

Mountain Big Sagebrush Communities on the Bishop Conglomerate in the Eastern Uinta Mountains

Sherel Goodrich
Allen Huber

Abstract—The Bishop Conglomerate forms broad, gently sloping pediments that include a mantle or veneer of coarse gravel and some cobble over underlying formations. These pediments cover large areas at the margins of the Uinta Mountains. Mountain big sagebrush (*Artemisia tridentata* var. *pauciflora*) communities cover rather large areas at the outer edge or lower end of these pediment-plains. These communities are a conspicuous feature of the Diamond Mountain, Brush Creek Mountain, and Taylor Mountain areas toward the eastern end of the Uinta Mountains.

Consistency, frequency, crown cover, and other features of plants on these pediment-plains suggest an ecological unit in which biotic and abiotic components are important to classification.

Features of classification include geomorphology, geology, gradient, soils, vegetation, wildlife, and human values. Classification, capabilities, values, and management implications are discussed. Mountain big sagebrush communities are compared to Wyoming big sagebrush (*A. tridentata* var. *wyomingensis*) communities of pediments associated with the Green River. Importance of recognizing differences between communities of these two sagebrush taxa are emphasized.

Study Sites and Methods

Numerous studies have been established on plateaus of Bishop Conglomerate of the eastern Uinta Mountains on the Ashley National Forest. Some of these are listed in table 1. These and other studies referred to in the following discussion are on file at the Supervisor's Office of the Ashley National Forest, Vernal, Utah.

Studies at sites listed in table 1 include Rooted Nested Frequency and Line Intercept of crown cover of shrubs in which 500 ft of intercept per site was standard. Studies also include ground cover determination by a point method. Procedures for these study methods are described by USDA Forest Service (1993). Rooted Nested Frequency studies provide quadrat frequency as well as nested frequency of plant taxa by which diversity of plant communities can be evaluated. For this paper quadrat frequency rather than nested frequency is used to express diversity. Frequency studies at each site included 100 quadrats of 2.7 ft² (50 x 50 cm). The procedures outlined by USDA Forest Service (1993) for Line Intercept

specifies including openings in crowns of individual shrubs as crown cover. Thus the measurements of crown cover referred to in this paper tend to overrate actual crown cover.

In addition to the above studies, line intercept of crown cover of shrubs has been measured at 36 other sites in this ecological unit. In addition production (air dry weight) by species has been measured at numerous sites of which data from 31 sites was reviewed for this paper. Production measurements were made by clipping and weighing green weight of annual growth by individual taxa. For the most part production measurements were taken from 30 plots of 0.98 ft square for each site. Dry weight was determined from dry weight tables or by comparing green weight with air dry weight after air-drying samples in paper bags. Study sites have a varied history of fire, herbicide applications, livestock grazing, and other management practices.

Comparisons with Wyoming big sagebrush/grass communities of pediments associated with the Green River are based on information provided for those communities by Goodrich and others (1999).

Plant nomenclature follows that of Welsh and others (1993). Authors of plant taxa are not listed in this paper. They can be found in Welsh and others (1993).

Abiotic and Biotic Features

The Bishop Conglomerate Formation varies from boulder-conglomerate to pebble-conglomerate. Deposition of the formation apparently began in Oligocene, or perhaps late Eocene. It mantles a smooth erosion surface and forms a pediplain (Winkler 1970). This formation is quite extensive on the south slope and on the north slope of the Uinta Mountains. Gradient of the plateau lands of this pediment is mostly less than 5 percent

At the eastern end of the south slope of the Uinta Mountains, lodgepole pine forests cover upper elevations of this pediment formation. At mid elevations of the formation, aspen is common and locally dominant. Toward the lower or southern edge of the formation, mountain big sagebrush-grass communities are extensive. These sagebrush communities that are below the aspen and lodgepole pine belts are the focus of this paper.

The study area is included in the Uinta Mountains Section of the National Hierarchical Framework of Ecological Units as discussed by McNab and Avers (1994). Consistent with that framework of ecological units, the study area is classified in this paper at the landtype level as a "Bishop Conglomerate Plateau/Mountain Big Sagebrush Ecological Unit." This name reflects abiotic and biotic components of the unit.

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Sherel Goodrich is Ecologist, Ashley National Forest, Vernal, UT 84078. Allen Huber is Rangeland Manager, Duchesne Ranger District, Ashley National Forest, Duchesne, UT 84021.

Table 1—Study sites with nested frequency data.

Study site name	Study no.	Comments
Taylor Mtn. Enclosure	31–4	Inside an enclosure with fence high enough to exclude wild ungulates as well as livestock. The enclosure was constructed in 1962. Data for this paper was taken in 1991.
Taylor Mtn.	31–4D	Outside the Taylor Mountain Enclosure with a history of cattle grazing since before establishment of the Ashley National Forest in 1908. Rest rotation grazing since 1960 with stocking rates at about 3.3 acres/AUM*.
Mud Spring	31–35A	Grazing history same as for 31–4D.
Grasshopper	32–66	Cattle grazing since before establishment of the Ashley National Forest in 1908. Rest rotation and deferred rotation grazing since 1967 with permitted stocking rates at about 2.74 acres/AUM*
Counting Corral	32–67	Grazing history same as for 32–66.
Diamond 3	32–78	Grazing history same as for 32–66. This site was burned in 1993. Data was taken in 1995 only two years after burning.

*AUM or Animal Unit Month is considered here to be equivalent to the grazing of 1 mature cow with calf for one month.

Average annual precipitation for this ecological unit likely varies between 12 and 20 inches. Frost-free period is 40 to 80 days (Ashcroft and others 1992). Summer thundershowers are common. Snow depth near the end of winter varies from about 1 ft in rare or occasional winters to 2 to 3 ft in most winters. Snow commonly covers the ground from November through April and through much of May in some years.

Soils are generally Typic or Pachic Argiborolls, Cryoborolls, and Calciborolls. Calciborolls are likely more common toward

the edges of the formation where the mantle of Bishop Conglomerate thins and contacts more calcareous substrates. Soils are generally fine, loamy mixed, fine mixed, or loamy-skeletal mixed.

Vascular plant communities are highly diverse with shrubs, graminoids, and forbs usually well represented (tables 2, 3, and 4). These communities generally support from 3 to 6 shrub species, 10 to 12 graminoid species, and 30 to 44 forb taxa. With a sample size of 100 quadrats of 2.7 ft² (50 x 50 cm) each,

Table 2—Percent quadrat frequency, average quadrat frequency (Ave. QF), and percent site consistency (percent con.) of plant taxa.

Plant taxa	Study sites						Average QF	Percent con.
	32–66	32–67	31–35A	32–78	31–4	31–4D		
Shrubs								
<i>Artemisia tridentata pauciflora</i>	41	44	12	3	29	35	27	100
<i>Cercocarpus montanus</i>						1	0	17
<i>Chrysothamnus viscidiflorus</i>	16	2	3	6	10	4	7	100
<i>Eriogonum corymbosum</i>						15	3	17
<i>Mahonia repens</i>					5		1	17
<i>Purshia tridentata</i>				4	47	27	13	50
<i>Symphoricarpos oreophilus</i>	1	8	4	2	10	5	5	100
Graminoids (Poaceae)								
<i>Bouteloua gracilis</i>						1	0	17
<i>Bromus anomalus</i>		1	1		1		1	50
<i>Bromus tectorum</i>						1	0	17
<i>Danthonia intermedia</i>		2					0	17
<i>Elymus elymoides</i>	50	66	51	53	25	41	48	100
<i>Elymus lanceolatus</i>	59	81	7	39	39	62	48	100
<i>Elymus spicatus</i>				7	44	1	9	50
<i>Elymus trachycaulus</i>			2				0	17
<i>Festuca ovina</i>	6	47	2	3	9	11	83	
<i>Koeleria macrantha</i>	34	1	7	2	6	6	9	100
<i>Poa fendleriana</i>	77	78	21	36	71	54	56	100
<i>Poa pratensis</i>	4	5	6	5		20	7	83
<i>Poa secunda</i>	49	62	28	66	6	1	35	100
<i>Stipa comata</i>	46	18	100	38	11	15	38	100
<i>Stipa hymenoides</i>					1		0	17
<i>Stipa lettermanii</i>	9	34	6	4	20	24	16	100
<i>Stipa nelsonii</i>	9	34	6	4	20	24	16	100

(con.)

Table 2 (Con.)

Plant taxa	Study sites						Average QF	Percent con.
	32-66	32-67	31-35A	32-78	31-4	31-4D		
Graminoids (Cyperaceae)								
<i>Carex obtusata</i>		5					1	17
<i>Carex petasata</i>			5				1	17
<i>Carex rossii</i>	44	70		34	1		25	67
Perennial forbs								
<i>Achillea millefolium</i>	1	6			1	2	2	67
<i>Agoseris glauca</i>	21	3	17	15			9	67
<i>Antennaria microphylla</i>	62	71	4	16	3	25	30	100
<i>Arabis drummondii</i>			3	6			2	33
<i>Arabis holboellii</i>	7			3			2	33
<i>Arabis perennans</i>			1				0	17
<i>Arabis</i> spp.		5			12	7	4	50
<i>Arenaria congesta</i>	94	88	81	85	1	54	67	100
<i>Aster chilensis</i>	1	24				3	5	50
<i>Astragalus agrestis</i>		3					1	17
<i>Astragalus argophyllus</i>	12	14		2			5	50
<i>Astragalus convallarius</i>	21	12	1		11	3	8	83
<i>Astragalus spatulatus</i>		4					1	17
<i>Astragalus tenellus</i>						2	0	17
<i>Balsamorhiza hookeri</i>	85	30	4	89	40	37	48	100
<i>Castilleja linearifolia</i>	3				17	8	4	50
<i>Cirsium</i> spp.						1	0	17
<i>Comandra umbellata</i>						2	0	17
<i>Crepis acuminata</i>					2	7	2	33
<i>Cryptantha flavoculata</i>						2	0	17
<i>Cymopterus longipes</i>					12		2	17
<i>Delphinium nuttallianum</i>			12	82	1		16	50
<i>Erigeron eatonii</i>	23		42	12	14		15	67
<i>Erigeron flagellaris</i>	12	57	1	33		21	21	83
<i>Erigeron pumilus</i>	7						1	17
<i>Eriogonum umbellatum</i>	1		15	2	26	28	12	83
<i>Gilia aggregata</i>				4	2	2	1	50
<i>Heterotheca villosa</i>		1	4				1	33
<i>Hymenoxys acaulis</i>		2				2	1	33
<i>Lesquerella</i> spp.						2	0	17
<i>Lewisia pygmaea</i>				4			1	17
<i>Linum lewisii</i>		1					0	17
<i>Lithophragma glabra</i>				63			11	17
<i>Lithospermum ruderales</i>					1	1	0	33
<i>Lomatium</i> spp.						9	2	17
<i>Lomatium triternatum</i>	27	2	48	6	11		16	83
<i>Lupinus argenteus</i>	94		77	19	3	35	38	83
<i>Lychnis drummondii</i>	3	1	7				2	50
<i>Mertensia fusiformis</i>	8	5	25	12	4	4	10	100
<i>Penstemon humilis</i>	12	8			5	19	7	67
<i>Penstemon</i> spp.						5	1	17
<i>Petrorhiza pumila</i>	19	26		8	20	29	17	83
<i>Phlox hoodii</i>		17					3	17
<i>Phlox longifolia</i>	2	39			11	25	13	67
<i>Phlox multiflora</i>	73	4	40	2	16	12	25	100
<i>Potentilla gracilis</i>	14	22	53			16	18	67
<i>Ranunculus glaberrimus</i>			7				1	17
<i>Sedum lanceolatum</i>					31	21	9	33
<i>Senecio integerrimus</i>			43	5	5	17	12	67
<i>Senecio multilobatus</i>					1	1	0	33
<i>Stellaria jamesiana</i>	30						5	17
<i>Taraxacum officinale</i>	3	49	41	3	1	14	19	100
<i>Thlaspi montanum</i>			40	13			9	33
<i>Trifolium gymnocarpon</i>	84	53	51	12	12	49	44	100
<i>Viola nuttallii</i>		4	2				1	33
<i>Zigadenus paniculatus</i>	1	6	20	4	2	8	7	100
Annual forbs								
<i>Androsace septentrionalis</i>				10		9	3	33
<i>Chenopodium</i> spp.			7				1	17
<i>Collinsia parviflora</i>			67	97		31	33	50
<i>Collomia linearis</i>			71	82		34	31	50
<i>Draba nemorosa</i>			10				2	17
<i>Gayophytum</i> spp.				53		1	9	33
<i>Gymnosteris parvula</i>				3			1	17
<i>Lappula occidentalis</i>					1		0	17
<i>Lepidium densiflorum</i>		3					1	17
<i>Polygonum douglasii</i>		2	49	64		58	29	67

Table 3—Vascular plant diversity and ground cover.

Site	Alpha	Beta	Crown cover of sagebrush	Ground cover
			----- Percent -----	
32-66	11.66	40	16.4	95
32-67	11.64	44	15.1	87
32-78	11.20	46	0.2	65 ^a
31-35A	10.91	45	5.0	87
31-4	5.98 ^b	46	32.4 ^c	95
31-4D	14.1	67	—	95
Average	11.35	48		92 ^d

^aAt 1.5 growing seasons after fire. Not included in average.

^bInside a 30-year old enclosure. Not included in average.

^cIn addition to sagebrush cover, crown cover of bitterbrush was 37.9 percent. Total crown cover of these two shrubs was 70.3 percent.

^d All sites included in this average have a long history of livestock grazing.

Table 4—Plant taxa with 100 percent site consistency at 6 sites on Bishop Conglomerate Plateau/Mountain big sagebrush ecological unit.

Taxon	Site consistency	Average quadrat* frequency
		----- n = 6 -----
Mountain big sagebrush	100	27
Yellowbrush	100	7
Mountain snowberry	100	5
Squirreltail	100	48
Thickspike wheatgrass	100	48
Muttongrass	100	56
Sandberg bluegrass	100	35
Needle-and-thread grass	100	38
Letterman needlegrass	100	16
Pussytoes	100	30
Ballhead sandwort	100	67
Hooker balsamroot	100	48
Bluebells	100	10
Many-flowered phlox	100	25
Dandelion	100	19
Hollyleaf clover	100	44
Death camas	100	7

*Quadrat size is 19.7 x 19.7 inches (50 x 50 cm).

average number of vascular plant taxa was 48 per site, and average number of taxa per quadrat was 11.35 (table 3).

Except for common dandelion (*Taraxacum officinale*) and perhaps Kentucky bluegrass (*Poa pratensis*), plants found at study plots across the ecological unit are mostly native to the area. Other introduced plants are of low consistency and of low frequency. An exception to native plant dominance is found in areas that have been seeded to smooth brome (*Bromus inermis*) and intermediate wheatgrass (*Elymus hispidus*).

Vascular plant production (table 5) is generally high enough to produce a ground cover of vegetation and litter that covers over 90 percent of the soil surface (table 6). With this extent of vascular plant and litter cover, cryptogamic crusts appear to be of minor importance as ground cover.

Table 5—Production (lbs/acre air dry wt.) at various shrub cover.

	Percent shrub cover		
	0-10 (n = 17)	11-20 (n = 8)	>20 (n = 6)
Graminoids	637	193	167
Forbs	175	204	179
Shrubs	37	660	915
Total	847	1054	1261

Table 6—Percent of production at various shrub cover.

	Percent shrub cover		
	0-10 (n = 17)	11-20 (n = 8)	>20 (n = 6)
Graminoids	75	18	13
Forbs	21	19	14
Shrubs	4	63	73
Total	100	100	100

Vascular Plants and Community Dynamics

Plant communities are highly diverse with high numbers of vascular plants (table 2). Vascular plants of high site consistency and high quadrat frequency are considered here to be the most descriptive of the ecological unit. Those with higher values are listed in table 4, and some of these are included in the following discussion.

Mountain Big Sagebrush

Crown cover of mountain big sagebrush on this ecological unit has been found between 0 percent and 38 percent depending on fire and other processes and management actions. As mentioned above the method used to determine crown cover tends to over estimate crown cover. The data indicate crown cover of sagebrush rarely, if ever, exceeds an average of 40 percent on sites of over 0.75 acres. Following fire, herbicide application, and plowing and seeding, sagebrush cover has been decreased to 0 percent. Within 15 to 25 years mountain big sagebrush has returned to pretreatment crown cover at most sites. At a few sites this happened in as little as 10 years. At sites plowed and seeded to aggressive grasses such as smooth brome and intermediate wheatgrass, the return of sagebrush has been slower. In some of these cases, sagebrush has not returned to pretreatment status after 40 years. However, it is present and slowly increasing in most of these treatments.

Essentially all of the dynamics of sagebrush studied or observed on this landscape has been concurrent with a long history of livestock grazing. It appears that livestock grazing has accelerated return of sagebrush after fire and herbicide applications. It also appears livestock grazing can push

crown cover of sagebrush beyond levels that would be found in absence of livestock grazing. However, as noted by Knight (1994) for Wyoming, presence of sagebrush should not be considered an artifact of livestock grazing. The conclusion of Johnson (1984) that the current distribution of sagebrush matches the distribution prior to settlement seems highly applicable to this ecological unit. Livestock grazing appears to have done little to move sagebrush beyond its presettlement distribution. It appears livestock grazing can increase sagebrush cover in areas where it existed prior to settlement. This is more likely for persistent, heavy use by livestock than for light or moderate use.

Snow mold and other features of winter can damage sagebrush (Nelson and Tiernan 1983; Sturges and Nelson 1986). Winter damage of sagebrush is evident on parts of this ecological unit. This is more conspicuous on concave and flat topography than on convex topography. At one study site (32-66), crown cover of sagebrush was decreased from 16 percent down to 5 percent in 7 years. At some other sites winter damage has limited sagebrush crown cover to less than 10 percent over as many as 4 decades (site 32-14). Other agents of injury to sagebrush include rodents that girdle the stems (Frischknecht and Baker 1972; Sturges 1983).

Regardless of agents of injury and mortality, including fire, herbicide applications, rodents, insects, and winter damage, mountain big sagebrush has persisted as a landscape dominant on the study area for several decades and probably thousands of years. Although livestock are likely to have increased crown cover of sagebrush on this area, the competitive ability of sagebrush indicates it was a strong component of these communities prior to introduction of Euro-American livestock.

With high ability to return after disturbance, sagebrush is clearly a major force in plant community dynamics. Other plant species generally respond or react to sagebrush. This is demonstrated in response of the understory to sagebrush reduction and recovery. As shown in tables 5 and 6, graminoid production is highly sensitive to crown cover of sagebrush. At 0 to 10 percent crown cover of sagebrush, graminoids produced an average of 637 lbs/acre (air dry weight) or 75 percent of annual herbage production. At 20 to 30 percent crown cover of sagebrush, graminoid production was decreased to an average of 167 lbs/acre or 13 percent of total production. Forbs respond similarly to grasses. However, the range of variation is narrower. At 0 to 10 percent crown cover, sagebrush contributed 4 of production. At 20-30 percent crown cover it increased to 73 percent of production.

The influence of high percent crown cover of shrubs is also indicated in alpha diversity as shown in table 3 for site 31-4. Crown cover of shrubs at that site far exceeded that of other sites, and alpha diversity was only about $\frac{1}{2}$ as high as at other sites.

Regardless of high percent crown cover of sagebrush and its suppression of the understory, the understory of this area appears to have high capacity to increase rapidly after disturbances that decrease sagebrush. As many as 37 forbs, 12 graminoids, and 4 shrubs have been found on burned sites at 2 years postfire. Plant and litter cover have been found as high as 90 percent at 5 to 7 years following fire (study sites 32-70 and 32-78), and this was concurrent with livestock grazing.

Other Shrubs

Average number of shrub taxa at nested frequency study sites was four. Both yellowbrush (*Chrysothamnus viscidiflorus* var. *lanceolatus*) and mountain snowberry (*Symphoricarpos oreophilus*) had 100 percent site consistency, but these had rather low quadrat frequency values (table 2). Yellowbrush and mountain snowberry appear to play a minor part in driving plant community dynamics. Although these shrubs sometimes show slight increase in early postfire years, crown cover of these shrubs rarely exceeds 2 percent. Other plants appear to be little influenced by these shrubs. However, bitterbrush is locally common to abundant on this ecological unit, and at high percent crown cover it appears to have at least moderate capacity to suppress other species.

Graminoids

Average number of graminoid taxa was 12 (table 3). Graminoids with 100 percent site consistency ($n = 6$) and with quadrat frequency of greater than 33 percent are muttongrass (*Poa fendleriana*), Sandberg bluegrass (*P. secunda*), needle-and-thread grass (*Stipa comata* var. *intermedia*), thickspike wheatgrass (*Elymus lanceolatus*), and squirreltail (*E. elymoides*). Two other grasses had 100 percent site consistency but had less than 33 percent quadrat frequency. These were Junegrass (*Koeleria macrantha*) and Letterman needlegrass (*Stipa lettermanii*). As indicated in table 5, graminoids are most productive when sagebrush canopy cover is less than 10 percent. However, they appear to be able to persist in sufficient abundance and vigor under as high as 30 percent crown cover of sagebrush to be able to rapidly respond to fire that decreases sagebrush cover.

Bluebunch wheatgrass (*Elymus spicatus*) is lacking or of low quadrat frequency at most sites. Grazing does not appear to be the factor in the absence of bluebunch wheatgrass, for it is abundant to dominant on adjacent, warmer ecological units of the south face of the Uinta Mountains with equal grazing history. The one site with over 10 percent quadrat frequency of bluebunch wheatgrass (31-4D) is at the ecotone with the south face of the Uinta Mountains.

Sheep fescue (*Festuca ovina*) had 83 percent site consistency, but average quadrat frequency of this plant was only 11 percent. Low frequency of this plant does not seem to be a function of grazing. More frequent graminoids are used equally or to a greater degree than is sheep fescue on this ecological unit. Also the sheep fescue complex is not found in great abundance in many areas of the Uinta Mountains that have been quite protected from livestock. Inherent factors appear to limit plants of this complex here.

Muttongrass appears to be the graminoid most capable of persisting at moderate to high frequency under high percent canopy cover of sagebrush. The ability of muttongrass to persist under dense canopy of sagebrush on this ecological unit indicates value of this plant as a descriptor of the sagebrush community type or habitat type for the area. Needle-and-thread grass appears to be the graminoid most capable of rapid increase following fire.

Graminoids appear to drive community dynamics in early successional stages. They dominate production in the early

years following fire and following herbicide application. However, they appear to be highly compatible with high diversity of forbs in the early years following disturbance.

Forbs

As high as 37 forb taxa have been recorded for a site with sample size of 100 quadrats of 2.7 ft². Average number of forb taxa was 31 (table 7). Those with 100 percent site consistency and greater than 33 percent quadrat frequency (table 2) are ballhead sandwort (*Arenaria congesta*), Hooker balsamroot (*Balsamorhiza hookeri*), and hollyleaf clover (*Trifolium gymnocarpon*). Others with 100 percent site consistency but with less than 33 percent quadrat frequency are pussytoes (*Antennaria microphylla*), bluebells (*Mertensia fusiformis*), many-flowered phlox (*Phlox multiflora*), common dandelion, and death camas (*Zigadenus paniculatus*).

Of these forbs ballhead sandwort, hollyleaf clover many-flowered phlox, and hooker balsamroot seem to be of some importance to classification of this ecological unit. By themselves they are not unique to this ecological unit, for they are widely distributed. However, collectively they appear to be quite descriptive of the unit. This ecological unit appears to be the principal habitat for many-flowered phlox in Utah.

Forbs appear to react to community dynamics more than to drive these dynamics. They decrease or increase in reaction to shrub and graminoid changes. Some, including ball head sandwort, dandelion, and pussytoes might be expected to increase with increasing intensity of ungulate grazing.

Fire

References that indicate fire of rather high frequency burned in communities of this ecological unit include Houston (1973) and Winward (1991). Additional evidence of comparatively high fire frequency includes the volatile nature of mountain big sagebrush communities. Based on a

large number of prescribed fires and attempted prescribed fires on the Ashley National Forest, basin big sagebrush and mountain big sagebrush communities are among the most easily ignited communities with capability to carry fire under weather conditions that will not support fire in many other plant communities.

The capability of sagebrush/grass communities to carry wildfire was well demonstrated in the Dry Fork Fire of 2000 on the south slope of the Uinta Mountains. In this fire, a sagebrush/grass community of the south face of the Uinta Mountains was the ignition source. From that point the fire was carried onto sagebrush communities of the Bishop Conglomerate Formation. These communities carried the fire into aspen and lodgepole pine communities.

Fire adapted species that occupy plant communities of this ecological unit are additional evidence of high fire frequency. As high as 37 forb taxa, 12 graminoid taxa, and 4 shrub taxa have been found in burned areas at two growing seasons postfire (site 32-78). Plants found in postfire communities are the same ones found prior to burning. Fire alters abundance of various taxa in different ways, but it seems to do little to change the presence of taxa.

Although sagebrush is greatly reduced by fire, it is not uncommon to find seedlings of sagebrush the year after fire. Indeed the dynamics of mountain big sagebrush itself is a strong indication of high adaptability to fire. It is common for mountain big sagebrush to return to 20 percent canopy cover within 15 to 25 years after fire. The recovery interval of sagebrush of 15 to 25 years could, perhaps, be an indicator of the fire return interval common to the history of this ecological unit.

Postfire response of bitterbrush appears to be more varied than for sagebrush. It generally increases after the initial reduction following fire, but recovery is much slower on some sites than on others.

Some other species increase rapidly in the first 1 to 3 years following fire including annuals such as blue-eyed Mary (*Collinsia parviflora*) and ground smoke (*Gayophytum* spp.). Abundance of these appears to be fire-dependant, as these

Table 7—Comparison of features of Wyoming big sagebrush communities (ARTRW) from pediments associated with the Green River and mountain big sagebrush communities (ARTRP) on the Bishop Conglomerate Plateau.

Community feature	ARTRW (n = 9)	ARTRP (n = 6*)
Crown cover of sagebrush (percent)	0–22	0–38
Total number of vascular plant taxa	51	93
Total number of shrub taxa	7	7
Total number of graminoid taxa	13	20
Total number of forb taxa	26	66
Ave. number taxa/site (alpha diversity)	18	47
Ave. number of taxa/quadrat (beta diversity)	2.92	11.35
Ave. number of shrub taxa/site	4	4
Ave. number of graminoid taxa/site	6	12
Ave. number of forb taxa/site	7	31 ¹
Shrubs with 100 percent consistency	1	3
Shrubs with >49 percent consistency	1	4
Graminoids with 100 percent consistency	1	7
Graminoids with >49 percent consistency	7	12
Forbs with 100 percent site consistency	0	8
Forbs with >49 percent site consistency	4	31
Average ground cover (percent)	58	92

*n = 6 except for crown cover of sagebrush for which n = 42.

species seem to respond from a soil-seedbank of long-lived seeds that are activated by fire. Regardless of the initial response to fire, nearly all species of the ecological unit show adaptability to fire. They increase after fire by soil-seedbanks, by sprouting, or by mobile seeds that are produced elsewhere but are transported to burned areas.

Capabilities and Values

Due to low gradient, the pediment surface, and capacity to produce 90 percent or more ground cover, this ecological unit is resistant to erosion. Roads across the unit are comparatively stable. This ecological unit has supported livestock grazing for about a century with little evidence of accelerated erosion.

Vascular plant diversity and ground cover have been maintained at high levels concurrent with livestock grazing. These features indicate this area has moderate to high capability to support livestock grazing concurrent with maintenance of a number of other values.

McArthur (1984) reported 87 wildlife species for sagebrush communities of the Intermountain Region. While total number of wildlife species can be expected to be less than this on any one ecological unit, high diversity of wildlife species are indicated for this one by the high diversity of plant communities of the unit. It has high capability to produce high value herbaceous forage and browse for wild ungulates.

Bitterbrush is closely hedged across the unit. This indicates high value of this plant for ungulates. However, mountain big sagebrush is lightly, if at all, hedged over much of the area. Hedging of this shrub by ungulates seems to be more prominent toward the lower edges of the unit where it contacts the south face of the Uinta Mountains where wild ungulates spend more time in winter.

This ecological unit has capability to support dense stands of sagebrush of high value for sage grouse nesting. High number of forbs and relative high production of forbs indicate high value brooding habitat for sage grouse. The unit also includes mesic drainages that support graminoid and forb dominated communities of high value for sage grouse brooding. Current numbers of sage grouse are much lower than in past decades. Livestock grazing was equally intense or of greater intensity in past decades than in the past few years. The history of sage grouse populations and the history of livestock grazing indicate factors other than livestock grazing are related to declines in sage grouse populations.

Compared to forested environments, wild ungulates are highly visible in the sagebrush communities of this ecological unit. Wild ungulates are abundantly seen on the unit in spring and mild winters. This indicates high value for recreational wildlife viewing. The high capacity of this unit to support wild ungulates also translates to high value for big game hunting opportunities.

Camping associated with this ecological unit is most common at its margin with the aspen and lodgepole pine ecotone. However, the unit does have low to moderate value for camping.

As discussed above, the ecological unit is highly capable of supporting fire and recovering from fires with frequency of 25 to 40 years.

Comparison of Mountain Big Sagebrush Communities With Wyoming Big Sagebrush Communities

Goodrich and others (1999) reported on Wyoming big sagebrush/grass communities of pediments associated with the Green River in Daggett County, Utah. These communities are at the base of the north flank of the Uinta Mountains where average annual precipitation is about 9 inches and snow depth is commonly less than 1 foot, and continuous snow cover is usually limited to December through February. In that environment crown cover of sagebrush was found from 0 to 22 percent compared to 0 to 38 percent in mountain big sagebrush communities of plateau lands of the Bishop Conglomerate Formation.

Hedging of sagebrush by wild ungulates is heavy in the Wyoming big sagebrush communities associated with pediments of the Green River. Hedging of sagebrush is light to locally moderate in the mountain big sagebrush communities on Bishop Conglomerate. Difference in hedging of sagebrush is likely a function of differences in snow depth and duration. Difference in hedging is also a function of pronghorn antelope (*Antilocarpa americana*). Pronghorn diets can include high percent of sagebrush (Cole 1956; Ngugi and others 1992; Olsen and Hansen 1977). Pronghorn are abundant during parts of the year in some of the Wyoming big sagebrush communities. They are rare to lacking in the mountain big sagebrush communities on Bishop Conglomerate.

While greater hedging of sagebrush by mule deer and pronghorn is a factor in difference of sagebrush crown cover, the primary factor is likely the climate and especially precipitation. Nine inches of annual precipitation of the Wyoming big sagebrush communities does not have the capacity to support as much sagebrush cover as does 12 to 20 inches of the mountain big sagebrush communities. This concept is supported by exclosures in the Wyoming big sagebrush communities that have prevented ungulate access. In these exclosures, sagebrush has not exceeded an average of 22 percent crown cover (Goodrich and others 1999). Other differences between communities of the two sagebrush taxa discussed below are considered to be primarily a function of climate.

Ground cover averaged about 55 to 59 percent in areas protected from livestock or that were grazed at moderate intensity in Wyoming big sagebrush communities compared to 90 percent or more ground cover concurrent with moderate to heavy livestock grazing in mountain big sagebrush communities.

Average number of vascular plant taxa was 19 and 47 for Wyoming big sagebrush and mountain big sagebrush communities respectively. Perhaps the most vivid contrast is seen in the number of forb taxa and production of forbs. Average number of forb taxa was 7 and 31 for Wyoming big sagebrush and mountain big sagebrush communities respectively (see table 7 for these and other comparisons). Production (air dry weight) of forbs in mountain big sagebrush communities of the Bishop Conglomerate Plateau ranged from 25 to 365 lbs/acre depending on the crown cover of sagebrush. Forb production in Wyoming big sagebrush

communities of Green River pediments is commonly as low as 3 to 10 lbs/acre.

Another conspicuous difference is the absence of bitterbrush in Wyoming big sagebrush communities and the presence and sometimes abundance of bitterbrush in mountain big sagebrush communities. Plants of *Chrysothamnus viscidiflorus* are present in communities of both sagebrush taxa. However, there is a difference at the level of variety. Sticky rabbitbrush (*Chrysothamnus* v. var. *viscidiflorus*) is specific for Wyoming big sagebrush communities, and yellowbrush is found at high consistency in mountain big sagebrush communities. Also mountain snowberry is consistently found in mountain big sagebrush communities of this ecological unit, but it is lacking in the Wyoming big sagebrush communities along the Green River.

Although needle-and-thread grass was of 100 percent consistency in both Wyoming big sagebrush and mountain big sagebrush communities, the long-awned variety (*Stipa comata* var. *comata*) was found only in Wyoming big sagebrush communities, and the short-awned variety (*S. c.* var. *intermedia*) was found only in mountain big sagebrush communities.

Management Implications

Mountain big sagebrush communities of the Bishop Conglomerate Plateau have diverse capabilities and values. These lands have been managed for multiple uses over the past several decades concurrent with maintaining ground cover and highly diverse plant communities. These uses appear to be compatible with maintaining processes such as fire and successional patterns consistent with the inherent capability of the land. The history of use and response to use indicates these communities have capability to continue to be managed for a number of uses concurrent with maintaining long-term productivity.

Inherent capabilities of mountain big sagebrush/grass communities of Bishop Conglomerate pediments and Wyoming big sagebrush/grass communities of pediments associated with the Green River are vastly different. Values expected of these communities could be outside reality if these differences are not recognized. Expectations for Wyoming big sagebrush communities based on a vision of mountain big sagebrush communities are indicated for disappointment, and they can be expected to lead to expensive failures in terms of habitat improvement projects.

The Wyoming big sagebrush communities have high value as winter range for mule deer and pronghorn and, in places, high value year-long for pronghorn. The mountain big sagebrush communities have high value for mule deer in spring, fall, and mild winters. They have low value for mule deer in normal and heavy winters, and they have low value for pronghorn year-long.

While the Wyoming big sagebrush communities might be of moderate to high value for sage grouse wintering areas, the low capability of these to produce forbs indicates low value for brooding habitat. Number of forbs and production of forbs in the mountain big sagebrush/grass communities of Bishop Conglomerate indicate high value brooding habitat for sage grouse.

Rating systems for condition and trend based on diversity, production, and species composition will not reflect reality

unless the inherent differences between communities of these two sagebrush taxa are recognized.

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