

DOME FIRE SEED BANK STUDIES

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Executive Summary

Soil samples were collected immediately following the Dome Fire to assess the viable seed bank. Samples were collected from ponderosa pine dominated sites. Collection sites represented three burn severities: crown fire with complete ground litter consumption, scorched trees with only partial ground litter consumption, and no burn. These will be referred to as intensive, moderate, and control sites for the purposes of this paper. Soil samples were collected from the surface (1-2" depth) and deeper samples (to 4" depth) to assess the differences between surface and deeper soil seed banks in the various burn severities.

The surface soil samples showed a large reduction in the available seed bank. Compared to samples from unburned areas, graminoids (grasses and sedges) were reduced 57.6% in the intensively burned samples and 63.5% in moderately burned samples. Non-graminoids (forbs and shrubs) were reduced 96.2% in intensively burned samples and 77.3% in moderately burned areas.

Deeper soil samples showed much more variation than surface soil samples. Compared to the unburned areas, graminoids were only reduced 2.2% in the intensively burned samples. However, grasses/sedges were reduced 95.6% in the moderately burned areas. Non-graminoids showed a 18.2% reduction in the intensive burn samples but a 56% **increase** in the moderately burned areas over the unburned areas. These numbers may be the result of a small sample size as well as natural seed bank spatial variation.

Surface soil samples were also collected from various areas seeded by the Forest Service. Seeds were applied by helicopter at approximately 40 seeds/square foot. Thirty graminoid germinants/ft² were observed in the germination trays from surface soil samples collected immediately following the seeding. However, field data collected 77 days post seeding showed that plants germinating from seeds (either from the added or natural seed bank) in the seeded areas averaged 0.60 sedges/ft², 0.81 grasses/ft², and 0.16 forbs/ft². Non-seeded areas had 0.32 sedges/ft², 0.01 grasses/ft², and 0.02 forbs/ft². That is, the additional seed added less than one grass seedling and one forb per square foot. Resprouting plants were also present but at less than 1.0/ft² in both treatments.

It is critical to note that the results presented here are specific to the date, location, and methods of the treatment and data collection. Nevertheless, it is clear that while the hotter areas of the Dome Fire greatly reduced the surface soil seed bank, there are still seeds present in the deeper soil layers. Importantly, the germination of seed from the deeper soil seed bank in burned areas can equal that found in unburned areas; although a larger sample size is needed to better assess this finding. Under field conditions, the Forest Service lost over 97% of the added seed indicating that the added seed will apparently not be a significant factor in revegetating the burned area enough to prevent erosion. Indeed, field observations indicate high levels of runoff and erosion from seeded and non-seeded burned areas.

I) METHODS:

A) Pre-Seeding Soil Samples

Soil samples were collected in the Dome Fire area to assess the viable seed bank (figure 1). All soil samples were collected from sites characterized by dense ponderosa pine forest prior to the burn (visually estimated at greater than 75% canopy cover). Collection sites represented three burn severities: crown fire with complete ground litter consumption, scorched trees with only partial ground litter consumption, and unburned forest patches. These will be referred to as intensive, moderate, and unburned areas for the purposes of this paper. In intensively burned areas all needles on the trees and the ground were consumed but the soil not sterilized (i.e. black ash was still present). At least 90% of the surface litter and duff was consumed. In moderately burned areas the trees and needles were scorched but some green needles were left on >75% of the trees. Needle litter was burned but not fully consumed. Unburned areas were within the fire area.

For each burn severity type (intensive, moderate, and unburned) two separate sites were sample (A and B). Within each site 3 soil samples were collected. Each sample, however, is composed of 3 subsamples taken within a 5 meter area. Each subsample is the soil area within a 23.7 x 33.9 cm (0.080343 m²) quadrat to a depth of approximately 1.50 inches. That is:

- a) 3 quadrats (subsamples) within a 5 meter area = 1 sample (0.241029 m²).
- b) 3 samples were taken in each site. Samples were separated by approximately 15 meters (i.e. 0.723087 m² sampled per site).
- c) 2 sites per burn severity type were taken (1.446174 m² sampled/burn type).

In addition, at one site within each burn severity type a single "deeper" soil sample was taken with a shovel to a depth of 4". As previously, a sample equals 3 quadrats. This was done in order to assess any possible seeds at deeper soil levels.

Soil samples were collected on the dates noted in table 1 below. Samples were stored in open plastic bags in a cool location until sample preparation. Soil samples were mixed and placed in trays on top of a thin sand layer (for water drainage) and placed outside under 30% shade cloth. The first watering took place on the day the samples were prepared. Soil samples were watered daily or as needed to keep the soil moist. Data was collected on the total number of graminoids (grasses and sedges) and non-graminoids (forbs and shrubs) which germinated. No attempt was made to differentiate between the various subcategories of plants (i.e. grasses vs. sedges etc.) due to the difficulties of identifying species at the seedling stages.

Figure 1: Seed bank soil sample sites and data collection points for field germination studies of added seed.

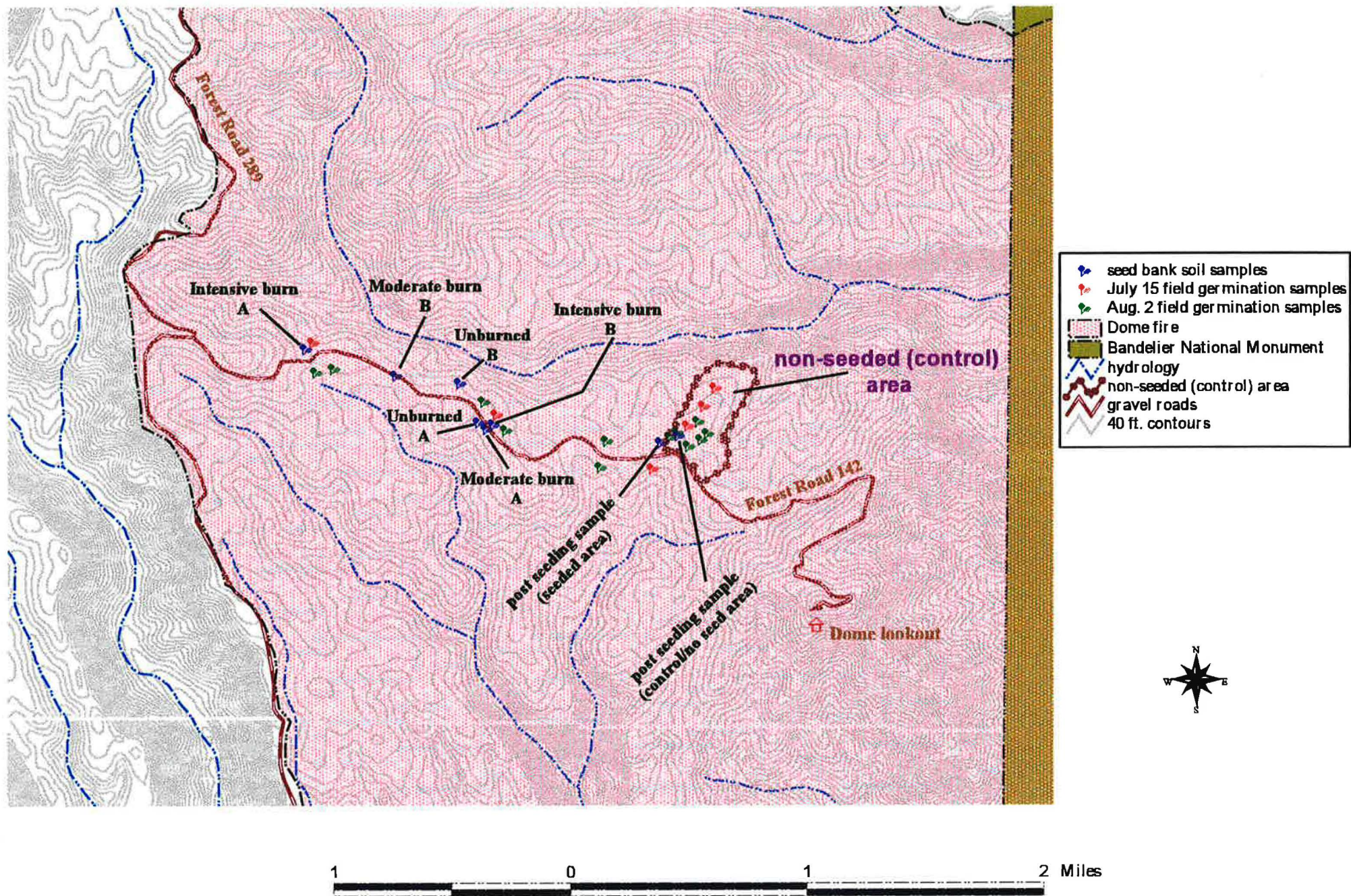


Table 1: Collection and preparation dates for pre-seeding soil samples.

Burn Severity	Site	Samples	Date Collected	Date Prepared
INTENSIVE	A	1,2,3,deep	May 3	May 6
	B	1,2,3	May 3	May 6
MODERATE	A	1,2,3	May 4	May 6
	B	1,2,3,deep	May 4	May 6
UNBURNED	A	1,2,3	May 8	May 9
	B	1,2,3,deep	May 8	May 9

B) Post-Seeding Soil Samples

Additional soil samples in the intensive burn areas were collected after the Forest Service aerielly seeded the area with commercially bought "native" seed mix between May 10th and (approximately) May 17th, 1996. Seed was added at approximately 40 seeds/square foot. Three samples from both a control (a non-seeded, but intensively burned area) and seeded areas (also intensively burned) were collected immediately following seeding (table 2, figure 1).

Sampling techniques were identical to the first set of soil samples (taken previous to seeding). That is, 3 quadrats formed one sample and three samples were taken per site. Sampling depth was 1 to 2 inches. No deeper samples were collected.

Table 2: Dates of collection and soil preparation for post-seeding soil samples.

Burn Severity	Treatment	Samples	Date Seeded	Date Samples Collected	Date Samples Prepared
INTENSIVE	Control (not seeded)	1, 2, 3	-----	May 15	May 16
	Seeded	1, 2, 3	May 14,15	May 15	May 16
(SEEDING RATE WAS APPROXIMATELY 40 SEEDS/FT2)					

Sample preparation and watering was as described above for the pre-seeding seed bank soil samples. As previously, data was collected on the total number of graminoids (grasses and sedges) and non-graminoids (forbs and shrubs) which germinated. No attempt was made to differentiate between the various subcategories of plants (i.e. grasses vs. sedges etc.) due to the difficulties of identifying species at the seedling stages.

C) Field Sampling of Germinants

Success of the Forest Service seeding effort was measured by counting the number of germinants present in seeded and non-seeded areas. Resprouting graminoids and non-graminoids were also counted in each treatment. Sampling was not conducted until sufficient precipitation had occurred for the seeds to germinate. While the seeds were applied in mid-May the first significant rainfall did not occur until mid-June based on data from the weather stations closest to the fire area (figure 2). Data was collected twice. The first set of data was collected on July 15 and the second set of data was collected on August 2, 1996 (figure 1).

Sample points in the seeded area were chosen by pacing 100 steps into an intensively burned area along a line perpendicular to the road and setting a stake in the ground at the 100th step. Data were collected along two 60 meter transects set in an "X" pattern with the stake at the center of the "X". The first transect of the first data point was laid out at a 20 degree bearing and the second arm of the "X" was laid out 90 degrees to this angle. The first transect of point 2 was laid out at a 40 degree bearing, the first transect of the third data point at 60 degrees etc.

Points were also sampled in the non-seeded (control) area. The first two sampling points were approximately 100 paces from the road. Subsequent points were measured from the previous data point. Transects were set up as described above.

Plant counts were made by placing a 22.7 x 33.9 cm quadrat every three meters along the transects. This equals 20 quadrats per transect and 40 quadrats per point. During the first sampling on July 15, only 3 data points (or 3 "X's" with a total of 120 quadrats) were sampled in each treatment. It is important to note that during this sampling data was collected on the total number of graminoids and non-graminoids present. No attempt was made to differentiate between the various subcategories of plants (i.e. grasses vs. sedges and forbs vs. shrubs etc.). Thus the final averages for new germinants represents the added and natural seed bank. The second sampling was doubled in size to 6 data points for each treatment. This was a total of 240 quadrats representing a total area of 19.28 m² (207.48 ft²) per treatment. Grass, forbs, and sedges germinating from seeds were tallied separately. Resprouting plants were also counted. However, they were grouped together. Resprouting graminoids includes grasses and sedges while non-graminoids includes forbs and shrubs.

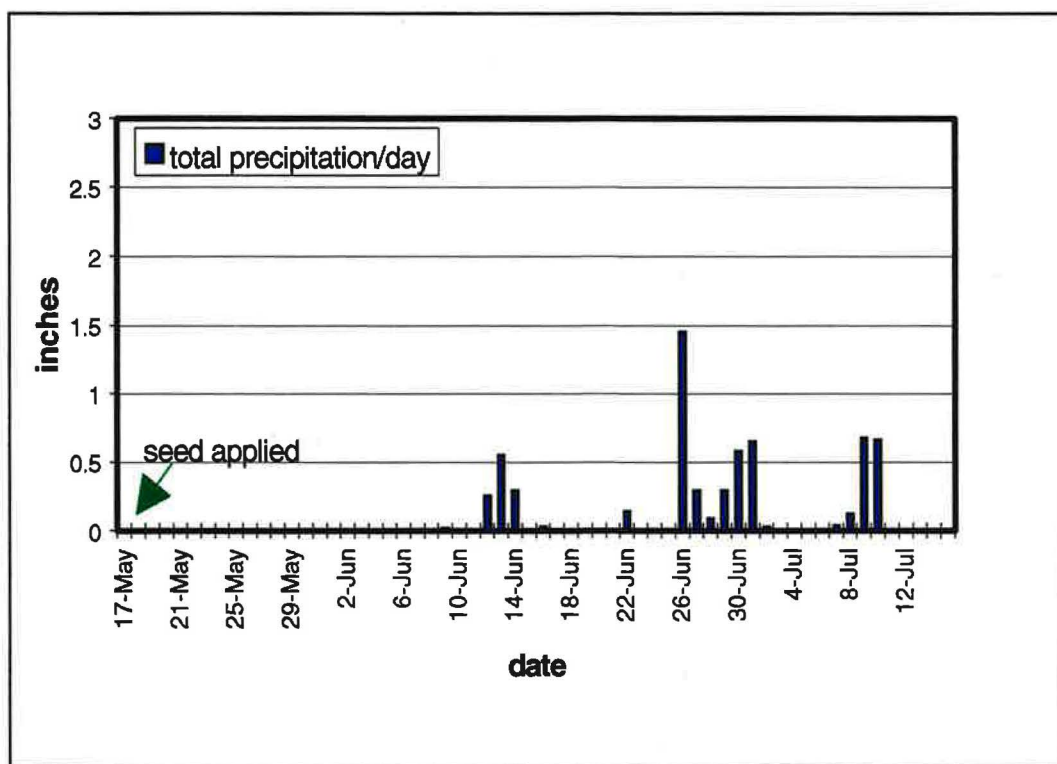


Figure 2: Precipitation data for May 17 - July 15, 1996. Pre-June 17 data from LANL station (9425 ft). Post-June 17 data from Ponderosa CG (7580 ft).

II) RESULTS

A) Pre-Seeding Soil Samples

Figure 3 shows the decrease in the surface soil seed bank as a result of the Dome Fire. Based on a sample size of 6 (which is composed of 18 subsamples), intensively and moderately burned areas had only 2.3 and 1.99 graminoid germinants per square foot respectively compared to 5.46 for control sites. There were 20.37 non-graminoid germinants/ft² in unburned areas compared to 0.77 and 4.62 germinants/ft² for intensively and moderately burned areas respectively.

The deeper soil sample produced more variable results. Here, intensively burned areas had the same number of grass/sedge germinants/ft² as did unburned areas: 17.35 and 17.37 respectively (figure 4). It is interesting to note that all of the grass/sedge plants in the intensively burned sample were, in fact, sedges. This result is consistent with field observations; sedges are the predominant germinant in the intensively burned areas at this time. Moderately burned areas only had 0.77 graminoid germinants/ft² (again, mostly, if not all, sedges). The deeper samples also showed a high variation in the number of non-graminoid germinants. Intensively burned areas had 3.47 non-graminoid germinants/ft², moderately burned areas 9.64, and unburned sites 4.24 non-graminoid germinants/ft².

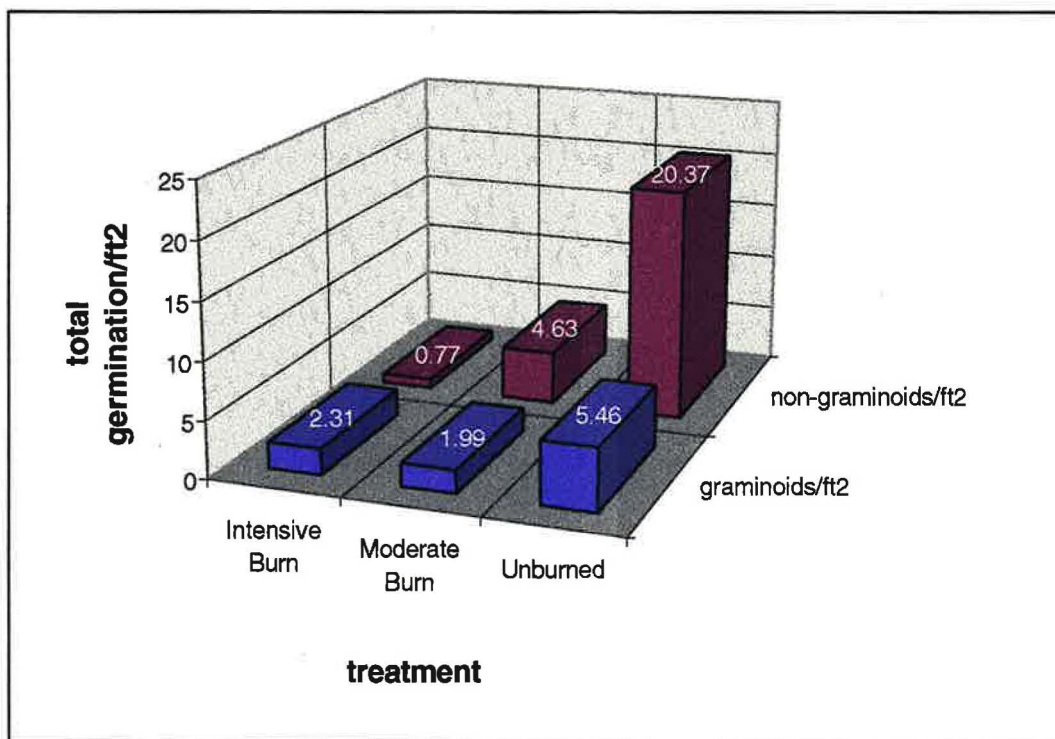


Figure 3: Germination from surface soil samples before aerial seeding (1-2" depth, n=6 per treatment with each sample composed of 3 subsamples). Note that graminoids include grasses and sedges. Non-graminoids include forbs and shrubs.

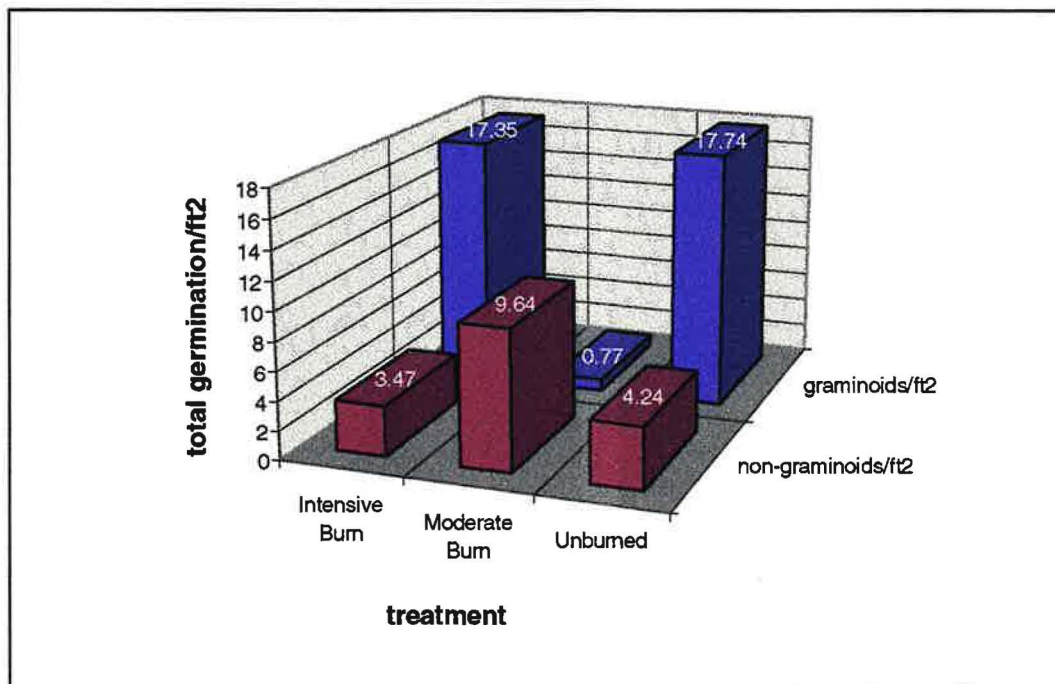


Figure 4: Germination from deeper soil samples before aerial seeding (to 4" deep, n=1 per trt. with each sample composed of 3 subsamples). Note that graminoids include grasses and sedges. Non-graminoids include forbs and shrubs.

B) Post-Seeding Soil Samples

As explained in the methods section, additional surface soil samples were taken after the Forest Service seeded most of the intensively burned areas from May 10 to approximately May 17th, 1996. One small area was not seeded as a control site. Samples of the control area (which essentially represents an additional sampling of the intensively burned areas) supports the original finding of a large decrease in the surface soil seed bank. This sample found less than one graminoid and one non-graminoid germinant per square foot in the intensively burned non-seeded area (figure 5). This compares closely with the sampling of intensively burned areas (previous to the seeding) which showed only 2.3 graminoid and 1.99 non-graminoid seedlings per square foot (figure 4). After aerial seeding, the seeded area had 30.2 graminoid germinants/ft² (figure 5).

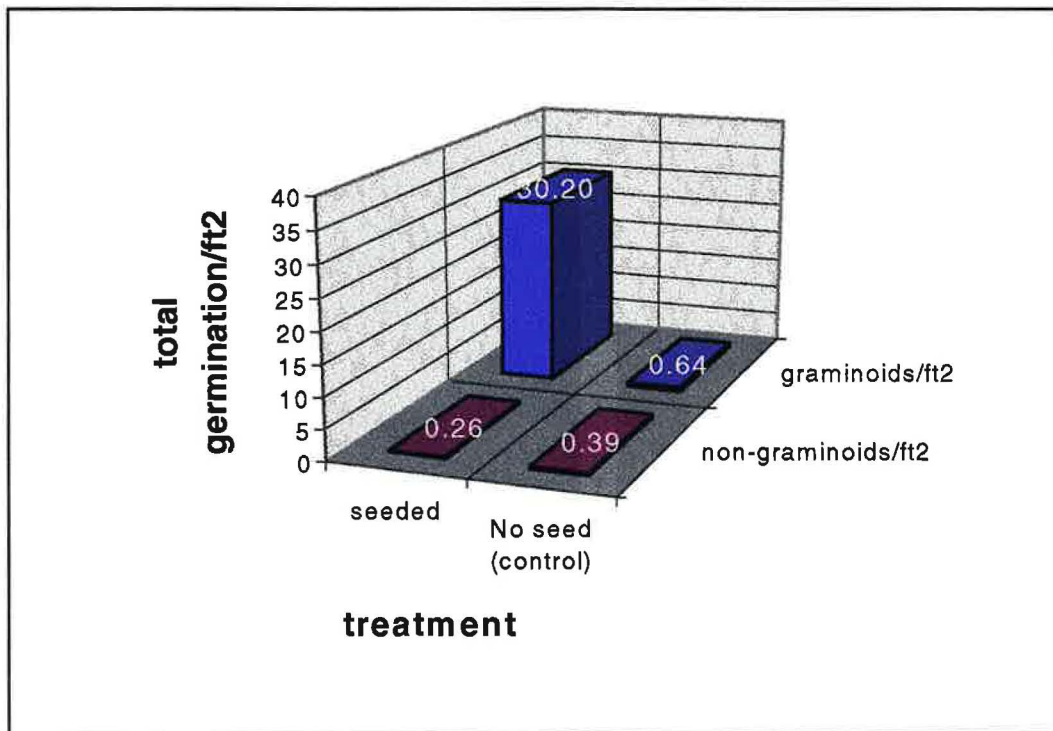


Figure 5: Germination from surface soil samples after aerial seeding in seeded and non-seeded areas (intensive burn areas only. N=3 per trt). Graminoids include grasses and sedges. Non-graminoids include forbs and shrubs.

C) Field Sampling of Aerially Applied Seed

Field sampling showed that over 85% of the applied seed had not germinated or was lost by July 15. Only 5.35 graminoid (which includes sedges from the natural seed bank as well as added seed) and 0.43 non-graminoid seedlings/ft² were present at this date (figure 6). The control area had 0.13 grass/sedge and 0.08 forb/shrub seedlings/ft² at this time. Resprouting plants averaged less than one per square foot for graminoids and non-graminoid plant types in both treatments. As of August 2 the germination and survival rate had fallen even further. Figure 7 presents the results in a form comparable to that of figure 6. Figure 8 breaks down the graminoid

category into new sedge seedlings (from the natural seed bank) and new grass seedlings (most likely from the added seed). It can be seen from Figure 7 that the survival of graminoids from seeds has decreased from 5.35 germinants/ft² on July 15 to 1.41 seedlings/ft² on August 2. If the sedges are excluded from this figure, survival from the added seed averaged only 0.81 seedlings/ft² (figure 8). Non-graminoid germinants averaged only 0.16 seedlings/ft². Control areas had 0.32 grass/sedges (which were 99% sedges) and 0.02 non-graminoid germinants/ft² at this date.

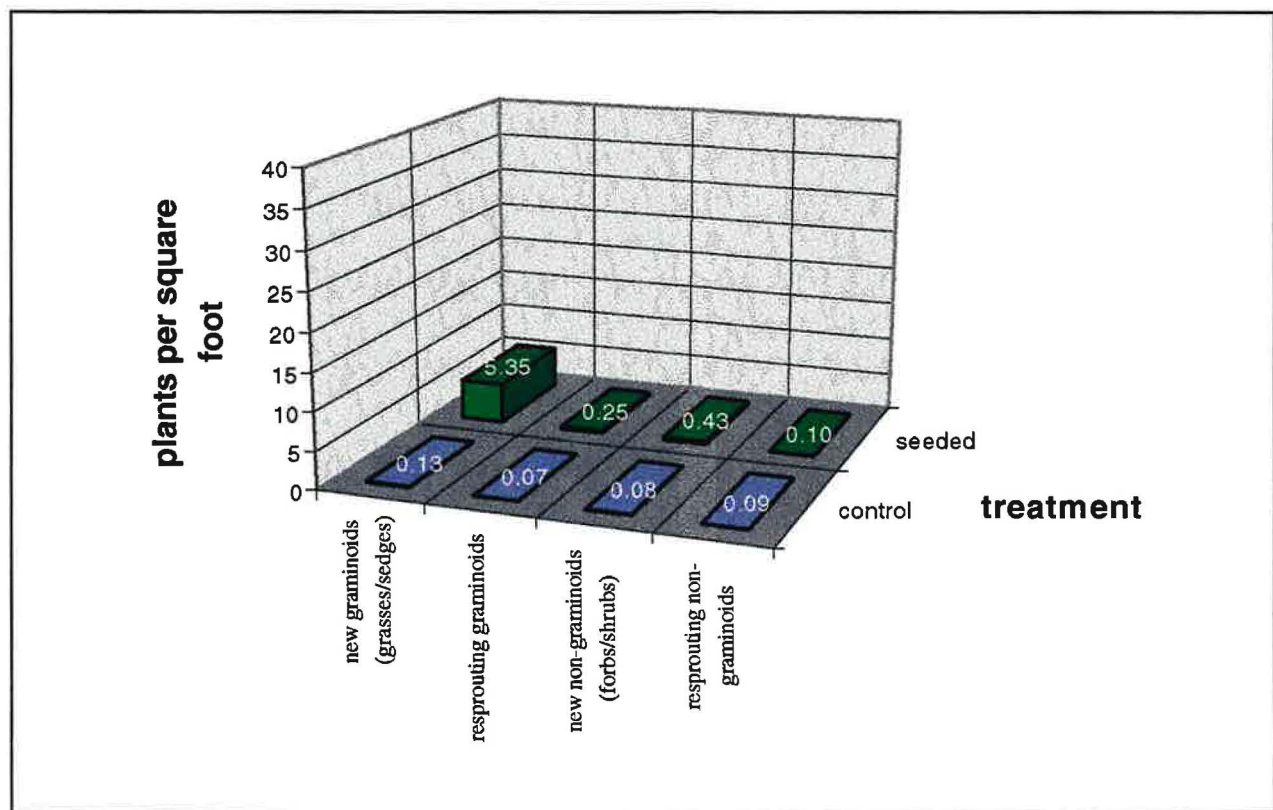


Figure 6: July 15 field germination/survival of new and resprouting plants in seeded and non-seeded areas.

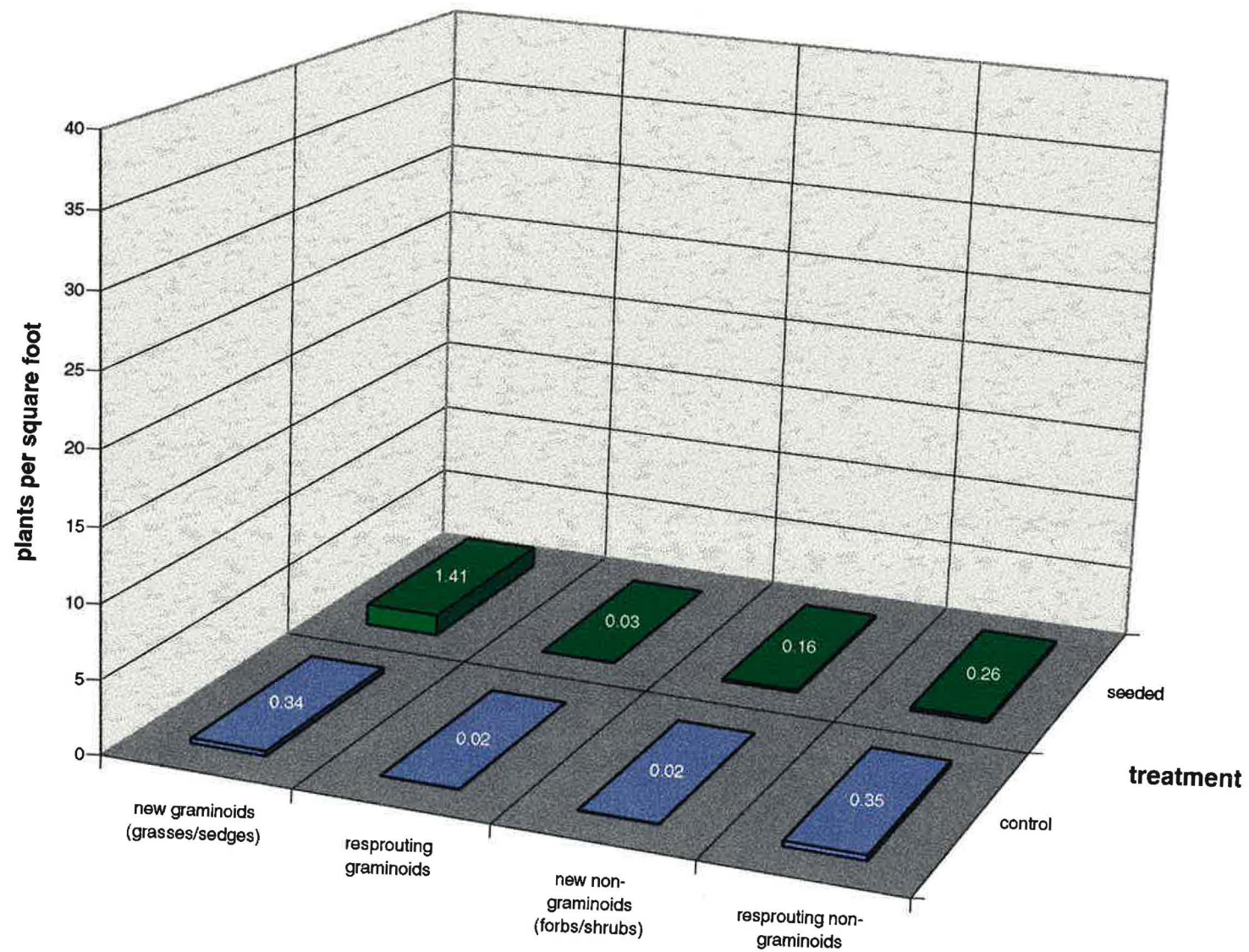


Figure 7: August 2 field germination and survival of plants in seeded and non-seeded areas. New graminoids are **grouped** for easier comparison to figure 6.

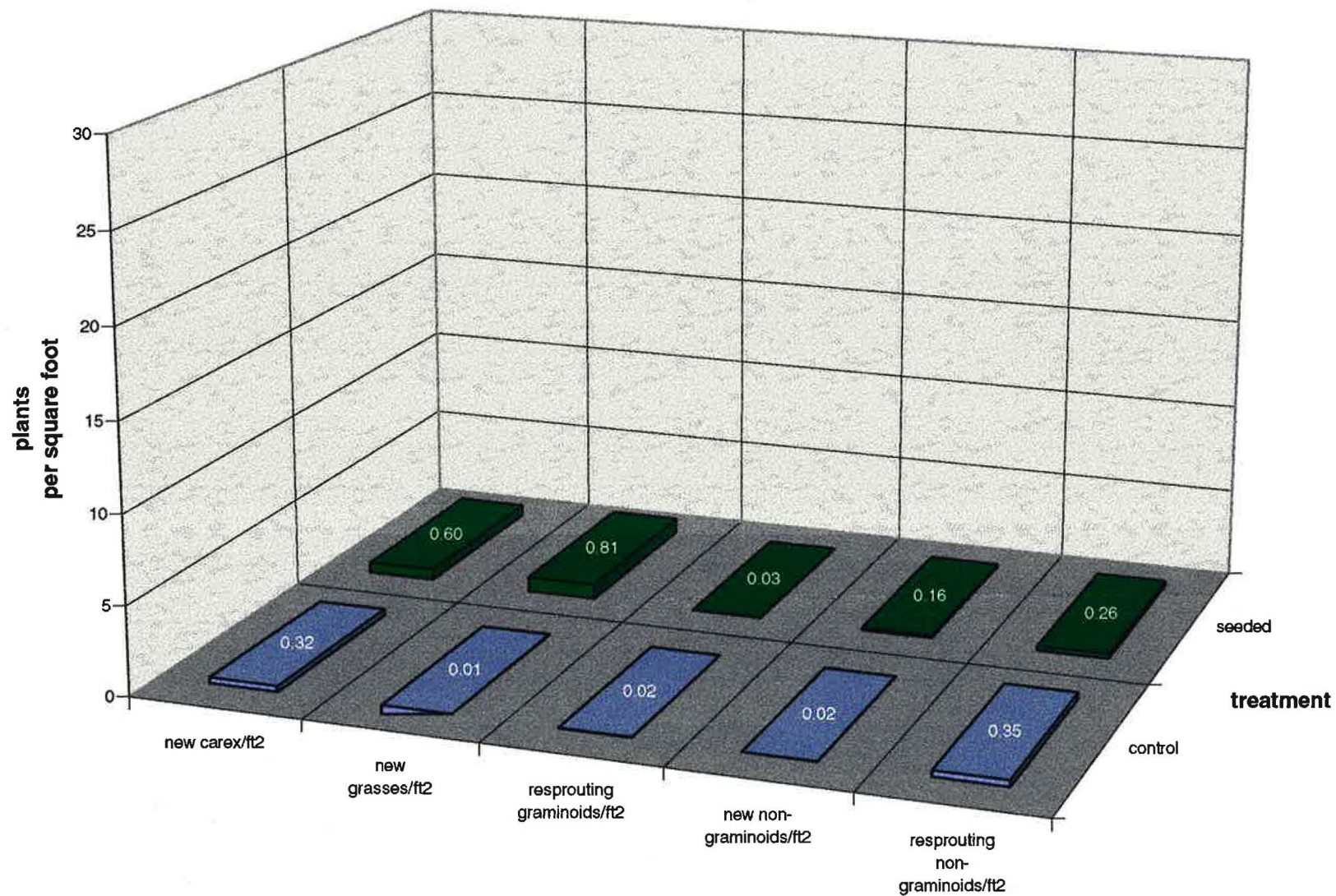


Figure 8: August 2 field germination/survival of plants in seeded and non-seeded areas.
Note the "new graminoid" category of figure 7 has been **broken down** into sedges and grasses.

III) DISCUSSION

As expected, the intense heat of the fire drastically reduced the seed bank near the soil surface. Figure 3 shows a clear trend of a decreasing seed bank quantity with increasing fire intensity. The few seeds which survived in intensively burned areas were sedges, mullein, *Chenopodiaceae*, and *Artemisia* sp. These plants were few and far between however (i.e. an average of 3 germinants/ft²), which indicates the heat of the fire was intense enough to destroy the majority of seeds in the top 2" inches of the soil.

Two to four inches below the soil surface, greater numbers of sedge, mullein, and seeds of other species (*Euphorbia* sp.) were apparently protected enough to survive the fire. Though the results were highly variable between deeper soil samples, larger quantities of seeds are clearly present. For example, the intensively-burned deeper soil sample had the same grass/sedge germination rate as that of the unburned area while the moderately burned area had a much lower germination rate. Conversely, the moderately burned area had a much higher non-graminoid germination rate than either the unburned or the intensively burned area. This variation from expected results (i.e. proportional changes in the seed bank relative to changes in fire intensity) probably reflects the natural variation in the seed bank. Seeds are not evenly distributed over an area but are clumped in various patterns due to the seed type, dispersal mechanism, location of parent plants, wind and water patterns, soil microtopography, site history and other factors. Field observations of the burned area supports these results. Large bare areas are often marked with tiny clumps of germinating sedges. Thus it is clear that there is still a seed bank, albeit patchy, remaining even in the intensively burned areas after the Dome Fire.

As for the seeding efforts, there are eye-catching pockets of green rye grass. However, it is often clumped, and thus most visible, near the edge of Forest Roads 289 and 142, and in higher elevation areas. Randomized sampling conducted away from road edge effects shows that in the areas sampled, over 85% of the added seed had been lost or not yet germinated 59 days after the seed was applied. Eighteen days later this figure had increased to over 97%. Field observations indicate the majority of the added seed germinated and did not survive. Extensive germination of the added seed was clearly visible on a tour through the area in early July. By July 15 it could be easily seen that large numbers of these germinants had disappeared; a result supported by the data. By the August 2 data collection, it was difficult to even find areas with seedlings in the seeded areas. Field observations showed that seedling mortality probably resulted from soil erosion caused by the intense summer monsoon rains. Sheet, rill and gully erosion is visible throughout the burn area. A burned chunk of wood elevated over 3" above the previous soil level was seen during the August 2 data collection trip (on a slope of less than 5%!). Undoubtedly some seed and seedlings were washed away as the upper layers of the soil eroded. More visible were the seedlings which remained anchored by a small rootlet after the top layers of soil had disappeared down the slope, leaving the seedlings to desiccate. Interestingly, it may be this very erosion which is bringing the buried sedge seeds closer to the surface and allowing them to germinate in such large numbers.

The results presented here are specific to the date, location, and methods of the treatment and data collection. Statistical theory and the spatial heterogeneity of the burn area do not allow the results to be widely extrapolated to other times and locations. Thus, the interpretation of the

data collected here is limited to ponderosa pine dominated sites along Forest Road 142. In addition, the results are limited to the growing conditions present during this study. Seeds germinate under various conditions; some favoring the heat of summer while others germinate in the early spring. It is likely that many seeds were in the collected soil samples as well as the burn area which may germinate under different conditions than those presented here. Within these limitations however, it is clear that the fire has greatly reduced the surface soil seed bank. The large quantities of seed aurally added to the soil surface after the fire appears to have only slightly increased the number of germinants present by early August. However, data suggest that there are still native seeds present in the deeper soil layers, which, along with resprouting vegetation, natural seed dispersal, and the few plants which survived from the added seed, will serve as sources to revegetate the Dome fire area.