# Fate of Fall-Sown Bitterbrush Seed at Maybell, Colorado

**Robert Hammon**
**Gary Noller**

**Abstract**: Approximately 50,000 acres of a nearly pure stand of bitterbrush, *Purshia tridentata* (Pursh), near Maybell, CO, has burned in the past 2 decades. Attempts at reclaiming bitterbrush stands by seeding burned land have been largely ineffective. A research project funded by the Colorado Division of Wildlife Habitat Partnership Program was initiated in the fall of 2000 to determine the causes of seeding failures. Initial observations on seeds planted in the fall of 1999 indicated that insects such as wireworms and cutworms may have been responsible in part for seeding failures. Seeds planted November 2000 had germinated by early April 2001, with little impact from insect or other predators noted during the 2000/2001 planting and establishment season. More than 90 percent of those seedlings died during the summer from drought. Only 1.25 percent of seeds planted in the fall of 2000 were still alive in October 2002, following the second year of drought. Seeds treated with insecticide and fungicide/rodent repellent and untreated seeds were planted in 10 seed caches on two dates (October 11 and November 15) in 2001. Samples taken on November 15 and December 19 showed that much of the seed planted on either date had already germinated. Several fungal pathogens were isolated in the fall from germinated seed. Rodents, possibly chipmunks, destroyed much of the November 15 planted seed at one site. Seedling emergence was 2 weeks to 1 month later in 2002 than 2001. Cutworms killed more than 25 percent of emerged seedlings at one site in April 2002. Most surviving seedlings were killed by drought during the summer of 2002, and by mid October, only 0.06 percent of fall 2001 planted seeds were still alive.

## Introduction

The rangeland west of Maybell, CO (Moffat County), was at one time the largest continuous stand of bitterbrush, *Purshia tridentata* (Pursh), in North America. More than 50,000 acres of this stand has burned since 1980 (fig. 1). Bitterbrush is a primary winter browse source for many large game mammals, including a large elk herd that winters in the area. Winter browse has been in short supply since the fires, and elk are increasingly moving to private lands, where they are causing considerable damage to haystacks and pastures. The bitterbrush has not regenerated from seed on the burned lands, with several attempts at reseeding resulting in failure. The causes of the failures are not known, and a research project was funded in 2001 by the Colorado Division of Wildlife Habitat Partnership Program to determine the fate of fall-seeded bitterbrush at Maybell.

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Robert Hammon, Western Colorado Research Center, 1910 L Road, Fruita, CO, U.S.A., e-mail: rhammon@lamar.colostate.edu. Gary Noller (Retired), Upper Colorado Environmental Plant Center, 5538 RBC #4, Meeker, CO 81641, U.S.A.

## Maybell Rangeland

Maybell, CO, is located in the extreme northwest corner of the State in Moffat County. Maybell is located at 40 degrees N latitude, at an elevation 6,300 ft above sea level. Annual precipitation is 12 to 15 inches, with about half of the total moisture falling as snow. The years 2000, 2001, and 2002 have all received lower than normal precipitation (fig. 2). The average annual temperature is 42 °F. Winter temperatures are very cold, with numerous instances of –50 °F recorded. Climactic data for Maybell can be accessed at http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?comayb. The rangeland near Maybell is classified as "Sandhills" range, within Land Resource Area 34. The deep sandy soils are classified as Cotopaxi loamy sands. They vary from fine sandy loams in the swales to loamy fine sands on hills and upland areas.

The research site is dominated by bitterbrush in unburned areas. Other shrubs associated with bitterbrush are big and silver sagebrush, gray horsebrush, and low and rubber rabbitbrush. These shrubs are now abundant within the burned areas. The principal grasses are Indian ricegrass, needle and thread, sand dropseed, and Sandberg bluegrass. Cheatgrass is a dominant weed in burned areas.

**Figure 1**—Rangeland near Maybell, CO. The dark vegetation across the center of the photograph is a remnant unburned stand of bitterbrush.

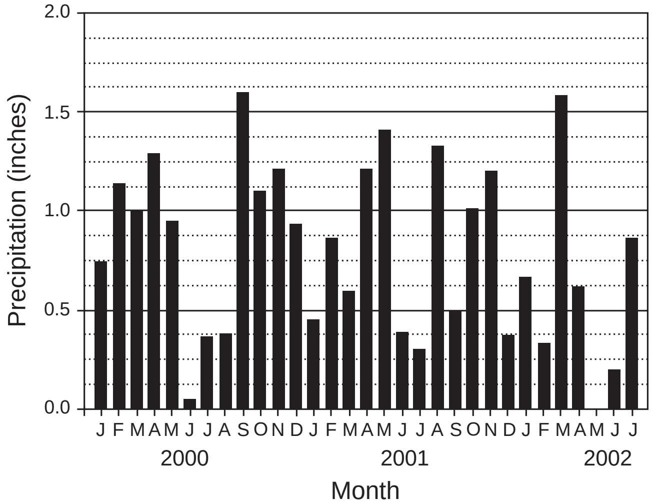


**Figure 2**—Precipitation at Maybell, CO, January 2000 to July 2002

Conspicuous forbs are hairy golden aster, buckwheat, lupine, loco, arrowleaf balsamroot, yarrow, death camas, scarlet globemallow, crypthantha, evening primrose, and daisy fleabane. Percent ground cover in unburned areas is about 25 percent, with ground cover generally less in burned areas.

# Fall Planting Studies: 2000 and 2001

## Fall 2000 Study

A simple nonreplicated seeding trial was planted in the fall of 2000, with the intention of observing seed fate and seedling behavior to use as a basis for more detailed studies in 2001. The studies were planted in two wildlife exclosures, denoted "Windmill" (N 40° 27.645'; W 108° 11.671'; elevation 6,354 ft) and "North" (N 40° 29.260'; W 108° 10.943'; elevation 6,314 ft). They are located approximately 5 miles west of the town of Maybell. Two hundred seeds were planted in each of two 10-foot-long strips at each site. One strip was planted with seed treated with imidocloprid (Gaucho 480 FS; 2 oz/cwt) and thiram (Thiram 42-S; 5 oz/cwt), and the other strip was planted with untreated seed. The Gaucho 480 FS is an insecticide intended to control soil inhabiting insects such as wireworms and white grubs and aboveground insect pests such as cutworms. The Thiram 42-S is primarily used as a fungicide, but also has rodent repellent characteristics when applied at high rates. The rate used in this study is recommended to repel rodents. The strips were planted on November 7, 2000. There were approximately 3 inches of snow on the ground at the time of planting, but the soils were not yet frozen. There was nearly continuous snow cover throughout the winter after planting.

The plots were visited on April 4, 2001, at which time many seedlings were observed. One foot of row from each strip was dug, and seeds recovered. Germination was calculated to be 79 percent. Seedling emergence was complete by mid-April 2001. A slight amount of insect and rodent feeding was noted on the seedlings during the spring observations, but the amount was insignificant. Feeding damage was observed in both treated and untreated strips. Significant mortality of emerged seedlings was observed during the summer of 2001, primarily due to drought. On May 1, 2002, 15 live seedlings were recorded at the Windmill site (3.75 percent survival of planted seeds), and three seedlings were found at the North site (0.75 percent survival). On October 7, 2002, nine seedlings were alive at the Windmill site and only one remained alive at the North site. The summer of 2002 was extremely dry (4.25 inches of precipitation through July), and mortality was attributed to drought.

## Natural Reproduction of Bitterbrush: Spring 2001

Many natural bitterbrush seedlings were observed in the area during the spring of 2001. All seedlings observed appeared to be from rodent-distributed seed caches. The number of seedlings per cache varied from seven to 30. The seed caches were most easily found along the sandy edges of roadways near mature bitterbrush stands. No caches were observed more than 30 ft from mature bitterbrush stands. This is probably due to the limited range of the rodents responsible for burying the seed. There was a slight amount of insect and rodent feeding damage on natural seedlings, but it was rare. Significant mortality from drought occurred during the summers of 2001 and 2002, and by October 2002, natural caches that had emerged during 2001 were difficult to find.

## Fall 2001 Study

The goal of the fall 2001 study was to evaluate planting date and seed treatments as factors influencing bitterbrush establishment. The sampling scheme was designed to determine the causes of seeding failure. The 2001 experiments were conducted in the same wildlife exclosures used in 2000. The 2001 experiment was a three-factor (planting date, seed treatment, location) randomized complete block design with four replications. The seed used in the experiments was produced in 1994 from Maybell Source plants at the Upper Colorado Environmental Plant Center near Meeker, CO. All seed was hand planted in 10 seed caches. A planting dibble was used to make a hole 1 to $1^1/_2$ inches in depth, into which the seed was placed. Plots were seeded on October 11 and November 15, 2001. The seed treatments were the same as used in 2000: Gaucho 480 FS (2 oz/cwt) plus Thiram 42-S (5 oz/cwt) or untreated. Twenty-five caches of each treatment were planted in each replication. The October 11 planting date was sampled on November 15, the day the second planting date was seeded. Both planting dates were sampled on December 19, 2001, April 9, 2002, and May 1, 2002. Five randomly chosen caches were dug on each sample date to determine seed fate. Samples were taken to the laboratory where seeds were removed and inspected for damage. Seed samples from the December 19 sample were sent to the Jefferson County Cooperative Extension Plant Diagnostic Clinic, Golden, CO, in December 2001 for pathogen identification after seed rots were observed. More samples from the same sample date were sent to the North Carolina State University Plant Pathogen Identification Laboratory, Raleigh, NC, for molecular characterization of the pathogens. Plots were evaluated again on June 18, 2002, and October 7, 2002, by randomly choosing five caches from each treatment per replication, and counting the live plants.

Results from fall 2001 and spring/summer 2002 sampling of the fall 2001 planted plots is displayed in tables 1 and 2. The most surprising aspect of the fall 2001 sampling is that much of the seed had germinated shortly after planting, instead of remaining dormant until spring. Seventy-seven percent of October 11 planted seed had begun the germination process by November 15. Germination of October 11 planted seed was significantly greater at the Windmill versus the North site, probably a result of drier soil conditions at the latter site. Seed treatments were responsible for a slight, but significant increase in germination, and reduction in damage of October 11 planted seed on the first sample date.

When the sites were visited on December 19, 2001, there were 2 to 4 inches of snow on the ground, and the soil was frozen. Five caches per treatment were sampled in one replication at each site, and data were not subjected to statistical analysis. Germination of October 11 planted seed was 92.6 percent on December 19, while that of November 15 planted seed was 13 percent. Seed planted on November 15 at the North site was destroyed by rodents between the time of planting and December 19. Only 20 percent of treated seed and 4 percent of untreated seed was recovered. Seed that was cracked and chewed upon was easily found in the samples. None of the intact seed recovered at the North site had germinated. Dry conditions, which were responsible in part for a shallow planting depth at the site, may have made the seed accessible to rodents. The holes made by the planting dibble tended to collapse before seed could be placed into them. This caused seeding depth to be less than 1 inch.

Five random seed caches from each treatment were dug from each replication on April 9 and again on May 1, 2002. No seedlings had emerged on April 9, 2002. In 2001, emergence was complete by that date. This difference may have resulted from differences between the 2 years in soil temperature. Seedlings had emerged on the May 1, 2002, sample date. Percent emergence, calculated by counting the number of seedlings divided by the number of seeds planted, was greatest for the October 11 planted seed at the North site, and least for the November 15 planted seed at that site. Differences in emergence at the Windmill site were slight, although there was significantly greater emergence of treated seed for the November 15 planting date than the October 11 planting date. On May 1, 6.8 percent of seeds at the Windmill site and 8.7 percent of seeds at the North site had emerged and were still alive. There was no significant impact of seed treatment on emergence, and interactions were not statistically significant for seed treatment x site or planting date

When the plots were visited on June 18, 2002, all emerged plants at the Windmill site were dead. Only two plants, in a

**Table 1**—Sample data from fall 2001. The November 15 sample was taken from only October 11 planted seed. The 19 December sample was nonreplicated, so not subjected to analysis of variance.

| | | | Sample dates[a] | | | | |
|---|---|---|---|---|---|---|---|
| Site | Planting date | Seed treatment | Recovery Nov. 15, 2001 | Germinated Nov. 15, 2001 | Damage[b] Nov. 15, 2001 | Recovery Dec. 19, 2001 | Germinated Dec. 19, 2001 |
| | | | - - - - - - - - - - - - - | - - - - - - - - Percent | - - - - - - - - | - - - - - - - - | - - - - - - - - |
| Windmill | October 11 only on first sample; both on second date | Both | 65.0 | 83.4a | 6.0 | 79 | 59.2 |
| North | | Both | 70.3 | 70.4b | 7.1 | 30.5 | 46.5 |
| | ***P*-value** | | **NS** | **.0158** | **NS** | | |
| Both | October 11 | Both | 67.6 | 76.9 | 6.6 | 57.5 | 92.6 |
| Both | November 15 | Both | | | | 52 | 13.0 |
| Both | October 11 only on first sample; both on second date | Treated | 72.5 | 82.2a | 4.1B | 56.0 | 54.7 |
| Both | | Untreated | 62.8 | 71.6b | 9.0A | 53.5 | 51.0 |
| | ***P*-value** | | **NS** | **.0373** | **.0727** | | |
| Windmill | October 11 | Treated | 65.0 | 86.8 | 4.7 | 54 | 100 |
| Windmill | October 11 | Untreated | 65.0 | 79.9 | 7.3 | 78 | 84.6 |
| Windmill | November 15 | Treated | | | | 90 | 22.2 |
| Windmill | November 15 | Untreated | | | | 94 | 29.8 |
| North | October 11 | Treated | 80.0 | 77.6 | 3.4 | 60 | 96.7 |
| North | October 11 | Untreated | 60.5 | 63.2 | 10.7 | 38 | 89.4 |
| North | November 15 | Treated | | | | 20 | 0 |
| North | November 15 | Untreated | | | | 4 | 0 |
| | ***P*-value** | | **NS** | **NS** | **NS** | | |

[a] Means followed by the same lower case letter are not significantly different at $P = 0.05$; means followed by the same upper case letter are not significantly different at $P = 0.10$.

[b] Seed was considered damaged if it appeared abnormal in any way. Most damage was due to chewing by rodents or mold from fungal growth.

**Table 2**—Sample data from spring 2002.

| | | | Sample dates[a] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | April 9, 2002 | | May 1, 2002 | | | |
| **Site** | **Planting date** | **Seed treatment** | **Recovery** | **Germinated** | **Recovery** | **Germinated** | **Cutworm damage** | **Emergence** |
| | | | *Percent* | | | | | |
| Windmill | | | 83.1a | 62.3a | 72.1a | 58.8a | 25.1a | 6.9 |
| North | | | 56.6b | 39.9b | 38.3b | 36.5b | 8.0b | 8.8 |
| | ***P*-value** | | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **.0027** | **NS** |
| | October 15 | | 80.9a | 62.0a | 65.6a | 58.5a | 18.8 | 10.9a |
| | November 15 | | 58.9b | 40.2b | 44.8b | 36.8b | 14.3 | 4.8b |
| | ***P*-value** | | **<0.0001** | **.0001** | **.0001** | **<0.0001** | **NS** | **.0007** |
| Windmill | October 15 | | 81.0a | 59.6a | 68.5ab | 59.0a | 27.7 | 5.3bc |
| Windmill | November 15 | | 85.2a | 65.0a | 75.8a | 58.5a | 22.6 | 8.5b |
| North | October 15 | | 80.7a | 64.4a | 62.8b | 58.0a | 9.9 | 16.5a |
| North | November 15 | | 32.5b | 15.4b | 13.8c | 15.0b | 6.1 | 1.0c |
| | ***P*-value** | | **<0.0001** | **<0.0001** | **<0.0001** | **.0001** | **NS** | **<0.0001** |
| | | Untreated | 68.4 | 51.0 | 56.0 | 49.3 | 16.9 | 7.3 |
| | | Treated | 71.4 | 51.1 | 54.4 | 46.0 | 16.2 | 8.4 |
| | ***P*-value** | | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| Windmill | | Untreated | 81.3 | 62.7 | 72.5 | 58.4 | 20.9AB | 6.3 |
| Windmill | | Treated | 85.0 | 61.9 | 71.8 | 59.2 | 29.3A | 7.5 |
| North | | Untreated | 55.5 | 39.3 | 39.5 | 40.3 | 12.9BC | 8.3 |
| North | | Treated | 57.7 | 40.4 | 37.0 | 32.7 | 3.1C | 9.3 |
| | ***P*-value** | | **NS** | **NS** | **NS** | **NS** | **.0835** | **NS** |
| | October 15 | Untreated | 79.5 | 62.8 | 62.8A | 60.0 | 18.3 | 10.8 |
| | October 15 | Treated | 82.2 | 61.2 | 68.5A | 57.0 | 19.4 | 11.0 |
| | November 15 | Untreated | 57.3 | 39.2 | 49.3B | 38.6 | 15.5 | 3.8 |
| | November 15 | Treated | 60.5 | 41.1 | 40.3B | 34.9 | 13.1 | 5.8 |
| | ***P*-value** | **NS** | **NS** | **.0860** | **NS** | **NS** | **NS** | |
| Windmill | October 15 | Untreated | 80.5 | 68.4a | 66.5 | 63.2a | 23.0 | 7.0cd |
| Windmill | October 15 | Treated | 81.5 | 50.7b | 70.5 | 54.9a | 32.4 | 3.5de |
| Windmill | November 15 | Untreated | 82.0 | 56.9ab | 78.5 | 53.5a | 18.9 | 5.5cde |
| Windmill | November 15 | Treated | 88.5 | 73.0a | 73.0 | 63.5a | 26.2 | 11.5bc |
| North | October 15 | Untreated | 78.5 | 57.1ab | 59.0 | 56.8a | 13.6 | 14.5ab |
| North | October 15 | Treated | 83.0 | 71.6a | 66.5 | 59.2a | 6.2 | 18.5a |
| North | November 15 | Untreated | 32.5 | 21.5c | 20.0 | 23.7b | 12.1 | 2.0de |
| North | November 15 | Treated | 32.5 | 9.2c | 7.5 | 6.3c | 0.0 | 0.0e |
| | ***P*-value** | | **NS** | **.0021** | **NS** | **.0309** | **NS** | **.0183** |

[a]Means followed by the same lower case letter are not significantly different at $P = 0.05$; means followed by the same upper case letter are not significantly different at $P = 0.10$.

single cache, were found in the samples at the North site. The cause of death of seedlings that had been alive on May 1 was probably drought. Less than $^1/_2$ inch of precipitation had fallen between the time seedlings emerged and the sample date. The plots were evaluated again on October 7, 2002, and the survival was the same as on June 18. No seedlings were found at the Windmill site, and only two were found at the North site.

## Insect Predators and Fungal Pathogens

Army cutworm, *Euxoa auxiliaris* (Grote), killed a significant number of seedlings at both sites; 25.1 percent of seedlings at the Windmill site and 8.0 percent at the North site were cut off by May 1, 2002. There were no statistical differences between planting dates or seed treatments. All recorded cutworm damage occurred between emergence and May 1.

All soil-inhabiting insects were collected from soil samples taken in the fall of 2001 and spring of 2002. Several species of ground beetles (Coleoptera: Carabidae) were found. While some of these are seed predators, it is not known if they prey upon bitterbrush seed. White grub larvae (Coleoptera: Scarabidae: *Phyllophaga* spp) were common in fall-collected samples, and adults were found in spring samples. These root-feeding insects are probably associated with grasses growing in the area. Seed predation by insects appeared to be of little significance to seedling establishment. Army cutworm was the only insect to affect bitterbrush establishment during this study. All specimens collected during the study are deposited in the Western Colorado Research Center insect collection at Fruita.

Two fungal pathogens were recovered from germinated seeds during the fall of 2001. They were cultured and initially identified as *Fusarium* spp. and *Rhizoctonia* spp. by the Jefferson County Plant Disease Diagnostic Laboratory, Golden, CO. Samples of rotted seed collected on December 19, 2001, were sent to The North Carolina State University Plant Pathogen Identification Laboratory, Raleigh, NC, for molecular characterization of the fungus. Two *Rhizoctonia*-like isolates were identified. The most common produced white mycelia and sclerotia after growth on PDA media. The other produced brown mycelia, but no sclerotia. Molecular analysis of these isolates showed that they were actually *Poculum* spp., probably unidentified species.

Two *Fusarium* species were also present, but not common. One produced a carmine red colony with cottony brown mycelia. The second isolate produced light pink to yellow colonies. One isolate was identified as *F. redolens*, and the second was determined to be an undescribed *Fusarium* species.

Thiram fungicide appeared to have some impact on protecting seedlings after emergence. Seed collected on December 19 was grown out in the greenhouse, and damping off type symptoms were more common on untreated seed than treated seed.

## Seed Age and Dormancy

The seed used in both the fall 2000 and 2001 planting studies was produced in 1994 and stored since that time. Germination tests were conducted in June 1995, September 1997 and March 2002 by the Colorado Seed Laboratory, Fort Collins, CO. Results from that testing are displayed in figure 3. The percent live seed increased and the percentage of dormant seed decreased over time. It is interesting to note that the percent germination recorded in the fall 2001 planting was greater than that recorded in the 2002 seed test of the same seed lot. The lack of seed dormancy is responsible for the fall germination of 2001 planting. The 2000 planting did not experience fall germination because of cold soil temperatures when the plots were seeded.

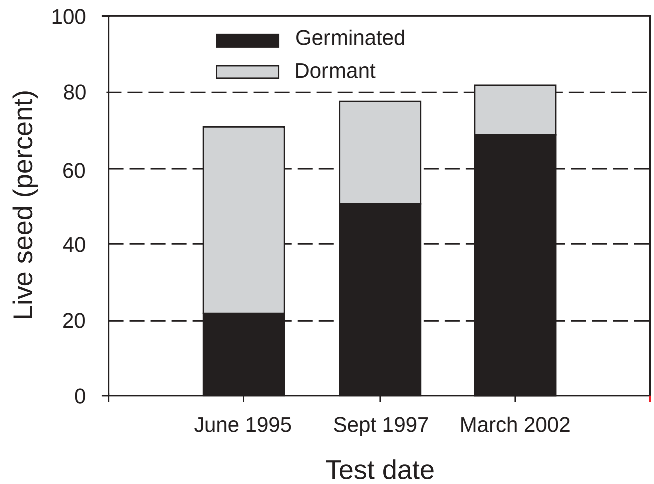


**Figure 3**—Germination tests conducted on 1994 produced seed used in experiments.

## Conclusions

- Several factors affected bitterbrush establishment from seed in this study. Fungal pathogens impacted seed before emergence. Cutworms killed many plants after emergence. Drought killed most other plants.
- Moisture affected seeding depth and germination, and lack of moisture killed most seedlings in the first 4 months after emergence.
- Once seedlings have survived their first year, they are much more capable of surviving drought.
- Fall germination of seed may be important in pathogenicity of *Fusarium*- and *Rhizoctonia*-like organisms.
- Gaucho seed treatment was not effective in controlling insects. Thiram was marginally effective in controlling pathogens and seed predation by mammals. Other compounds may be more effective.