
Needle-and-thread	*Hesperostipa comata* (Trin. & Rupr.) Barkworth
Onespike oatgrass	*Danthonia unispicata* (Thurb.) Munro ex Macoun
Pinegrass	*Calamagrostis rubescens* Buckl.
Prairie junegrass	*Koeleria macrantha* (Ledeb.) J.A. Schultes
Pubescent wheatgrass	*Agropyron spicatum* (Pursch) Scribn & J.G. Sm. var. *pubescens* Elmer
Rough fescue	*Festuca campestris* Rydb.
Sand dropseed	*Sporobolus cryptandrus* (Torr.) Gray
Sandberg bluegrass	*Poa secunda* J. Presl.
Sixweeks fescue	*Vulpia octoflora* (Walt.) Rydb.
Snake River wheatgrass	*Elymus wawaiensis* J. Carlson & Barkworth[1]
Thurber's needlegrass	*Achnatherum thurberianum* (Piper) Barkworth
Western needlegrass	*Achnatherum occidentale* (Thurb. ex S. Wats.) Barkworth
Western wheatgrass.	*Pascopyrum smithii* (Rydb.) A. Löve
Wheatgrasses	*Agropyron* Gaertn. spp.
Shrubs and trees	
Antelope bitterbrush	*Purshia tridentata* (Pursh) DC.
Basin big sagebrush	*Artemisia tridentata* Nutt. ssp. *tridentata*
Bitter cherry	*Prunus emarginata* (Dougl. ex Hook.) D. Dietr.
Black greasewood	*Sarcobatus vermiculatus* (Hook.) Torr.
Black sagebrush	*Artemisia nova* A. Nels.
Budsage	*Artemisia spinescens* D.C. Eat.
Curlleaf mountain-mahogany	*Cercocarpus ledifolius* Nutt.
Common chokecherry	*Prunus virginiana* L.
Douglas-fir	*Pseudotsuga menziesii* (Mirbel) Franco
Foothills sagebrush	*Artemisia tridentata* Nutt. ssp. *xericensis* Winward ex R. Rosentreter & R. Kelsey
Fourwing saltbush	*Atriplex canescens* (Pursh) Nutt.
Gardner's saltbush	*Atriplex gardneri* (Moq.) D. Dietr.
Little sagebrush	*Artemisia arbuscula* Nutt. ssp. *longiloba* (Osterhout) L. Shultz
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
Low sagebrush	*Artemisia arbuscula* Nutt.
Mallow ninebark	*Physocarpus malvaceus* (Greene) Kuntze
Mountain big sagebrush	*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb.) Beetle
Mountain snowberry	*Symphoricarpos oreophilus* Gray
Quaking aspen	*Populus tremuloides* Michx.

Common name(s)	Scientific name and authority
Rabbitbrush, goldenbush	*Ericameria* Nutt.
Rocky Mountain juniper	*Juniperus scopulorum* Sarg.
Rubber rabbitbrush	*Ericameria nauseosa* (Pallas ex Pursh) Nesom & Baird
Saskatoon serviceberry	*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roemer
Shadscale	*Atriplex confertifolia* (Torr. & Frém.) S. Wats.
Shinyleaf ceanothus; snowbrush ceanothus	*Ceanothus velutinus* Dougl. ex Hook.
Sickle saltbush	*Atriplex falcata* (M.E. Jones) Standl.
Singleleaf pinyon	*Pinus monophylla* Torr. & Frém.
Snowberry	*Symphoricarpos* Duham. spp.
Spiny hopsage	*Atriplex spinosa* (Hook.) Moq.
Stiff sagebrush; scabland sagebrush	*Artemisia rigida* (Nutt.) Gray
Subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
Threetip sagebrush	*Artemisia tripartita* Rydb.
Utah juniper	*Juniperus osteosperma* (Torr.) Little
Utah serviceberry	*Amelanchier utahensis* Koehne
Utah snowberry	*Symphoricarpos oreophilus* Gray var. *utahensis* (Rydb.) A. Nels.
Western juniper	*Juniperus occidentalis* Hook.
Western snowberry	*Symphoricarpos occidentalis* Hook.
Winterfat	*Krascheninnikovia lanata* (Pursh) A.D.J. Meeuse & Smit
Wyoming big sagebrush	*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young
Yellow rabbitbrush	*Ericameria viscidiflora* (Hook.) L.C. Anders.

[1] Currently not included in The PLANTS Database.

Source: USDA NRCS 2001.

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