Estimating Potential Downy Brome Competition after Wildfires

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Highlight: *To plan for revegetation and management of big sagebrush communities burned in wildfires, wildland managers need guidelines for estimating potential downy brome competition. A bioassay technique was used to determine the density of viable downy brome caryopsis in relation to burn and seedbed characteristics. The amount of unburned organic matter was found to be the characteristic most highly correlated with potential populations of downy brome. By determining the relative cover of ash and unburned organic matter, land managers can estimate potential reinfestation of downy brome and thus determine best weed control-seeding techniques in wildfire rehabilitation.*

The destruction of degraded big sagebrush (*Artemisia tridentata*) communities by wildfires lets wildland managers rehabilitate range areas with stable perennial forb, grass, and browse mixtures. The success of rehabilitation treatments rests heavily on the amount of competition from the alien annual grass, downy brome (*Bromus tectorum*). Not all big sagebrush communities contain downy brome, but many degraded communities have been invaded by this alien weed. Downy brome is a highly successful competitor with perennial grass seedlings (Evans and Young, 1972a). Degraded big sagebrush/downy brome communities are largely closed to seedlings of perennial grasses (Robertson and Pearse, 1945). Burning destroys the nonsprouting big sagebrush and reduces the reserve of downy brome seed (caryopses). However, studies have shown that some downy brome seed usually survives wildfires and, if not checked by perennials, the annual grass eventually dominates the site (Klemmedson and Smith, 1964). Land managers need guidelines for determining how many downy brome seeds survive in burned seedbeds. With this information they can estimate potential downy brome competition and determine whether weed control will be needed in seeding of perennial grasses.

It is important to note that this study deals with burned shrub/annual grass communities and not annual grasslands. Fewer downy brome seeds survive in fires that burn woody fuels than in herbaceous grass fires.

Our purpose was to develop ways to predict potential competition from downy brome after big sagebrush plant communities had been burned in wildfires.

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Methods

In 1973, we selected for sampling six sites in the 14,000-ha (35,000 acres) Hallelujah Junction wildfire, which burned in late July of that year. Pre-burn vegetation consisted of big sagebrush/Thurber needlegrass (*Stipa thurberiana*) or big sagebrush/Great Basin wildrye (*Elymus cinereus*), with moderate to heavy invasion of downy brome in the understory. The soils of all of these sites were derived chiefly from decomposing quartz-diorite. However, the soils of the Great Basin wildrye sites are highly influenced by erosional products from Pliocene Age beds of volcanic ash.

In 1974, we added three sites with similar soils in the 4,000-ha Seven Lakes Mountain fire and three small fires, each less than 10 ha in area, that occurred in the Medell Flat area north of Reno, Nev. At each of the burned sites we sampled in 1974, we also sampled unburned adjacent communities.

More detailed descriptions of the vegetation, soil, physiography, microenvironment, and land-use history are given by Evans and Young (1970) and Young and Evans (1974). Sites were selected by the seral status of the pre-burn vegetation (Table 1). We estimated seral status from familiarity with the area before the fire and from unburned islands of vegetation left on some sites. These estimates are subjective, but it is the type of decision land managers must make on a daily basis. The Medell Flat fires burned in two research exclosures where stand composition, competition, and micro-environmental data had been collected in several different experiments over a 15-year period. Intensity of burning was estimated from the quantity of ash vs unburned organic matter and the height of burned sagebrush stumps on each site.

On each site, 20 rectangular plots 0.1 m^2 in area were randomly located. The percent cover of ash and unburned organic matter was estimated. A grid dividing the plot into 36 squares, 5.29 cm by 5.29 cm, was laid over the plot. The number of squares occupied by unburned organic matter and depressed topography (a measure of rough vs smooth soil surface) was recorded. The unburned organic matter consisted of herbaceous material (litter) on the soil surface. Depressed topography consisted of areas lower (2.5 cm or more) than the plane of the plot area. As the last stage in sampling, all unburned organic matter and ash to the level of the soil surface were collected for bioassay. On the unburned sites, only bioassay samples were collected.

Samples collected in the field were placed in the greenhouse and bioassayed for viable downy brome caryopses, as per the methods developed by Young et al. (1969). The bioassay is a very simple technique involving the placing of samples in small cups on sterile sand and covering them with vermiculite. The samples were assayed for 8 weeks, and the emerging seedlings were counted and removed weekly.

We sampled the density of downy brome plants growing in 1974 on the six Hallelujah Junction fire sites where the number of downy brome caryopses was estimated in 1973.

Table 1. Characteristics of six big sagebrush communities that were burned in the Hallelujah Junction wildfire in 1973, three communities from the Seven Lakes Mountain fire, and three communities from Medell Flat spot fires of 1974.

Fire site	Pre-burn vegetation	Seral status	Fire intensity	Seeded in fire rehabilitation
Hallelujah Junction				
1	Big sagebrush/Great Basin wildrye/downy brome	low	low	yes
2	Big sagebrush/Thurber needlegrass/downy brome	low	high	yes
3	Big sagebrush/downy brome	low	high	no
4	Big sagebrush/Thurber needlegrass/downy brome	intermediate	very high	no
5	Big sagebrush/Great Basin wildrye/downy brome	low	high	yes
6	Big sagebrush/bitterbrush/Thurber needlegrass/downy brome	intermediate	high	yes
Seven Lakes Mountain				
7	Big sagebrush/Thurber needlegrass/downy brome	low	low	no
8	Big sagebrush/Thurber needlegrass/downy brome	low	moderate	no
9	Big sagebrush/Thurber needlegrass/downy brome	low	hot	no
Medell Flat				
10	Big sagebrush/rabbitbrush/downy brome	low	low	no
11	Big sagebrush/downy brome	low	low	no
12	Big sagebrush/rabbitbrush-horsebrush/downy brome	low	high	no

The number of downy brome plants was counted in 10 randomly located 0.1-m^2 plots at each site.

Results and Discussion

Before the Hallelujah wildfire, we estimated on the basis of two extensive studies (Young et al., 1969; Young and Evans, 1975) that 5,000 to 8,000 downy brome seeds per m^2 were present in most degraded big sagebrush communities. These caryopses are not uniformly distributed, but are largely concentrated in the litter under the shrub canopies (Young and Evans, 1975).

After the fire, we found from 20 to 300 germinable seeds in the bioassay (Table 2). This possible 96 to 99% reduction in viable downy brome seeds is a product of the intensity of this large wildfire and the concentration of viable caryopses under the shrub canopies. The potential reduction in competition from the loss of seeds is significant in terms of post-burn succession. As few as 43 downy brome seedlings per square meter moderately reduced the establishment of seedlings of crested wheatgrass (*Agropyron desertorum*), whereas 688 plants per square meter prevented perennial grass seedling establishment (Evans, 1961).

Table 2. Density of downy brome seedlings per square meter, bioassayed from six burned big sagebrush communities of the Hallelujah Junction wildfire in 1973 and sampled in the field in 1974 on the same sites.[1]

	Seedling density	
Site	Bioassay	Field sampling[2]
1	315 a	240
2	34 b	7
3	21 b	T
4	36 b	T
5	39 b	12
6	58 b	46

[1] Means followed by the same letter are not significantly different at the 0.01 level of probability, as determined by Duncan's multiple range test.
[2] "T" indicates less than 1 downy brome seedling per m^2.

The estimated downy brome competition is in close agreement with population densities sampled the following season in the field. The two sites with the highest estimated competition were in closest agreement. Not all of the sites were seeded in rehabilitation of the fire (Table 1), but sites 2, 3, and 5 support excellent stands of seeded wheatgrasses, alfalfa (*Medicago sativa*), and fourwing saltbrush (*Atriplex canescens*). On site 1, with relatively dense downy brome competition, the seeded species failed to establish; and on site 6, a poor stand of seeded species resulted with moderate downy brome competition.

In 1974 on different fires, bioassay of paired burned and unburned communities indicated a greater than 80% reduction in germinable downy brome seeds (Table 3). However, in all but one site (No. 9), the number of remaining germinable seeds was much higher than we found the previous year at the Hallelujah fire. The areas sampled in 1974 had generally not burned with the same intensity as those sampled in 1973 because we either sampled near the margin of the Seven Lakes Mountain fire or in the relatively small Medell Flat fires so we could compare burned and unburned communities.

Table 3. Density of downy brome seedlings per square meter, bioassayed from burned and unburned big sagebrush communities in the Seven Lakes Mountain and Medell Flat fires.

	Seedling density		
Site	Burned	Unburned	Reduction (%)
7	560	5,400	90
8	320	4,800	93
9	46	3,300	99
10	1,100	6,400	86
11	860	5,100	83
12	470	8,600	94

Seedbed Characteristics

The post-burn seedbed at all sites consisted of varying proportions of (a) unburned organic matter, (b) ash, and (c) bare, litter-free soil (Fig. 1). Each site could be characterized by the preponderance of one type of seedbed.

Unburned Organic Matter

For recognizing where a relatively large number of downy brome caryopses survived the wildfire, the key is the amount of unburned herbaceous organic matter on the soil surface. The cover of unburned organic matter is significantly correlated (P = 0.01) to the density of downy brome seedlings obtained from bioassay at all sites (Table 4). Organic litter is vital to establishment of downy brome, because almost all of the viable seeds of this species are found on the top of the soil

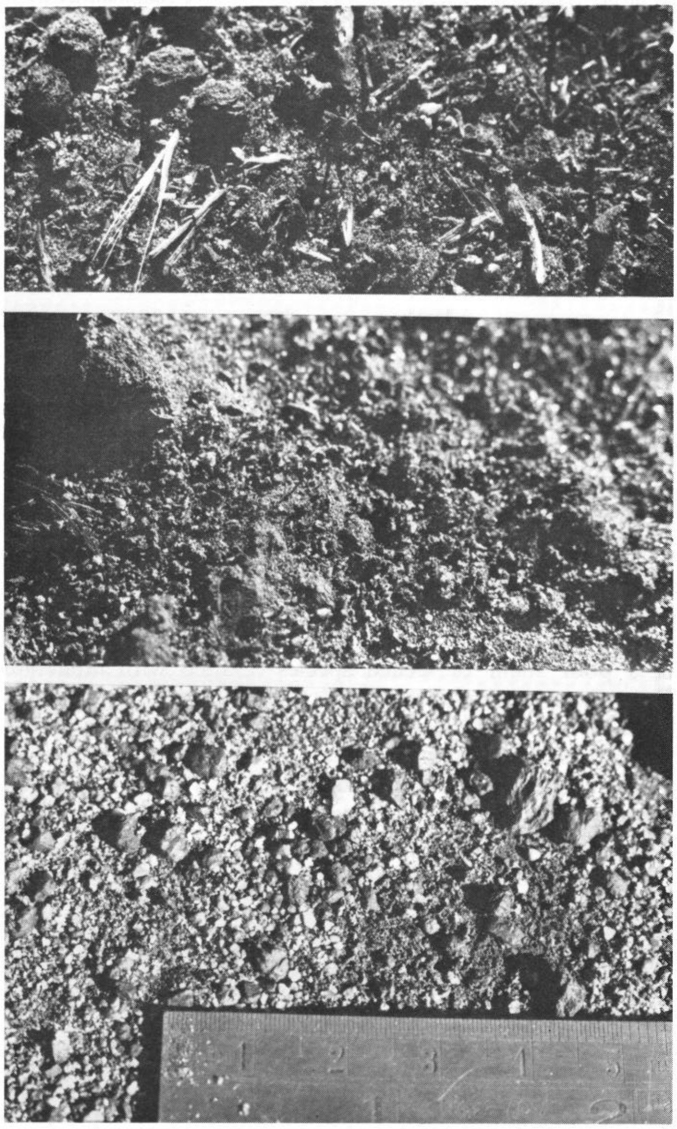

Fig. 1. *Three types of seedbeds found in burned big sagebrush communities: (top) unburned organic matter, with downy brome caryopses; (middle) ash, with the downy brome caryopses consumed; and (bottom) bare seedbed, with minimum potential to support germination.*

surface in the herbaceous litter (Young et al., 1969) and in accumulations of big sagebrush leaves under shrub canopies (Young and Evans, 1975). The litter is also essential for germination of downy brome because it creates a favorable microsite in terms of temperature and moisture (Evans and Young, 1970). The survival of downy brome seeds is very uneven in a burned big sagebrush community. The bulk of the germinable seeds are under the shrub canopies (Young and Evans, 1975). Consumption of the shrubs and litter in the fire kills the subcanopy downy brome seeds. The slight skift of litter between shrubs does not burn with sufficient intensity to kill all the downy brome seeds.

Very large wildfires such as the Hallelujah Junction blaze, which burned for several days out of control, contain many areas similar to site 1, where the fire consumes the shrubs, but leaves considerable unburned organic litter. This less-complete burning is probably a result of variable fuel conditions and diurnal fluctuation in temperature, relative humidity, and winds, which reduce the intensity of the fuel consumption.

Ash cover

Occurrence of ash forms a partial complement to the occurrence of unburned organic matter. Ash is left when the shrubs are consumed and the litter accumulates under the canopies. Burning of the herbaceous vegetation leaves very little ash, which disperses with the first breeze after the fire. The ash provides an ideal nutrient-rich seedbed, in which almost all of the downy brome caryopses have been consumed by the fire, the litter under the canopy will not be completely consumed and beneath the surface ash there will be a layer of viable downy brome seeds and sagebrush leaves.

Bare Seedbeds

On sites or parts of sites where the pre-burn density of downy brome and shrubs had been low, and the fire almost completely consumed the litter, there was little residual reproductive potential of downy brome. Sites 3 and 4 were characterized by these stark, bare seedbeds. Both of these sites produced less than one downy brome seedling per square meter in 1974.

Other Seedbed Characteristics Sampled

Although ash and unburned organic matter can be weighed, this measurement is of value in estimating potential downy brome populations only if the two are separated. A heavy sample can reflect barren-ash or seed-rich litter (Table 4). Frequency of unburned organic matter occurrence from the 36 subplots is nearly as efficient as cover estimates of the entire plot in predicting the size of potential downy brome populations. Frequency is probably a more objective, though time consuming, measurement.

Seedbed Quality

We have stressed potential downy brome competition because the bioassay populations show only relative differences to the lower field establishment. Note that all of our

Table 4. Correlation coefficients for relations between cover (%) of unburned organic matter and density of downy brome; cover (%) of unburned organic matter and ash; and frequency (%) of depressed topography in 12 burned big sagebrush communities.[1]

Fire site	Year	r value	Cover (%) Unburned organic matter	Cover (%) Ash	Frequency (%) of depressed topography
Hallelujah Junction					
1	1973	0.932**	25 a	13 bc	8 ab
2	1973	0.879**	5 b	9 bc	2 d
3	1973	0.764**	4 b	4 c	3 cd
4	1973	0.866**	5 b	44 a	6 b-d
5	1973	0.779**	5 b	42 ab	12 a
6	1973	0.658**	12 b	6 c	7 bc
Seven Lakes Mountain					
7	1974	0.940**	28 b	4 b	18 a
8	1974	0.968**	32 ab	6 b	17 a
9	1974	0.918**	5 c	18 a	14 a
Medell Flat					
10	1974	0.893**	35 a	2 b	2 b
11	1974	0.977**	40 a	8 b	3 b
12	1974	0.963**	34 a	6 b	4 b

[1] **Indicates significance at the 0.01 level of probability. Means followed by the same letter are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test. Two years' results are compared separately.

estimates in 1973 were higher than the 1974 actual establishment in the field. The difference between bioassay and field establishment is a function of seedbed quality in terms of the duration of temperature and moisture able to support germination. Also, the 8-week bioassay allows many dormant downy brome caryopses to germinate (Young et al., 1969). The bioassay samples are covered with vermiculite, because downy brome caryopses cannot germinate on the surface of a bare seedbed (Evans and Young, 1972b). Sites with much unburned organic matter not only have the greatest reserve of downy brome caryopses, but because of litter cover, also have the seedbed environment conducive to germination. A slight skift of unburned organic matter is needed for downy brome dominance. Otherwise, succession retreats to dominance by mucilaginous-seeded forbs that can germinate on bare seedbeds (Evans and Young, 1970).

The only seedbed compensation for the lack of litter is depressed or uneven topography (Evans and Young, 1972b). The amount of microtopography is a product of the surface soil structure and texture, slope, and previous animal actions such as livestock trampling and rodent activity. Site 1, with a large reserve of viable seeds, has litter cover (unburned) and favorable microtopography to insure germination (Table 4). The sites with the lowest reserve of seeds and lowest litter cover also have the least microtopography, largely because wind erosion smooths and levels a bare site after the fire.

Significance to Management

After degraded big sagebrush communities have been burned, the first growing season allows brief ecological transition. Dynamic successional patterns marshal forces leading toward stable perennial grass and shrub dominance or degradation to downy brome and root-sprouting shrubs. During this time, downy brome seeds and achenes of root-sprouting shrubs increase (Young and Evans, 1974), and downy brome ecotypes probably hybridize (Young et al., 1972). Degraded big sagebrush communities in the central Great Basin do not contain reserves of native perennial-grass caryopses (Young and Evans, 1973). Therefore, the land manager must plant desirable plant seeds to preempt the wildfire-released environmental potential, before downy brome again closes the communities.

How can the land manager judge the sites that can be seeded, without further reducing competition by mechanical or herbicidal treatment? This study has shown that the amount of unburned organic matter after the wildfire can be used to estimate the amount of potential downy brome competition. The land manager must solve this riddle, or else the phoenix of an alien life form, downy brome, will rise from the ashes to haunt future management of the resource.

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