

Add p-#
references to
summary
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EXECUTIVE SUMMARY

Results of Seed Bank Studies B. gracilis Germination Experiments and More

November 1995

DISCLAIMER: The following data, results, and interpretation are observational studies only. They in no way represent rigorous scientific studies as detailed in section 3.45a-d, paragraph C, volume 2 of the International Code of Science (1995, United Nations rule book for tennis, ball bouncing, and peace keeping operations in National Park Service areas. Only available in Slovak and German, \$14.95 plus tax). That is, these studies and tests were meant to show general trends only. Please keep this in mind or I'll report you to the commander in chief.

The Studies:

1) Rainfall Records 1995

* self explanatory

2) Calculations for Seeding Rates and Mixes used in 1995

* self explanatory

3) Seed Bank Study - Site 1: Results from Oct. 1994 Seed Application

* Summary: Native grass seed was applied in tree interspaces on designated treatments in Oct. '94. May 1995 seed bank study shows that tree interspaces (bare soil) are nearly devoid of grass seeds (either natural or added in Oct. 1994) and forbs.

In "all soil" samples from seeded treatments, grasses per m² is up to 10 times greater than in all soil samples from non-seeded treatments (despite the fact that litter areas were not seeded in '94, only tree interspaces were seeded). Seed in bare soil is lost to predation and moved to litter areas.

Bare soil areas are also equally devoid of forbs. "All soil" areas have a large # of forbs (318 per m²).

Natural revegetation of bare areas may be impossible given the lack of seeds and stressful conditions. Revegetation of litter areas may be possible (by forbs) if the PJ overstory is removed and adequate moisture available.

(litter + bare
soil sites
?)
confusing

by ants?
washed

this isn't consistent w/
?

4) Seed Bank Study - Site 1: 7 Days Post Seeding

* Summary: Not an accurate study since soil samples were extremely small and # of samples limited. (Soil samples from a unknown mix of bare and litter areas) (though July '95 seeding was applied evenly over the treatments).

Nevertheless it appears that ant predation or other factors have caused a 79% reduction in the grass seed bank in 7 days. Maximum germination was 21% in seed only plots to a low of 9% in imprint/seed and rake/seed plots. Note that grass germination/m² in no seed plots equaled that of imprint and rake plots.

5) Seed Bank Study - Site 1: 21 Days Post Seeding

* Summary: Improved sampling used in this study (larger and more samples). Samples taken from bare soil areas.

Greater than 91% loss of seed in the seed bank within 21 days. Maximum germination was 8.23% on rake/seed plots.

Non-seeded plots showed "normal" grass germination/m² levels (nearly zero) compared to the previous study of 116 grasses/m².

6) Seed Germination Field Data (from Quadrats) - Site 1: 3 Months Post Seeding

* Summary: Non-seeded plots showed low to zero grass germination.

Seeded plots had very low germination/survival. Maximum was 3.4% (43.7 plants/m²) in the imprint/seed plots. Overall it appears there has been a 96% reduction of the added grass seed in 3 months. Further environmental stresses and predation may reduce this number to 1% survival or less.

7) Seed Bank Study - Site 3 (Guaje): 8 Days Post Seeding

* Summary: Improved sampling used in this study (larger and more samples). Samples taken from bare soil areas.

Non-seeded plots showed low grass germination as expected.

Germination in seeded plots ranged from a low of 4.24 % in seed only plots to 32.17 % in rake seed plots. A small rain event (0.1 in.) may have moved some seed out of bare areas (thus accounting for low germination rates in seed only plots) or other factors may be at work.

Seems to be a sampling problem since imprinted plots in Guaje (w/o significant ant predation) are lower

dave\seedtest\summary thru on 1 Aug 95

2) 1/2 frames per plot x 1 1/2' x 1 1/2'

state actual parameters

show it there follow up on those

follow up

only?

detail

clarify

why not just indicate that we may track survivorship next year -

How do we explain what you can see on the ground
in terms of imprints full of germinants - sampling
on bias of an observer - ?
CASUAL

8) Seed Germination Field Data (from Quadrats) - Site 3 (Guaje): 3 Months Post Seeding

* Summary: Non-seeded plots showed low to zero grass germination as expected.

Imprint and seed only plots had very low germination/survival. Rake/seed plots fared better with a germination rate of 7.68%. The raking may have helped protect the seed in terms of germination and survival. Overall it appears there has been a 92% reduction of the added grass seed in 3 months (despite there being no ants at this site). Additional environmental stresses and predation may reduce this number further.

Again - survivorship will be evaluated next year

9) Allelopathic Effects of PJ Litter and Slash on *B. gracilis*

* Summary: No allelopathic effects were found on the germination or survival of BOGR seedlings.

10) Soil Surface Effects on *B. gracilis* Germination and Growth

* Summary: The highest germination rates are found in bare soil treatments. Litter and litter/slash on the soil surface reduce germination rates to nearly half that of bare soil treatments.

However, seedlings in bare soil were severely stressed and showed poor vigor and growth. They would not have survived without daily watering.

Seedlings in litter were very vigorous and grew more than 3x taller than seedlings in bare soil. Litter on the soil surface help retain soil moisture and moderated soil temperatures.

Indicate rationale for doing this exp.

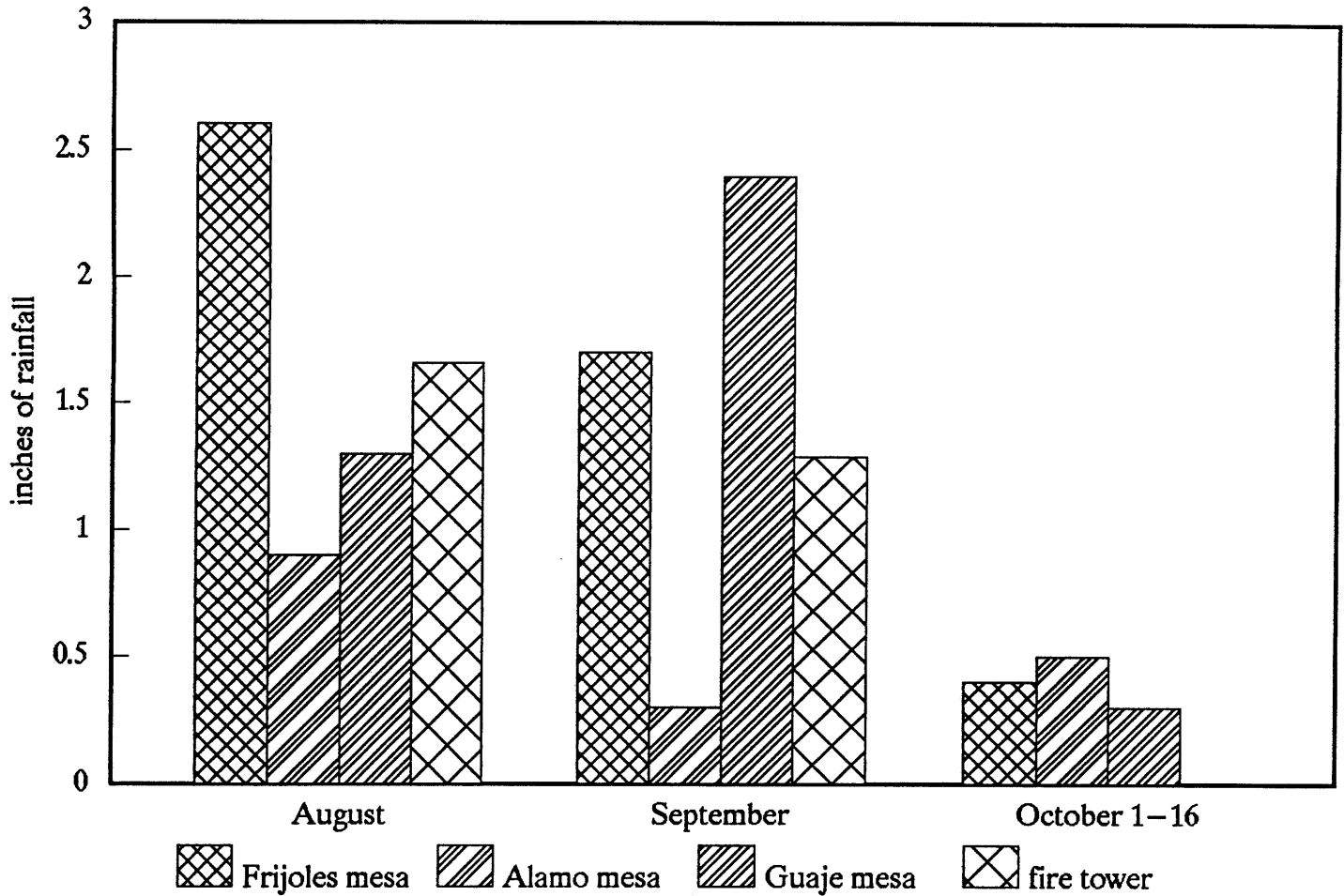
11) Germination of Coated Seeds - 2:1 and 5:1 Seed Coatings

* Summary: Study was done late in the season (during cool temperatures) and should be repeated next year during the summer growing season.

Nevertheless, it appears that the seed coats had no effect of germination either when placed on the soil surface or sowed in the soil. In fact, 2:1 coated seeds had a slightly higher germination rate.

Study development, data collection and analysis, and interpretation done by the 1995 Revegetation Crew: David Snyderman, Sam Fitton, Dan V, Laura Trader, and Claire Madsen. Checks or cash accepted.

Rainfall Records 1995



dave\seedtest\rainfall.wk3
graph: rainfall

— provide elev. & UTM
coordinates for each gauge

— also a map of study areas
relative to one another

Calculations for Seeding Rates and Mixes
used in 1995

November 1995

1). Desired Seeding Rate:

a). The generally recommended agriculture seeding rate (for grasses?) is 40 live seeds/ft². We tripled this to 120 live seeds/ft² as our desired seeding rate.

Note: "live seed" means actual viable seed. This is determined from germination tests of viability.

Conversion to metric: 120 seeds/ft² x 10.76 ft²/m² = 1291 seed/m²

2). Desired Mix:

50 % Bouteloua gracilis (BOGR) = 1291 live seeds/m² x .50 = 645.6 BOGR live seeds/m².

30 % Andropogon scoparius (ANSC, little bluestem) = 1291 live seeds/m² x .30 = 387.3 ANSC live seeds/m².

20 % Sporobolus crytandrus (SPCR) = 1291 live seeds/m² x .20 = 258.2 SPCR live seeds/m².

3). Conversion of number of live seeds desired (above #2) to weight of live seeds desired:

a) Find the # of seeds/lb. This is usually on the seed bag or you may have to look in a standard text. Note this figure may vary depending on the source.

BOGR = 825,000 seeds/lb

ANSC = 260,000 seeds/lb

SPCR = 5,600,000 seeds/lb (give or take one).

b) Convert seeds/lb to seeds/kg:

BOGR: 825,000 seeds/lb divided by .454 Kg/lb = 1,817,180 seeds/kg

ANCS: 260,000 seeds/lb divided by .454 Kg/lb = 572,687.2 seeds/kg

SPCR: 5,600,000 seeds/lb divided by .454 Kg/lb =
12,334,802 seeds/kg

c) Finally, use "b" above to determine the weight of live seed in grams desired:

BOGR: 645.6 live seeds/m² divided by 1,817,180 seeds/kg
= .000355275 kg/m² x 1000 grams/kg = 0.355275 g/m² live seed.

ANCS: 387.3 live seeds/m² divided by 572,687.2 seeds/kg
= .000676285 kg/m² x 1000 grams/kg = .676285 g/m² live seed.

SPCR: 258.2 live seeds/m² divided 12,334,802 by seeds/kg
= .000020932 kg/m² x 1000 grams/kg = .020932 g/m² live seed.

4). Determination of Total Seed needed per m²:

Now that you know the weight of live seeds desired per m² per species, you must consider that the germination rate and the purity is not 100%. That is, you will have to apply more seed than necessary to achieve the desired **live seeding rate** stated above. This is done by determining Pure Live Seed (PLS) where:

PLS = germination x purity

(where purity = total seed - inert matter)

Example: X species with 80% germination and 50% purity

PLS = .8 x .5 = 40% PLS

This means that out of a 100 kg bag only 40 kg would be live seed.

Note: The PLS figure will change with each seed lot as the germination and/or purity change. Check your seed! Below are the figures we used to calculate the 1995 seed:

Total Seed Needed per m² = desired wgt of seed/m² divided by PLS:

BOGR = 0.355275 g/m² live seed desired divided by .5681
PLS = .62536 g/m² necessary to achieve desired seeding rate with live seeds.

ANCS: = .676285 g/m² live seed desired divided by .2578
PLS = 2.6232 g/m² necessary to achieve desired seeding rate with live seeds.

SPCR: = .020932 g/m2 live seed desired divided by .93
PLS = .022505 g/m2 necessary to achieve desired
seeding rate with live seeds.

5). Determination of Total seed needed per plot:

Since each plot is 15 m on each side then the area is:

15 x 15 = 225 meters squared (m2) per plot

Total seed/plot = 225 m2/plot x g/m2 of each species (see
above)

Example: 225 m2/plot x .62536 g/m2 BOGR = 140.71
grams/plot needed.

Indicate actual measurements were done on a volumetric basis

FINAL NOTE: THERE ARE MULTIPLE WAYS TO DO THE ABOVE CALCULATIONS
AND ARRIVE AT THE SAME ANSWER. DO IT HOWEVER THE HELL YOU WANT.

(i.e.)

large +
medium

7.5 gmt
cups

+
film
container

Seed Bank Study - Restoration Site 1 (Frijoles Mesa)
Results from Oct. 1994 Seed Application
May 1995

Objective:

To study the viability of grass seed applied in Oct. 1994 to restoration site 1. That is, how much mortality occurred over the winter due to loss of viability, rotting, and predation?

Methods:

1) Native grasses were seeded on Oct. 21, 1994 under the following conditions:

- a) *focused on* Treatments (raking, imprinting etc...) were performed in tree interspaces ~~only~~. That is, the bare areas between the trees. *Edges of little mats were incidentally seeded.*
- b) Seeding rate was approximately 430 live seeds/m² (about 40 live seeds/ft²).
- c) The seeding mix was:
- 75% Bouteloua gracilis (blue grama) *(approx 0.2 oz/ft²)*
- 25% Andropogon scoparius (little blue stem) *(approx 0.2 oz/ft²)*

In addition to the above, 2 hand collected species were also added. However, these seeds were not cleaned (thus included much inert matter) nor was the viability tested. The 2 species were:

Needle and Thread Grass (approx. 2.5 oz/plot)
Little seed rice grass (approx. 0.1 oz/plot)

- d) *Heavy* Slashing of the plot did not occur until the spring and early summer of 1995; *light slashing was done in fall 1994.*

2) Soil surface samples were collected on May 16 and 17, 1995 using the following method:

- a) 4 samples per plot were collected.
- b) Each sample point was located 7.5 meters down the side of the plot and 2.5 meters into the center.

c) A sample equals roughly 6 square inches. Unfortunately, the area collected was only visually estimated so all numbers are very approximate. Soil was collected to a depth of 1 to 1.5".

d) All plots were sampled once and seeded plots were sampled twice as follows:

i) First sampling: samples were taken without regard to the soil surface and sampled at the rate of 4 samples/plot for all plots.

focused ii) Second sampling (the following day): samples were taken from bare soil areas since these are the areas where the seed and treatments had been ~~applied~~ the previous Oct. Note, however, that the second sampling from bare soil areas was only from seeded plots and was only 2 samples per plot instead of 4 samples per plot.

(approx same size 6" x 1 1/2")?

3) Soil Sample preparation:

entire (or - sub-set)?
✓

Soil samples were well mixed and spread in large wooden flats over a sand base.

Flats were placed in the greenhouse at the U.S.F.S. Rocky Mountain Exp. Station in Albuquerque and watered daily.

Expected Results:

Sample size per sampling point = approximately 6 inches diameter or 0.018233 m²

Total area sampled per plot = 0.018233 m² x 4 sampling points/plot = 0.072933 m².

Desired seeding rate = 430 live seeds/m².

Expected seed germination: 0.072933 m² X 430 live seeds/m² =
31.4 seedlings expected

Results:

All Soil Samples (litter and bare soil mixed)		
Treatments	Average # of seedlings/m ²	% germination
Controls	13.71	N/A
Imprint (no seed)	22.85	N/A
Slash only (no seed)	18.28	N/A
Imprint/seed	54.84	12.74
Rake/seed	123.4	28.66
Broadcast seed	114.26	26.54
Forbs (All treatments)	318.40	N/A

Ave.

Bare Soil Samples		
Treatments	Average # of seedlings/m ²	% germination
Controls	N/A	N/A
Imprint (no seed)	N/A	N/A
Slash only (no seed)	N/A	N/A
Imprint/seed	9.14	2.12
Rake/seed	9.14	2.12
Broadcast seed	18.28	4.25
Forbs (All treatments Ave)	18.28	N/A

N/A = not applicable (cannot be calculated).

SEE THE ATTACHED GRAPHS.

Seed bank - how seeded
Forb / Grass
318.4 / 18.28

318.40

18.28

336.68 / total seeds/plot

- All soils

Discussion:

1). Background/Natural Seedbank (non-seeded treatments):

Grasses: Data from control plots and non-seeded treatments (graph: grassbank m2) show that there are very few native viable grass seeds in the soil seed bank. The number of seedlings per meter squared (m2) that germinated averaged 18.28 grass seedlings/m2 with a range from 13.71 to 22.85. Considering these seeds germinated under better than normal environmental conditions (i.e. daily waterings), it is highly doubtful that significant revegetation will take place under natural conditions given the lack of rainfall and other environmental stresses. *from germinates in the soil seed bank*
poor soil
undependable

Forbs: There is a large difference between the number of forb seeds in "all soil" areas (soil samples from both litter and bare soil areas) and bare soil samples (graph: avg. forbbank). Bare soil areas averaged only 18.28 forbs/m2 while "all soil" areas averaged 318.4 forbs/m2. No doubt the difference between these numbers is due to the forb seed bank in litter under PJ trees. It appears that seeds in bare soil areas are either subject to greater predation, greater environmental stresses, or are washed or blown away (potentially to litter areas). It is important to note that this may mean that bare areas can not revegetate themselves given the paucity of forb seeds (and, as this and subsequent studies show, grass seeds too). Areas with litter may have more revegetation success especially if microconditions in the litter areas can be improved. For example, given that most of the forb species in the P-J ecosystem are found in full sunlight and that P-J overstory as well as litter can intercept up to 60% or more of available rainfall, the removal of the woody overstory appears to be a step in the right direction in terms improving light and moisture availability needed for germination, establishment, and eventually revegetation of degraded sites by forbs.

A note of warning: This seed bank study missed the annual spring forbs which were very prolific in 1995. Cordylanthus wrightii and Lupinus kingii both germinated before soil samples were taken. They were dominant species during the summer growing season. Neither plant germinated in the soil samples we collected. Either all the viable seed had already germinated or the environmental conditions to which the soil samples were subjected (high summer heat, daily watering, etc...) were not correct for germination of these species. It is possible that we missed other species due to improper environmental conditions.

on bare soil interspaces

2) Seed bank in Treatments seeded in Oct. 1994:

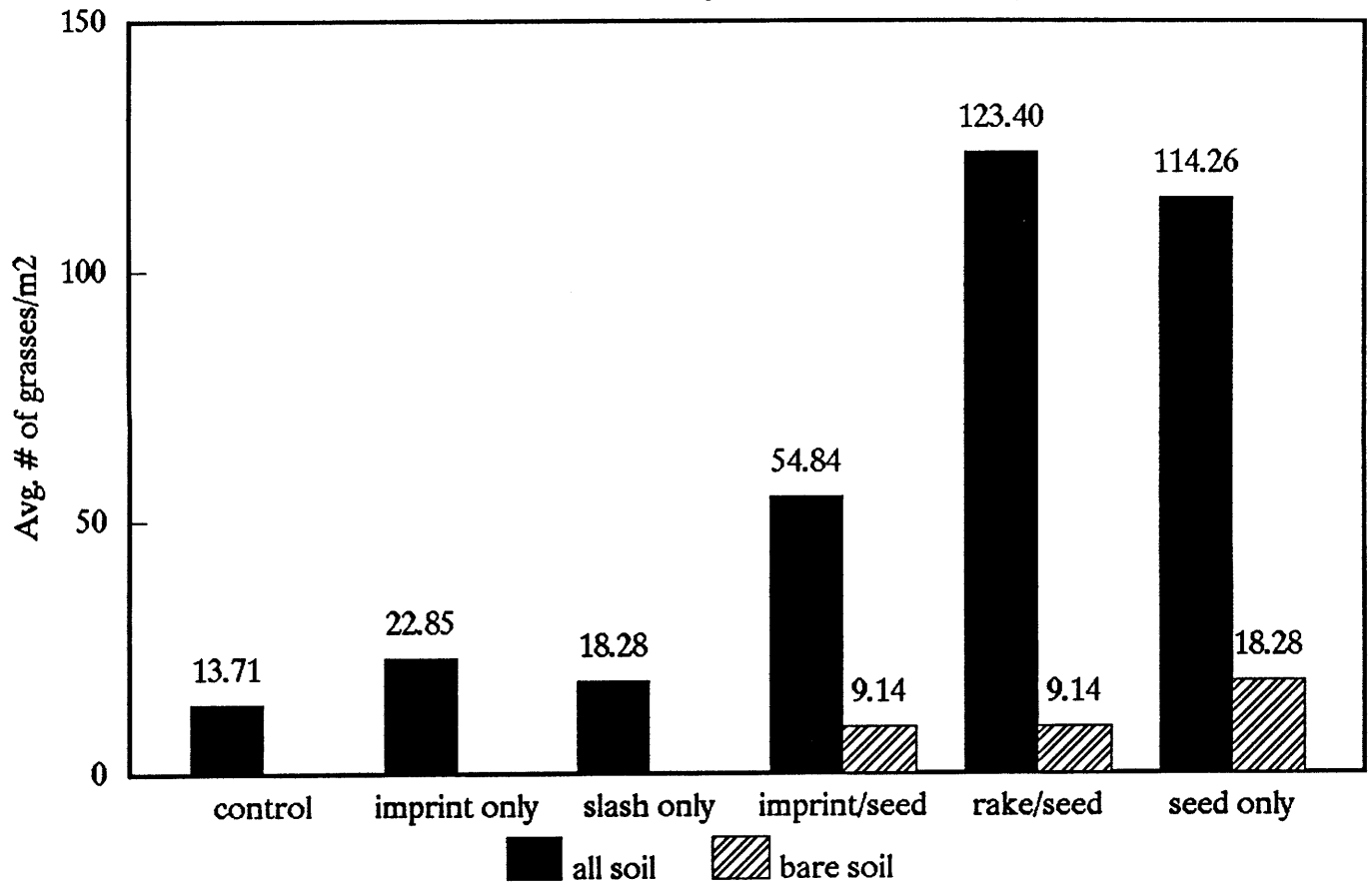
Grasses in Bare Soil: Note that during the Oct. 1994 treatment, grass seed was ^{4. cv seed} ~~only sowed in tree interspaces (bare soil) and not in litter areas.~~ Despite this treatment, the bare soil areas are nearly devoid of applied grass seed (graph: %grassbank '94). Germination success in the seeded plots ranged from 2.12% to only 4.25%. These figures are essentially equal to germination in plots where no seed was added on a per m² basis (graph: grassbank m2). It appears that all grass seed added in Oct. 1994 had either lost viability, been eaten, or washed away. It is also clear that revegetation of the bare areas under natural conditions ^{will} be extremely slow ~~and difficult if not impossible~~, as there are clearly very few natural seeds present in the bare soil interspaces. In addition, the few seeds that are present would be subject to the extreme conditions in the field (and would not be watered daily as in our study) and no doubt suffer a high rate of mortality leaving the final seedling establishment rate at nearly zero.

without
active management

Grasses in "all soil" areas: Soil samples from the "all soil" samples (a mixture of bare and litter areas) seem to contain a slightly larger seed bank as a result of the added grass seed despite the fact that grass seed was ^{to cv} ~~only sowed in tree interspaces (bare soil) and not in litter areas.~~ The higher germination rates in these areas must be from grass seed blowing or washing into litter areas from ^{litter seed} ~~seeded~~ areas. In the litter, seeds may be more protected from the environmental extremes as well as predation by ants and other organisms.

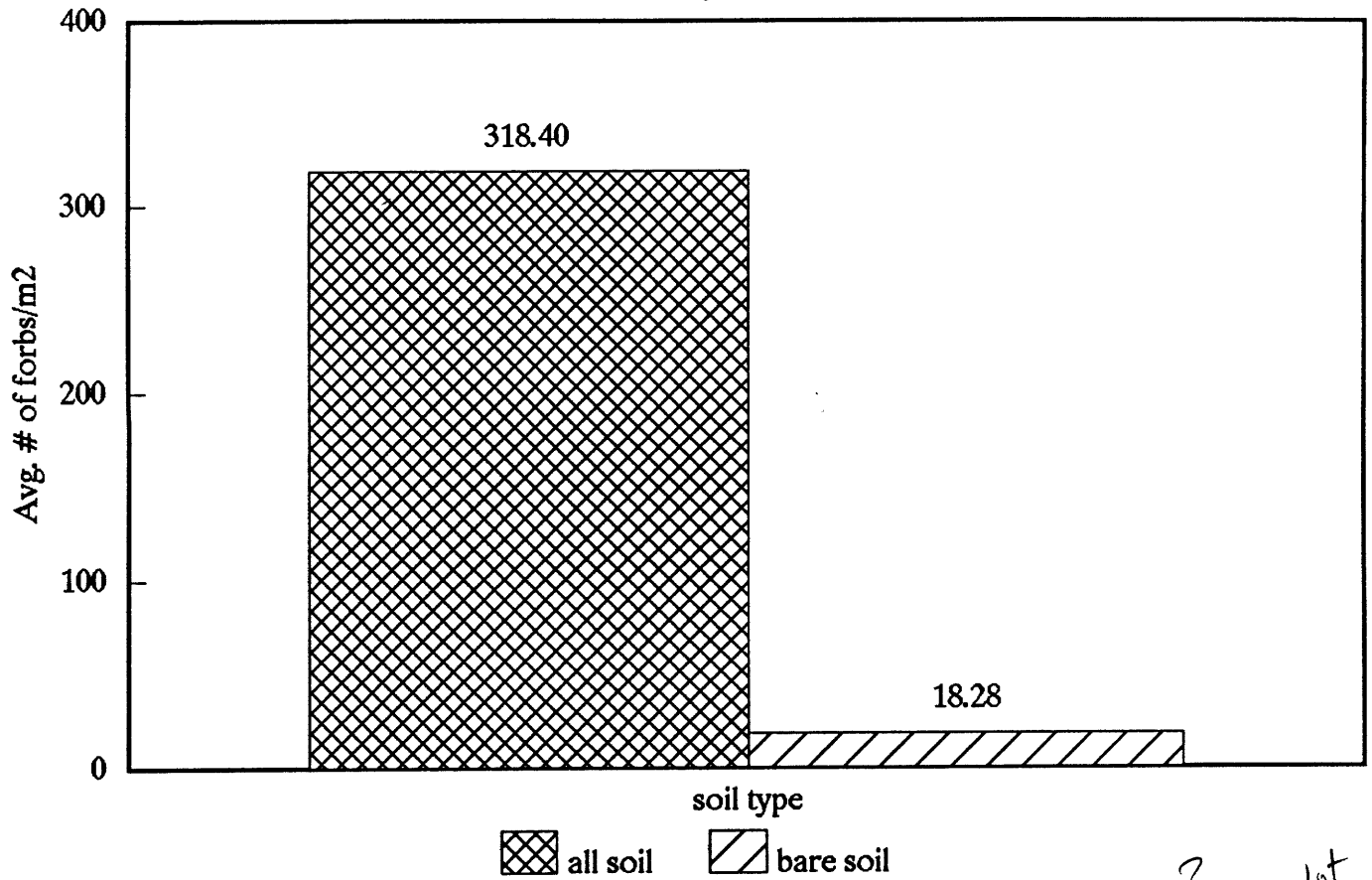
better ^{preservation} ~~protection~~ of seed by litter and from storage

Average # of Grasses/m2 – Restoration Site 1 (Frijoles Mesa)
Results from May 1995 Seed Bank Study



file: dave\seedtest\seedban1.wk3
Graph: grassbank m2

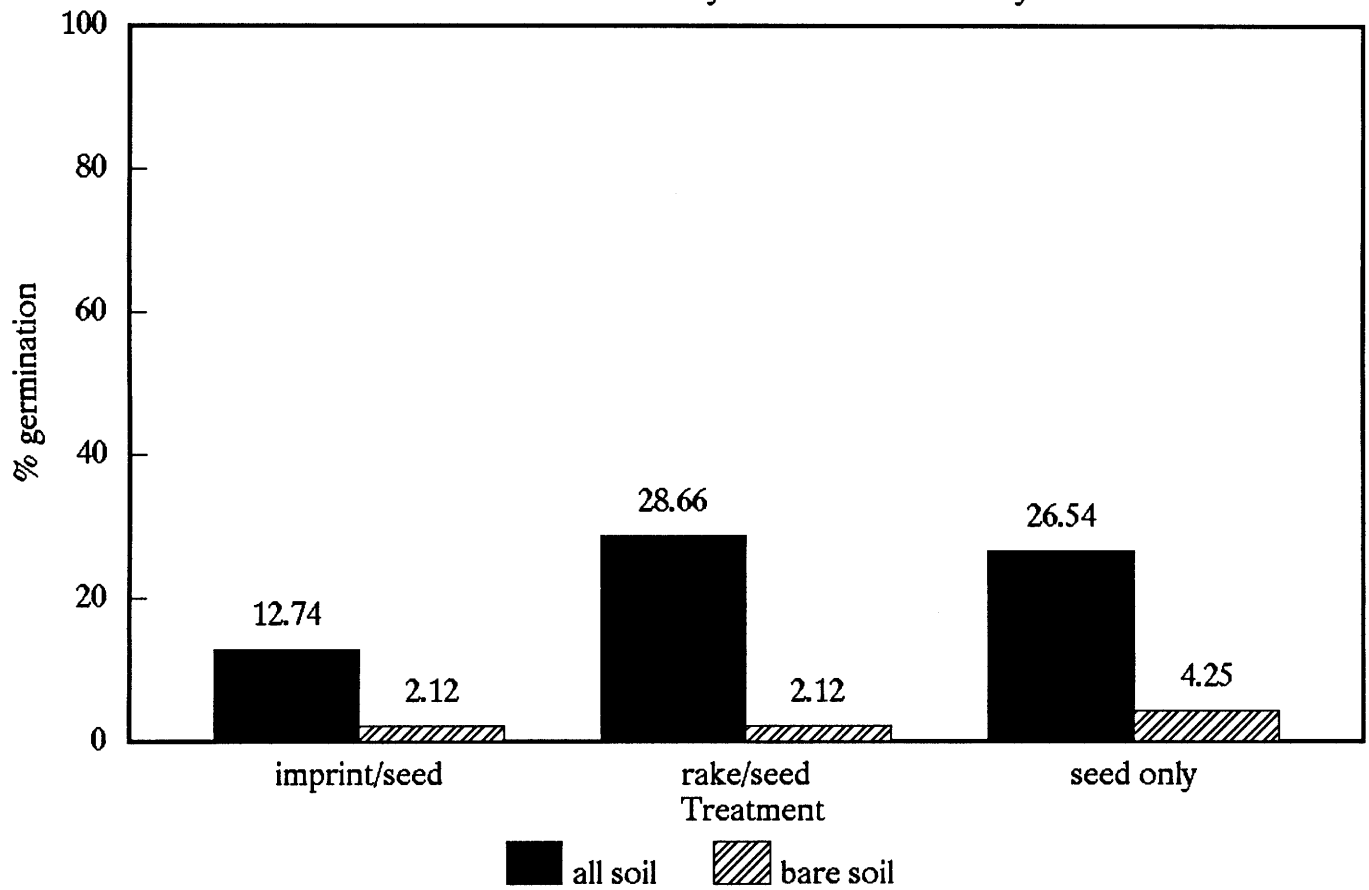
Average # of Forbs/m² – Restoration Site 1 (Frijoles Mesa)
Results from May 1995 Seed Bank Study



file: dave\seedtest\seedban1.wk3
Graph: avg. forbbank

Add total phab sample ?
@ 336.68/seeds/plot

Percent Grass Germination in plots seeded Oct. '94 – Res. Site 1
Results from May 1995 Seed Bank Study



file: dave\seedtest\seedban1.wk3
graph: %grassbank '94

Results of Seed Bank Tests For Restoration Site #1
 Site was seeded Oct. 1994
 Soil collected May 16 and 17, 1995
 Soil was stored in a fridge
 soil was then set in flats
 Final results were recorded August 18, 1995

NOTE: "all soil" = soil collected randomly from bare and litter
 (4 samples/plot. each sample = 6" dia, 2" depth)
 "bare soil" = soil collected randomly from bare soil (a)
 (2 samples/plot. each sample = 6" dia., 2" depth)
 The "bare soil" was collected since seeds had only been
 in bare areas the previous Oct. 1994. The "correc. 2x"
 the fact that sample size from bare areas was half the
 so results from bare soil areas have been doubled.

treatment	plot#	grass seedlings				other weeds			
		all soil	bare soil	correc.2x		all soil	bare soil	correc.2x	
control	10	0				6			
control	20	2				40			
control	30	1				10			
imprint o	11	3				14			
imprint o	24	2				10			
imprint o	32	0				5			
slash onl	12	1				27			
slash onl	25	2				86			
slash onl	31	1				3			
imprint/s	13	8	1	2		36	1	2	
imprint/s	22	2	0	0		24	3	6	
imprint/s	34	2	missing	missing		29	missing	missing	
rake/seed	14	9	1	2		7	0	0	
rake/seed	23	4	0	0		20	0	0	
rake/seed	35	14	0	0		11	0	0	
seed only	15	3	0	0		10	0	0	
seed only	21	3	0	0		13	2	4	
seed only	33	19	2	4		67	0	0	

notes: forbs appear to be mostly fleor golden aster (chvi)

? I thought a lot of them
 were Erigeron flagellans ?

treatment	avg # grass seedling/sample		avg # forb seedling/sample	
	all soil	bare soil	all soil	bare soil x2
control	1.000		18.667	
imprint o	1.667		9.667	
slash onl	1.333		38.667	
imprint/s	4.000	0.667	29.667	2.667
rake/seed	9.000	0.667	12.667	0.000
seed only	8.333	1.333	30.000	1.333

Given the desired seeding rate in Oct. 1994 was about 40 live seeds/ft²
 (Conversion to metric: 40 seed/ft² x 10.76 ft²/m² = 430 seed/m²)
 and the soil area collected is roughly 6" dia. x 4 samples = 113.04" sam
 (Conversion to metric: 113.04" sq x 6.452/10000 = 0.072933 m² sampled)
 then 430 live seeds/m² x 0.072933 m²/sample = 31.4 seedlings/sample expe
 BUT ONLY IN SEEDED PLOTS!

plants/m² = avg # plants/sample divided by 0.072933 m²/sample
 % germination/trt=avg seedling/sample divided by 31.4 seedling expected/

# of grasses/m ²			% germin. grass/trt		
treatment	all soil	bare soil	treatment	all soil	bare soil
control	13.71		imprint/s	12.74	2.12
imprint o	22.85		rake/seed	28.66	2.12
slash onl	18.28		seed only	26.54	4.25
imprint/s	54.84	9.14			
rake/seed	123.40	9.14			
seed only	114.26	18.28			

Graph: grassbank m2
 file: dave\seedtest\seedban1.wk3

Graph: %grassbank '94

	# of forbs/m2	
treatment	all soil	bare soil
control	255.94	
imprint o	132.54	
slash onl	530.17	
imprint/s	406.77	36.56
rake/seed	173.68	0.00
seed only	411.34	18.28

	avg # of forbs/m2	
	all soil	bare soil
soil type	318.40	18.28

Graph: avg. forbbank

(NO GRAPH FOR THE ABOVE)

file: dave\seedtest\seedban1.wk3

Seed Bank Study - Restoration Site 1 (Frijoles Mesa)
7 Days Post Seeding
August 1995

Objective:

To study the seed bank of restoration site 1 seven days after sowing native grass seeds. Specifically, how does harvester ant predation and ^{for} other factors reduce the amount of seed?

Methods:

1) Native grasses were seeded on July 18 and 19, 1995 at 1291 live seeds per meter. The mix was as follows:

- a) 50% Bouteloua gracilis (blue grama)
- b) 30% Andropogon scoparius (little bluestem)
- c) 20% Sporobolus crytandrus (sand dropseed)

See the project report or Brian Jacobs for more information on treatments, seeding, etc...

2) Soil surface samples were collected on July 26, 1995 using the following method:

- a) 2 samples per plot were collected.
- b) Sample collection points were randomly located.
- c) A sample equals ^{23.3}11.65 x 16.65 cm (approximately one half of a picture frame used for quadrat data collection). Soil was collected to a depth of 1.5 to 2". (Total area sampled per plot = 23.3 x 33.3 cm).
- d) Samples were taken without regard to the soil surface (bare vs. litter areas) since seeds were distributed evenly over all areas.
- e) Only 4 plots were sampled as the idea was to get an indication of the trend on the plots and not do a definitive study. That is, had the ants taken a large amount of seed?

3) Soil Sample preparation:

a) Soil samples were mixed well and placed in a cool place until the following day.

b) 6-pack planting trays were prepared as follows:

i) 1st layer or 25% of tray (tray bottom): a thin layer of sand.

ii) 2nd layer (next 50% of tray): soil from areas adjacent to res. site 1 (minus any rocks, roots etc...)

iii) Final layer: soil samples from the site. Soil was spread 1/4" deep in the trays (+ or - 1/4").

iiii) NOTE: The number of 6-pack trays used per plot varied. This was not considered important as the surface area collected per plot was the same (where the majority of seed would be located) while the depth of the soil collected may have varied thus changing the soil volume in the sample. The idea was to spread the sample thin enough so seeds could germinate.

4) Samples were watered daily.

5) On 8/3/95 (8 days post collection) a very thin layer of potting soil was added to the tops of all samples to decrease drying out between waterings and ~~decrease~~ *minimize* differences between samples with organic material (samples collected in litter areas) vs. samples with no organic material (samples from bare soil areas).

varying amounts of

Expected Results:

Total area sampled per plot = 23.3 x 33.3 cm or .077589 m².

Seeding rate = 1291 live seeds/m².

Expected seed germination: .077589m² X 1291 live seeds/m² =
100 seedlings expected

Results:

Treatment/Plot	Avg.# of seedlings/m2	% germination per trt.
Rake/seed (plot 14)	116	9 %
Broadcast seed (21)	270.6	21 %
No seed (slash only) (31)	116	N/A
Imprint/seed (34)	116	9 %

N/A - not applicable. Cannot be calculated since no seed was added and the original seed base is unknown.

SEE THE ATTACHED GRAPH: GERMR1-7DAY.

Discussion:

ANT PREDATION (AND POTENTIALLY OTHER FACTORS) HAVE RESULTED IN A GREATER THAN 79% REDUCTION IN THE SEED BANK WITHIN 7 DAYS OF SEEDING RESTORATION SITE 1.

It is clear that the ants had a significant predatory impact on the distributed seed. Given that there was no rain or other significant weather events inbetween seeding and soil sample collection (i.e. the seed did not wash or blow away) the ants (or potentially other predators such as birds) removed at least 80% of the distributed seed with in 7 days. Considering we seeded at 1291 live seeds/m2 or nearly 300,000 seeds per plot the ants (or other predators have stole (!) over 240,000 seeds/seeded plot.

this can't be right

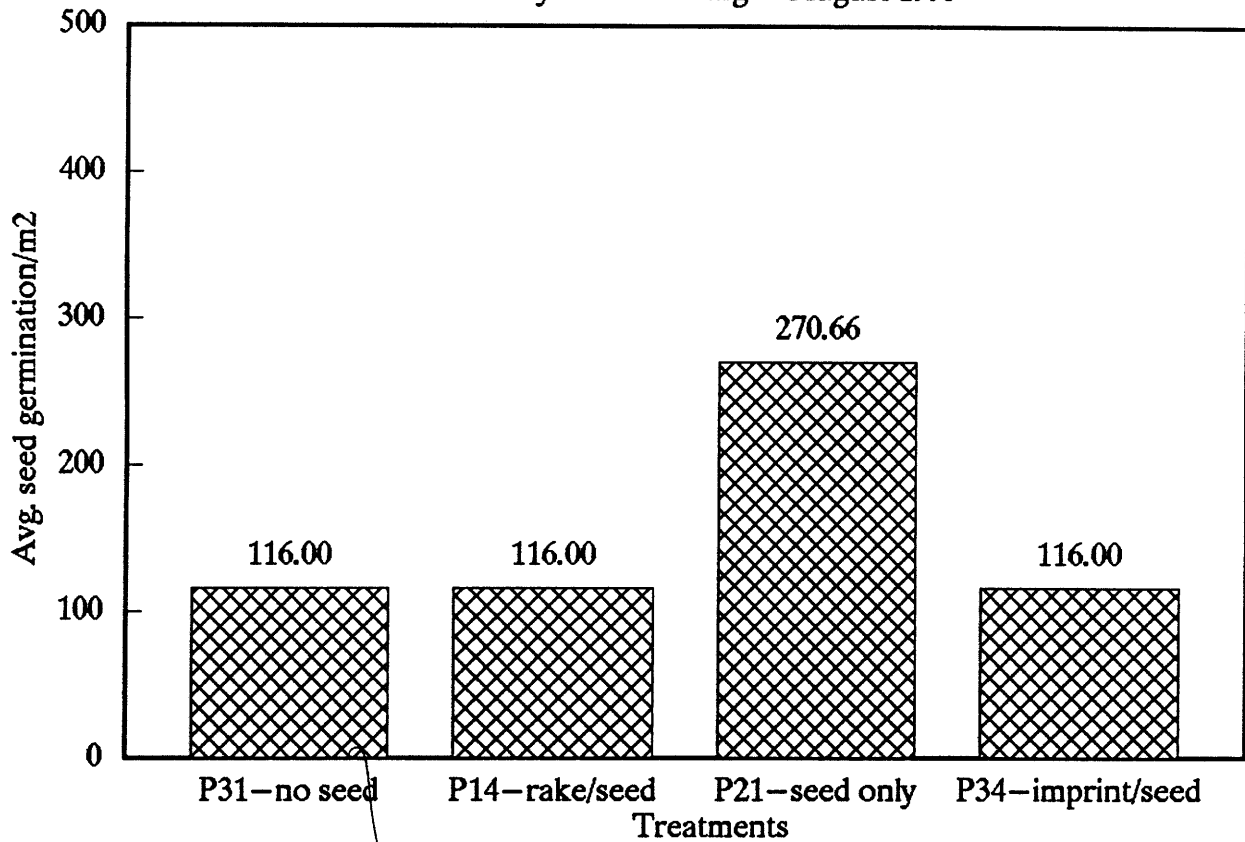
The results also show the plot which was not seeded (plot 31) had as many germinates as the rake/seeded plot (plot 14) and the imprint/seeded plot (#34). Also contrary to expectations the broadcast seeded plot (#21) had nearly double the germinates of all the other plots (it was expected that the rake plots may offer some protection for the seeds thus resulting in a higher germination rate vs. broadcast seeded plots in which the seeds are left on the soil surface). One should interpret these results with the following warnings:

where did this come from?
Also @ 3 116 counts
seems suspicious
Did something get mixed up here?

1) Only 2 soil samples were collected per plot and the total area collected was small. Larger samples and more replicates should have been collected.

2) The number of germinates is so small and the variability potentially so large that the final results should be taken as general trends only in terms of seed loss due to ant predation of other factors. This data should probably not be used to suggest differences between plots.

Average Grass Germination per m² – Res. Site 1 (Frijoles Mesa)
7 Days Post Seeding – August 1995

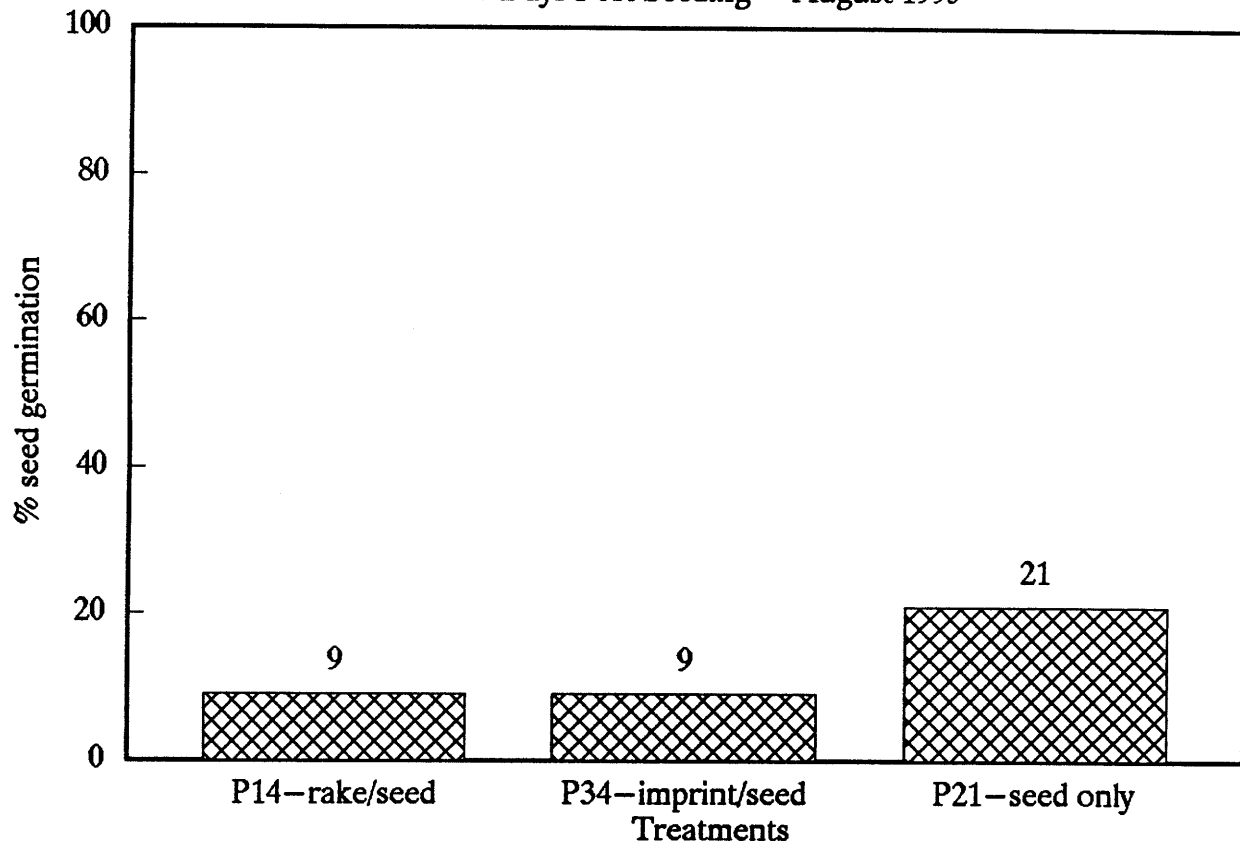


dave\seedtest\germr1.wk3
graph: m2 germr1-7day

- this can't be right based on everything else we've seen -
- too many 116's - was this data all from Sam F. ?
- is there any possibility of contamination of the now-seeded flat from
 - 1) accidental seeding -
 - 2) potting soil
 - 3) sample waddy plot -

Aside from ~~AAAAA~~ illustrating a high level of seed predation - this particular experiment seems pretty ~~much~~ suspect.

Percent Grass Germination – Seeded Plots – Res. Site 1 (Frijoles Mesa)
7 Days Post Seeding – August 1995



dave\seedtest\germr1.wk3
graph: %germr1-7day

Restoration Site 1 - Grass Seed Germination Data from
soil samples taken 7 days post seeding

Date seeded: 7/18 and 7/19, 1995

soil samples collected: 7/26

Expected germination based on soil area collected: 100

	Total Seed Germination by plot			
date	P14-rake/	P21-seed	P31-no se	P34-inprint/seed
7/26	0	0	0	0
8/4	2	4	0	0
8/17	4	14	2	6
8/25	6	16	3	7
9/8	9	21	9	9
9/22	9	21	9	9

Note: since expected # of seedlings=100 the following is
absolute and % germination.

(though % germination cannot be calculated for
P31 (slash only - no seed)).

Total germination data for graphing purposes:

P31-no se	9
P14-rake/	9
P21-seed	21
P34-impri	9

Germination per m2 (=total germination per sample/.077589 m2
per sample):

P31-no se	116.00
P14-rake/	116.00
P21-seed	270.66
P34-impri	116.00

graph: m2 germR1-7day

Percent germination data of seeded plots for graphing purposes:
(% germ. = total germination/100 expected*100)

P14-rake/	9
P34-impri	9
P21-seed	21

graph: %germr1-7day

file: dave\seedtest\germr1.wk3

Seed Bank Study - Restoration Site 1 (Frijoles Mesa)
21 Days Post Seeding
August 1995

Objective:

To study the grass seed bank of restoration site 1 21 days after sowing native grass seeds. Specifically, how does ant predation and other factors reduce the seed pool?

Methods:

- 1) Native grasses were seeded on July 18 and 19, 1995. See write up on 7 Day post seeding soil bank study for more information.
- 2) Soil surface samples were collected on August 10, 1995 using the following method (NOTE: this method is somewhat improved from the method used in the 7 Day Post Seeding seed bank study):
 - a) 4 samples per plot were collected.
 - b) Each sample collection point was located 7.5 meters down the side of the plot and 4 meters into the center.
 - c) A sample equals 23.3 x 33.3 cm (one picture frame used for quadrat data collection). Soil was collected to a depth of 1 to 1.5".
 - d) Unlike the 7 Day seed bank study, in which samples were taken without regard to the soil surface, samples were preferentially taken from bare soil areas since these are the areas we wish to revegetate and so samples would have approximately the same amount of organic material present.
 - e) 5 plots were sampled.
- 3) Soil Sample preparation:

Soil samples were prepared as previously noted in the 7 Day Post Seeding seed bank study. See that write-up for more information.
- 4) Samples were watered daily.

ADDITIONAL PREPARATION PROCEDURES FOR THIS SEED BANK STUDY:

- 5) All 6-pack planting trays were topped with a thin layer of potting soil to prevent drying out between waterings.
- 6) Soil samples were split between a sun and a 30% shade treatment to establish the effect of a moderated environment on the germination and establishment of the grasses.

Expected Results:

Sample size per sampling point = 23.3x33.3cm or .077589 m2.

Total area sampled per plot = .077589 m2 x 4 sampling points/plot = .310356 m2.

Seeding rate = 1291 live seeds/m2.

Expected seed germination: 0.310356 m2 X 1291 live seeds/m2 = 401 seedlings expected in samples from seeded plots.

5455

Results:

No trends were noted in germination rates differences between the sun and shade treatments. Some samples had higher germination in the sun compared to their shade counterparts while other samples had the opposite effect, ~~conclusion~~. Due to this lack of trends the germination counts from the sun and shade treatments were combined to give the total germination count.

Treatment - Plot #	⁵⁴⁵⁵ Average Germin. per m2	% Germination per treatment
Broadcast seed - # 21	70	5.73
Imprint/seed - # 22	106	8.23
Rake/seed - #23	109.5	8.48
Imprint/no seed - #24	0	N/A
Slash only (no seed) # 25	6.44	N/A

N/A - not applicable. Cannot be calculated since no seed was added and the original seed base is not known.

SEE THE ATTACHED GRAPH.

Discussion:

big - huge loss of seed factors due to predation or other factors

The overall trend first noted in the 7 Day Post Seeding seed bank study (see previous study) has continued at 21 days. The maximum overall germination (under highly favorable conditions of daily watering) has dropped from 21% to 8.48 % supporting the idea that the ants had (and continue to have) a significant predatory impact on the distributed seed. Given that there was no rain between seeding and soil sample collection (i.e. the seed did not wash away) the ants (or potentially other predators such as birds) removed at least 91 % of the distributed seed with in 21 days.

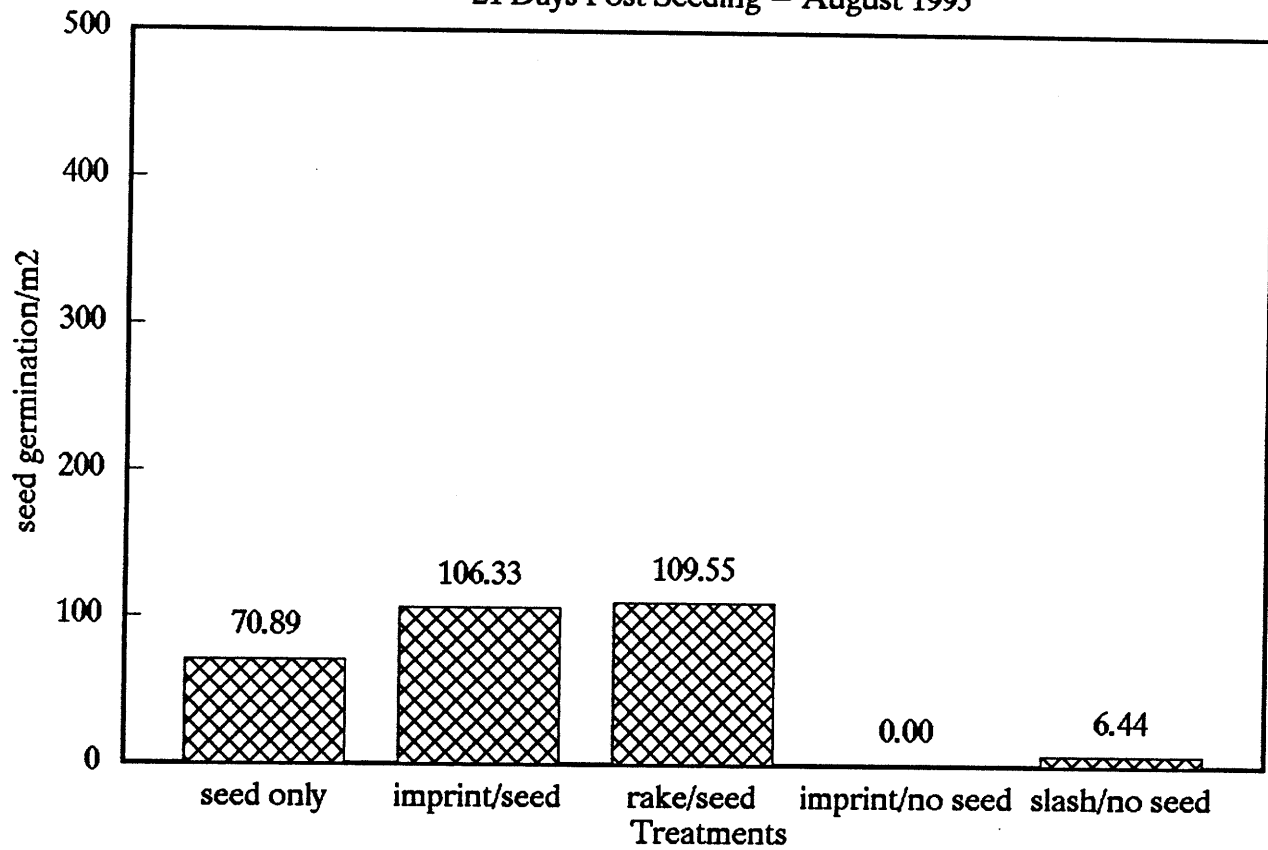
The results of this study are also much more consistent with expectations of seeding treatment vs. germination. That is, those plots with no seed added had no grass seed germination while those plots with the most intensive seeding method (raking or imprinting) had the highest germination success. The broadcast seeded plot was in the middle of these two extremes. Nevertheless, the differences between plots is extremely small (as is the overall germination success) and the slightly higher success rate of raked or imprinted plots is certainly not enough to endorse these labor intensive methods where ant populations are high.

As noted in the previous study one should interpret these results with the following warnings:

- 1) Only 4 soil samples were collected per plot and the total area collected was small. While these samples were 4 times larger than the previous study there was no replication.
- 2) The number of germinates is so small and the variability potentially so large that the final results **should be taken as general trends only**. This data should probably not be used to suggest differences between plots. What is the general trend?

AS NOTED IN THE PREVIOUS STUDY (7 DAY POST SEEDING SEED BANK STUDY) ANT PREDATION (AND POTENTIALLY OTHER FACTORS) HAVE RESULTED IN A GREATER THAN 91% REDUCTION IN THE SEED BANK WITHIN 21 DAYS OF SEEDING RESTORATION SITE 1.

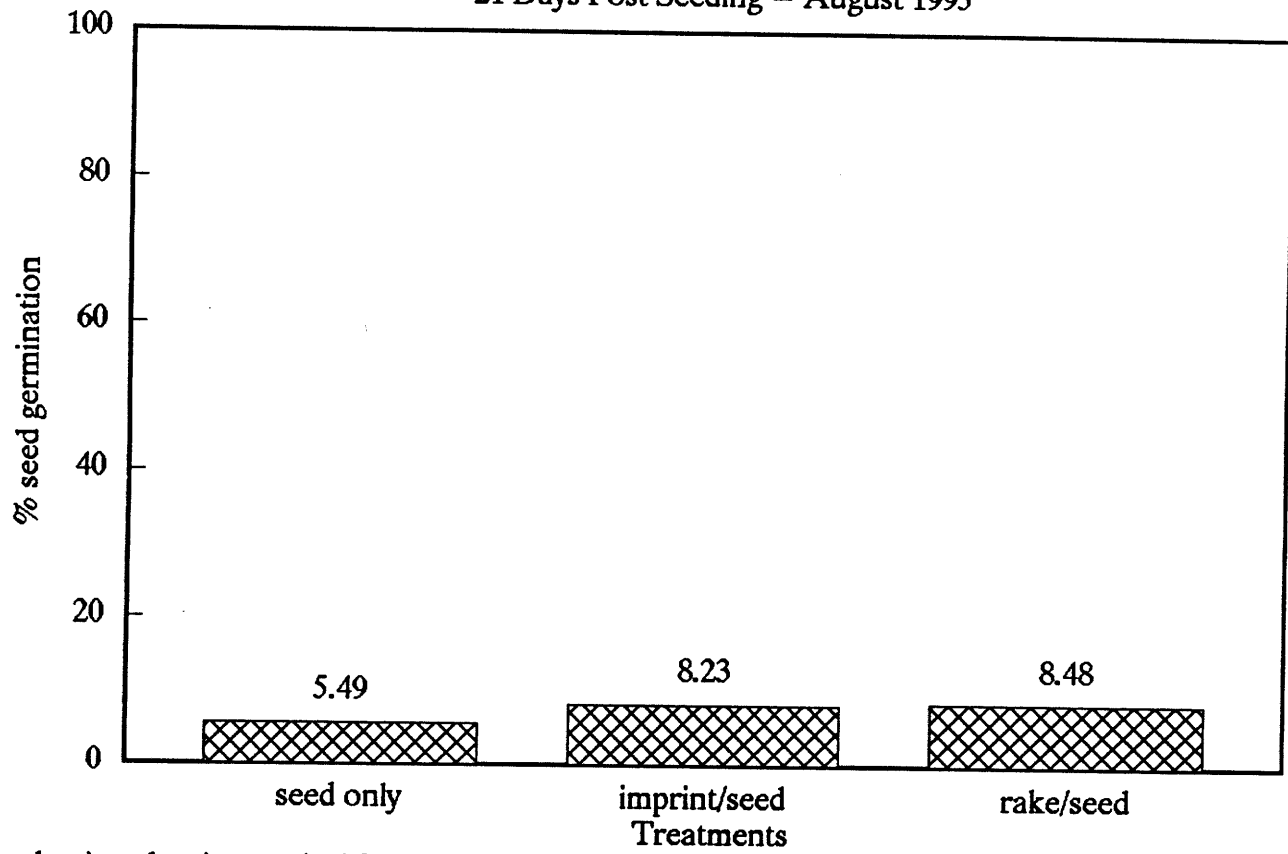
Grass Germination/m2 in All Treatments – Res. Site 1
21 Days Post Seeding – August 1995



dave\seedtest\germr1.wk3
graph: m2 germr1-21day

This looks more like what you
would expect to see —

Percent Grass Germination in Seeded Treatments – Res. Site 1
21 Days Post Seeding – August 1995



dave\seedtest\germr1.wk3
graph: %germr1-21day

Restoration Site 1 - Grass Seed Germination Data from
soil samples taken 21 days post seeding

Date seeded: 7/18 and 7/19, 1995

soil samples collected: 8/10/95

Expected germination based on soil area collected: 401

(area sampled = $23.3 \times 33.3 \text{ cm} / 10000 = .077589 \text{ m}^2$ and

$.077589 \text{ m}^2 \times 4 \text{ samples/plot} = .310356 \text{ m}^2/\text{sample}$

finally $.310356 \text{ m}^2/\text{sample} \times 1291 \text{ seeds/m}^2 = 401 \text{ seedlings expected/sample}$

The following is the raw data from the soil samples

Note that the samples were split into sun and shade treatments, however
since no definitive trend was found for sun vs. shade (for example
more germination in the shade) the two samples were combined (below).

	Plot 21 sun	Plot 21 shade	Plot 22 sun	Plot 22 shade	Plot 23 sun	Plot 23 shade	Plot 24 sun	Plot 24 shade	Plot 25 sun	Plot 25 shade	
	seed only	seed only	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	seed
8/11	0	0	0	0	0	0	0	0	0	0	0
8/21	2	14	13	8	8	11	0	0	0	0	0
8/25	2	14	14	7	10	11	0	0	0	0	1
8/28	3	17	18	12	14	14	0	0	0	0	1
9/1	5	15	18	9	14	15	0	0	0	0	1
9/8	5	18	18	13	15	16	0	0	0	0	1
9/22	5	17	18	15	16	18	0	0	0	0	2

The following is the combined totals of sun and shade:
Total germination:

	Plot 21 seed only	Plot 22 imprint/srake/seed	Plot 23 imprint/srake/seed	Plot 24 imprint/srake/seed	Plot 25 imprint/srake/seed	
8/11	0	0	0	0	0	0
8/21	16	21	19	0	0	0
8/25	16	21	21	0	1	1
8/28	20	30	28	0	1	1
9/1	20	27	29	0	1	1
9/8	23	31	31	0	1	1
9/22	22	33	34	0	2	2

Final Germination in all plots (total #):

	seed only	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	imprint/srake/seed	
All Treat	22	33	34	0	2	2

Final germination per m2 per treatment:
(= total germination per sample/.310356 m2 per sample)

seed only 70.89
imprint/s 106.33
rake/seed 109.55
imprint/n 0.00
slash/no 6.44

graph: m2 germR1-21day

Percent seed germination for seeded plots only.
Since expected = 401 then % germ. = total/401 * 100

seed only 5.49
imprint/s 8.23
rake/seed 8.48

graph: %germR1-21day

file: dave\seedtest\germr1.wk3

Native Grass Seed Germination on Restoration Site 1
(Frijoles Mesa) 3 Months post seeding
Results from the Quadrat Data Collection
October 1995

Objective:

To study germination success on Restoration site 1 (Frijoles Mesa) 3 months post seeding with native grass seeds.

Methods:

1) Native grasses were seeded on July 18 and 19, 1995 at 1291 live seeds per meter. The mix was as follows:

- a) 50% Bouteloua gracilis (blue grama)
- b) 30% Andropogon scoparius (little bluestem)
- c) 20% Sporobolus crytandrus (sand dropseed)

See the project report or Brian Jacobs for more information on treatments, seeding, etc...

2) As per the standard operating procedure for the project, meter tapes were laid out on the diagonal (forming an X across the plot). Transect and quadrat data were collected along the meter tape. Quadrat data was collected with the following protocol:

- a) Meter tapes were laid out from N to S and E to W.
- b) Data (transect and quadrat) was collected on the right side of the meter tape as it goes from 0 meters to 2121 meters (that is, from N to S or from E to W).
- c) Quadrats were taken at 1, 5, 9, 12, 16, and 20 meters on both transects for a total of 12 quadrats/plot.
- d) The picture frame used for quadrats (23.3 x 33.3 cm interior) was laid with the short end flush with the tape.
- e) Seedlings were counted within each quadrat (in addition cover estimates and density data was were also collected but are not presented here).

Expected Results:

Total area per quadrat = 23.3 x 33.3 cm or .077589 m².

0.077589 m²/quadrat x 12 quadrats/plot = .931068 m² sampled/plot.

Seeding rate = 1291 live seeds/m².

Expected seed germination: .931068 m² X 1291 live seeds/m² =
1202 seedlings expected!!!

Results:

The average seedling count per treatment and the average percent germination per treatment is presented below. Also SEE THE ATTACHED GRAPH.

Treatment	Average # seedlings /m ²	Average % germination /treatment
control	0	N/A
imprint/no seed	0.35	N/A
no seed	0	N/A
imprint/seed	43.7	3.38
rake/seed	29.4	2.27
broadcast seed	28.6	2.22

N/A - not applicable. Cannot be calculated as a % since base figure (the natural seedbank) is unknown.

Discussion:

The overall trend first noted in the 7 and 21 Day Post Seeding seed bank studies has continued. The maximum overall germination has dropped from 21 % and 13.6 % respectively in the previous studies to a measly 3.3% in the plots after 3 months. It is clear from the previous 2 studies that the ants had a major impact in reducing the seed available for germination and establishment. Additional factors such as desiccation, additional predation, trampling (by humans and animals), and other causes has further reduced this low germination rate to almost nothing.

Overall, the differences between the seeding treatments is so small that it is highly doubtful there are any significant differences between the treatments. It is also doubtful that, at restoration site 1, the more labor intensive treatments are worth the time and effort.

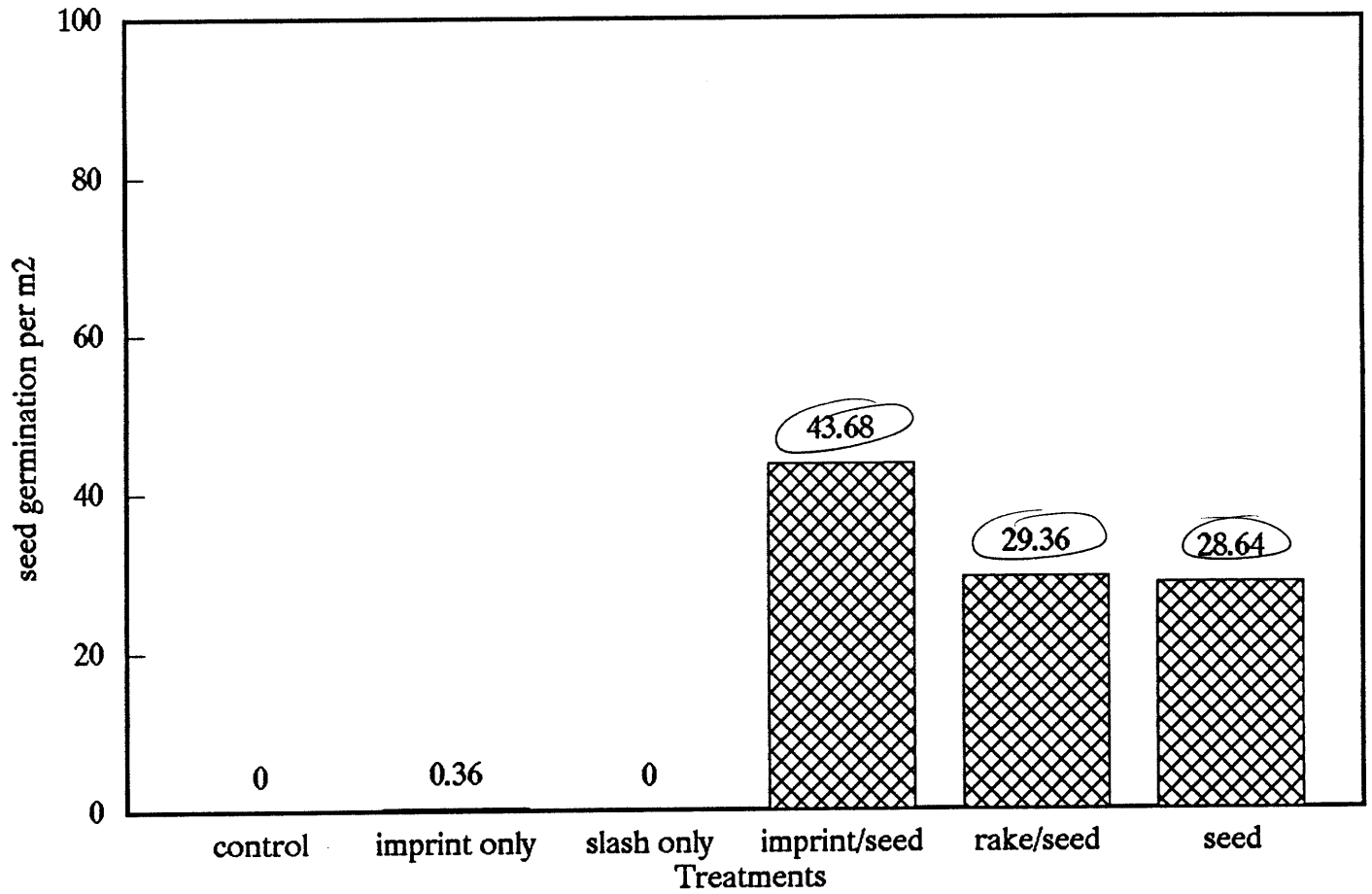
The extremely poor germination success just within the 3 month time period also, at first glance, does not seem to bode well for applying any seeds to these sites. This is especially true if one considers the additional mortality which will certainly occur within the next year. However, one must remember that the seeding rate of 1291 live seeds per meter is extremely high (3 to 4 times the recommended seeding rate for agricultural fields) so that even a germination and establishment rate of 1% will leave 13 new plants per meter². While not a golf course it is certainly an improvement over the current state of affairs. Ultimately, a cost/benefit analysis will have to be done to determine if 13 new plants per meter² is worth all the expense.

Also, we may need to look at other planting methodologies and not base a final decision on seedling establishment.

RESULTS: ANT PREDATION AND OTHER FACTORS HAVE RESULTED IN A GREATER THAN 96% REDUCTION OF THE ADDED GRASS SEED WITHIN 3 MONTHS OF SEEDING RESTORATION SITE 1.

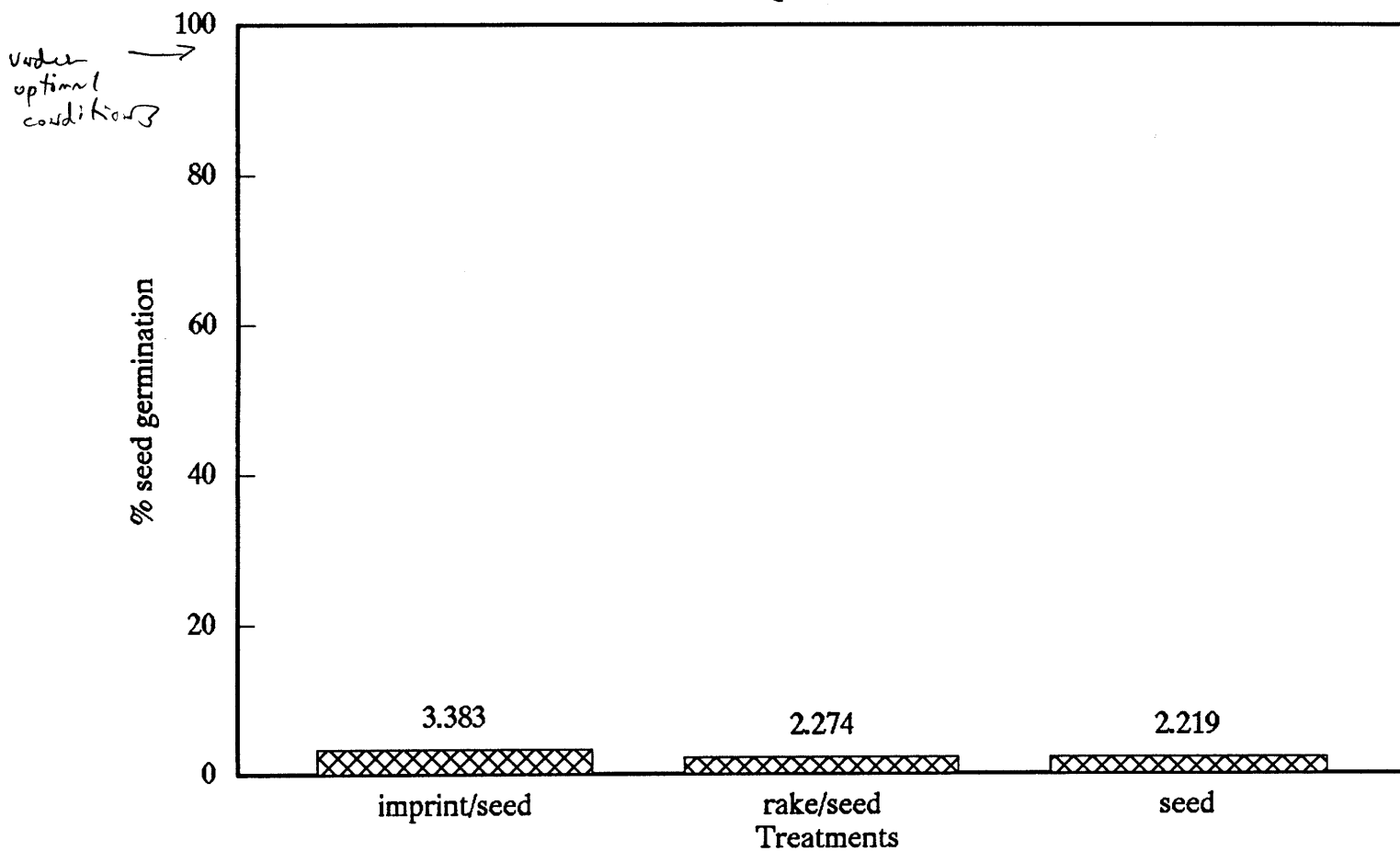
Considering site conditions I think this is actually a pretty significant achievement —

Total Seed Germination on Restoration Site 1 (Frijoles Mesa)
Data from Quadrats – Oct. 1995



dave\seedtest\res1quad.wk3
filgraph: # germR1-quad

Percent Seed Germination on Restoration Site 1 (Frijoles Mesa)
Data from Quadrats - Oct. 1995



dave\seedtest\res1quad.wk3
filgraph: % germR1-quad

Grass Seed Germination Data from the Quadrats
at Restoration Site 1 - Frijoles Mesa
Oct. 1995 Arranged by Treatment

Sample size is 12 picture frames per plot
1 picture frame = 23.3x33.3 cm or .077589 m2
.077589 x 12 frames/plot = .931068 m2
.931068m2 x 1291 live seeds/m2 = 1202 seedlings EXPECTED!

Treatment	Plot #	Seedling count	Avg. Coun /trt.	% germ. /trt.
control	10	0	0	n/a
	20	0		
	30	0		
imprint o	11	1	0.333333	n/a
	24	0		
	32	0		
slash onl (no seed)	12	0	0	n/a
	25	0		
	31	0		
imprint/s	13	29	40.66667	3.38325
	22	46		
	34	47		
rake/seed	14	34	27.33333	2.273988
	23	12		
	35	36		
broadcast seed	15	13	26.66667	2.218525
	21	20		
	33	47		

Following is a summary of the above data
for graphing purposes:

Average grass germination/m2/trt:
seedlings/m2

control	0
imprint o	0.36
slash onl	0
imprint/s	43.68
rake/seed	29.36
seed	28.64

graph: # germr1-quad

	% Germination/treatment
imprint/s	3.383
rake/seed	2.274
seed	2.219

file: dave\seedtest\res1quad.wk3
graph: % germR1-quad

Seed Bank Study - Restoration Site 3 (Guaje Mesa)
8 Days Post Seeding
August 1995

Objective:

To study the seed bank 8 days after seeding the site with native grass seeds. Specifically, how does ant predation and other factors reduce potential seed germination?

Methods:

1) Native grasses were seeded on July 31, 1995 following methods used for Res. site 1 (Frijoles Mesa). See write up on Res. site 1, 7 and 21 Day post seeding soil bank study for more information.

2) Soil surface samples were collected on August 8, 1995 using the same methods detailed in the Res. site 1, 21 Day post seeding seed bank study. See that write up for more information.

Expected Results:

Sample size per sampling point = 23.3×33.3 cm or .077589 m².

Total area sampled per plot = .077589 m² x 4 sampling points/plot = .310356 m².

Seeding rate = 1291 live seeds/m².

Expected seed germination: $0.310356 \text{ m}^2 \times 1291 \text{ live seeds/m}^2$
= 401 seedlings expected per sample in seeded plots.

Results:

No major trends were noted in germination rates/ differences between the sun and shade treatments. There was a slight tendency to have higher germination in full sunlight but it was felt the differences were not large enough to suspect skewing of the data due to growing conditions. Thus, germination counts from the sun and shade treatments were combined to give the total germination count.

Plot # Treatment	average germination/m2	% germination per trt.
21 No seed	6.44	N/A
25 imprint only	16.11	N/A
23 seed only	54.78	4.24
24 imprint/seed	257.77	19.95
25 rake/seed	415.65	32.17

N/A - not applicable. Cannot be calculated since original seed base is unknown.

SEE THE ATTACHED GRAPH.

Discussion:

The data suggest that raking and imprinting may have some positive effect in protecting and promoting germination. Raked plots averaged 32.17% germination compared to 19.95% for imprinted plots, only 4.24% for "seed only" plots and nearly 0% germination for non-seeded treatments.

The absence of ants at this site may have also had a positive effect on the increased seed bank found in our soil samples. Comparatively, site 3 (Guaje) had a 31% greater germination rate than site 1 (Frijoles). On an absolute basis however, the overall germination rate at Guaje was not as great as would be anticipated. At restoration site 1 the soil seed bank germination rate varied from 9% to 21% with an average of 13% on seeded treatments after 7 days. At

*I'm confused
by this
distinction
between a
comparative &
absolute basis
???*

*please
clarify
for me.*

*what is this?
based on?*

restoration site 3 the germination rate varied from 4.24% to a high of 32.17% with an average of 18.8% after 8 days. That is, there is only a 5.8% average difference between sites. There are a number of possible explanations for this none of which will quickly and easily explain the results (read: more tests are needed!):

- 1). Restoration Site 1 (Frijoles Mesa) soil samples taken for the seed bank study 7 days post seeding were very small and may not be representative.

- 2). Restoration Site 1 soil samples were taken from an unknown soil mix - i.e. bare and litter areas. The first seed bank study (May 1995) shows that litter areas typically have more seeds of all types in the seed bank while bare areas are nearly devoid of seeds.

- 3). Restoration site 3 (Guaje) soil samples were taken mainly from bare soil areas and thus may not be strictly comparable to the results of Res. site 1 - 7 day seed bank study.

- 4). At restoration site 3 there was a small rain event (0.1 inches) between seeding and soil sample collection. This may have moved some of the seed into litter areas.

- 5). Seed loss from environmental factors is nearly as great on both sites (i.e. - the data is correct; though the seed losses may come from different factors such as ants on site 1 and ??? on site 3).

In conclusion, the overall average germination rates in both sites was fairly low. This is especially true in site 3 (Guaje) where one would anticipate that the lack of harvester ants would have left a larger potential seed bank. If the data is not biased, it appears the environmental influences (predation, seed movement, etc...) is similar at both sites though potentially greater at restoration site 1 where ant predation may have reduced the seed bank 31% below restoration site 3 seed bank.

Restoration Site 3 (Guaje) - Grass Seed Germination Data from
soil samples taken 8 days post seeding

Date seeded: 7/31/95

Soil samples collected 8/8/95

Expected germination based on soil area collected: 401 seedlings

area collected = $(23.3 \times 33.3 \text{ cm}^2 / \text{sample}) / 10000 \text{ cm}^2 / \text{m}^2 \times 4 \text{ samples} = .310356 \text{ m}^2$

$.310356 \text{ m}^2 / \text{sample} \times 1291 \text{ live seeds} / \text{m}^2 = 401 \text{ seeds} / \text{sample}$

The following is the raw data from the soil samples

Note that the samples were split into sun and shade treatments, however while there is a tendency for more germination in the sun, no major trend was found for sun vs. shade (for example twice as many seeds always germinating in shade) so samples were combined (below)

	Plot 21 sun no seed	P 21 shade no seed	P 22 sun rake/seed	P 22 shade rake/seed	P 23 sun seed only	P 23 shade seed only	P 24 sun imprint/s	P 24 shade imprint/s	P 25 sun imprint/s	P 25 shade imprint/s
8/8	0	0	0	0	0	0	0	0	0	0
8/17	0	1	54	30	5	3	19	22	0	0
8/21	0	2	67	45	7	3	31	29	0	3
8/28	0	2	71	55	8	7	41	37	1	3
9/8	0	3	73	56	7	10	43	36	1	4
9/22	0	2	72	57	7	10	42	38	2	3

The following is the combined (sun+shade) total germination:

	P21-no se	P22-rake/P23-seed	P24-impr	P25-imprint only
8/8	0	0	0	0
8/17	1	84	8	41
8/21	2	112	10	60
8/28	2	126	15	78
9/8	3	129	17	79
9/22	2	129	17	80

Final germination totals (from 9/22):

	P21-no se	P22-rake/P23-seed	P24-impr	P25-imprint only
9/22	2	129	17	80

Final germination per m²/trt. (= total/.310356 m² sampled per plot)

no seed 6.44
imprint o 16.11
seed only 54.78
imprint/s 257.77
rake/seed 415.65

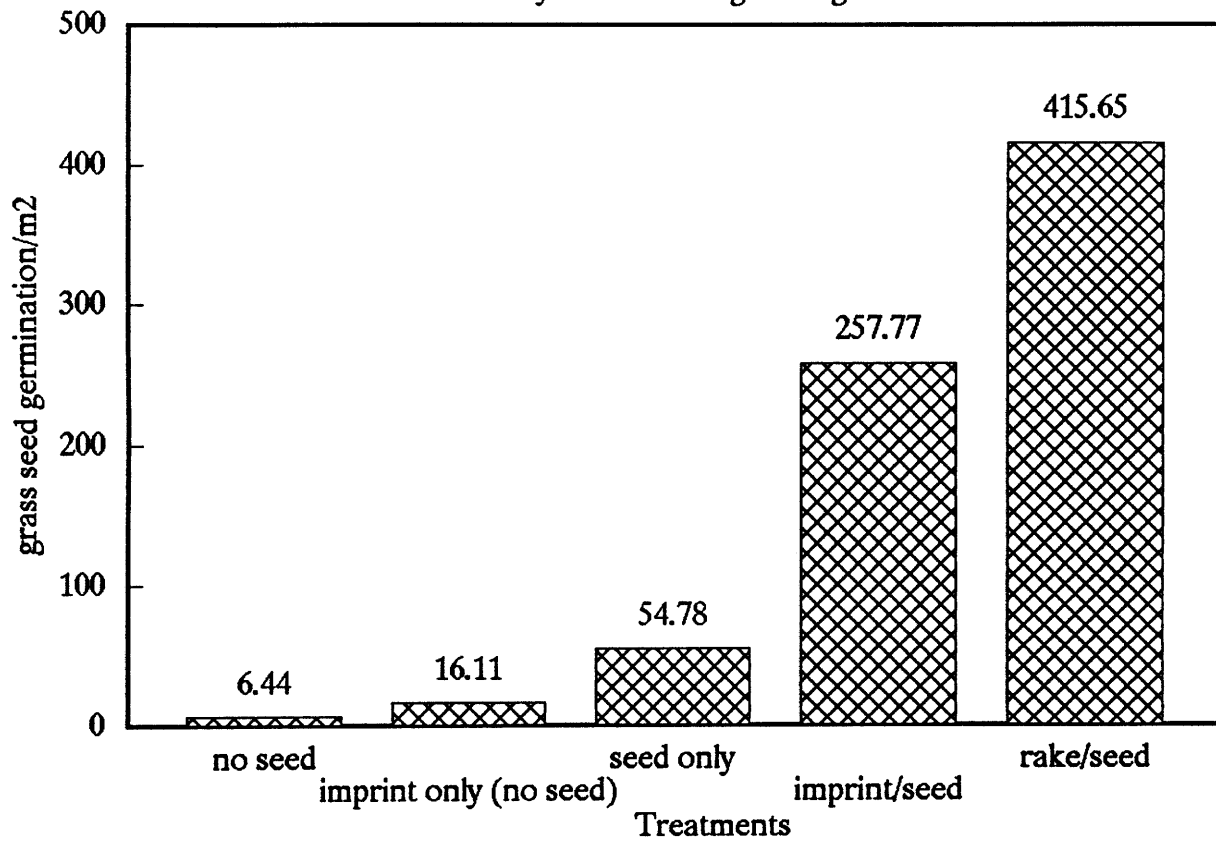
graph: m2 germR3-8day

The following is the combined (total seed germination in both the sun and shade)
expressed as a % of expected germination (Total (sun + shade) Seedling count/401= Percent)

seed only 4.24
imprint/s 19.95
rake/seed 32.17

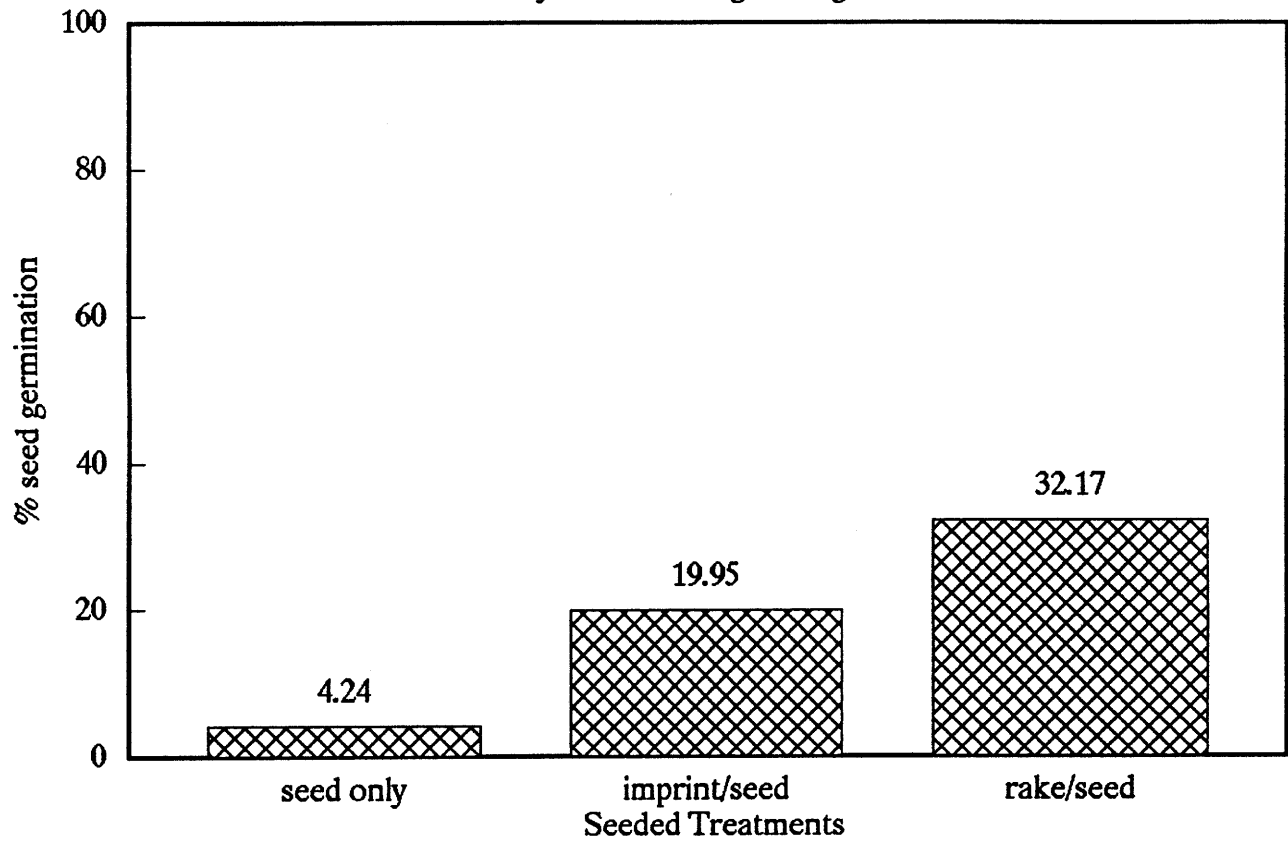
Graph created: % germR3-8days
file: dave\seedtest\germR3.wk3

Grass Germination per m2 – Res. Site 3 (Guaje Mesa)
8 Days Post Seeding – August 1995



file: dave\seedtest\germr3.wk3
graph: m2 germR3–8days

Percent Grass Germination per seeded Trt. — Res. Site 3 (Guaje Mesa)
8 Days Post Seeding — August 1995



file: dave\seedtest\germr3.wk3
graph: % germR3-8days

Native Grass Seed Germination on Restoration Site 3
(Guaaje Mesa) 3 Months post seeding
Results from the Quadrat Data Collection
October 1995

Objective:

To study germination success on Restoration site 3 (Guaaje Mesa) 3 months post seeding with native grass seeds.

Methods:

1) Native grasses were seeded on July 31, 1995 at 1291 live seeds per meter. The mix was as follows:

- a) 50% Bouteloua gracilis (blue grama)
- b) 30% Andropogon scoparius (little bluestem)
- c) 20% Sporobolus crytandrus (sand dropseed)

See the project report or Brian Jacobs for more information on treatments, seeding, etc...

2) As per the standard operating procedure for the project, meter tapes were laid out on the diagonal (forming an X across the plot). Transect and quadrat data were collected along the meter tape. Quadrat data was collected with the following protocol:

- a) Meter tapes were laid out from N to S and E to W.
- b) Data (transect and quadrat) was collected on the right side of the meter tape as it goes from 0 meters to 2121 meters (that is, from N to S or from E to W).
- c) Quadrats were taken at 1, 5, 9, 12, 16, and 20 meters on both transects for a total of 12 quadrats/plot.
- d) The picture frame used for quadrats (23.3 x 33.3 cm interior) was laid with the short end flush with the tape.
- e) Seedlings were counted within each quadrat (in addition cover estimates and density data were also collected but are not presented here).

Expected Results:

Total area per quadrat = 23.3 x 33.3 cm or .077589 m².

0.077589 m²/quadrat x 12 quadrats/plot = .931068 m²
sampled/plot.

Seeding rate = 1291 live seeds/m².

Expected seed germination: .931068 m² X 1291 live seeds/m² =
1202 seedlings expected!!!

Results:

The average seedling count per treatment and the average percent germination per treatment is presented below. Also SEE THE ATTACHED GRAPH.

Treatment	Average # seedlings /m ²	Average % germination /treatment
control	0	N/A
imprint/no seed	0.36	N/A
no seed	0	N/A
imprint/seed	10.74	0.83
rake/seed	99.17	7.68
broadcast seed	12.89	1.00

N/A - not applicable. Cannot be calculated as a % since base figure (the natural seedbank) is unknown.

Discussion:

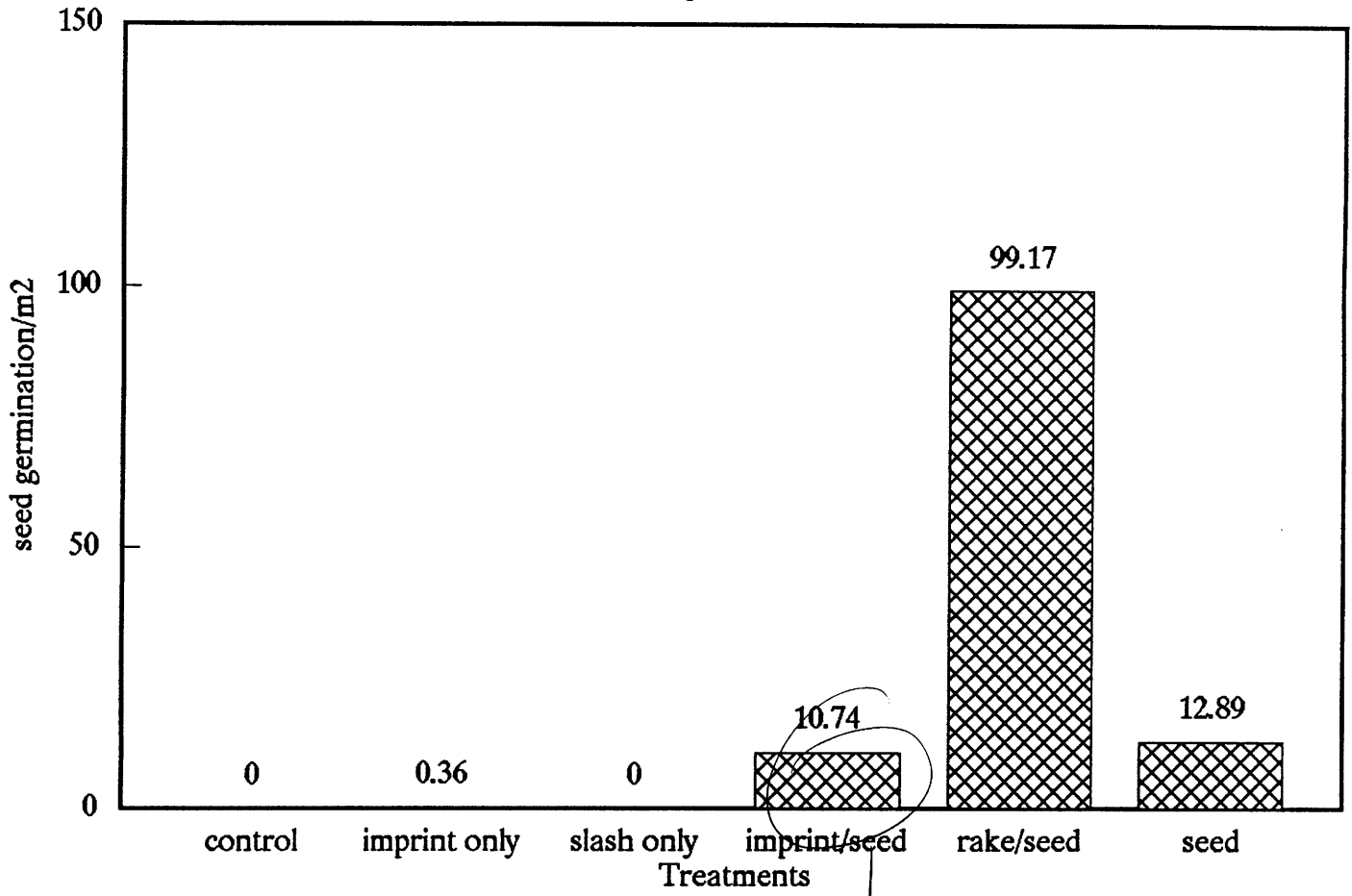
There has been a large drop in potential seedling germination since the seed bank study 8 days post seeding. In that study seed germination ranged from a low of 6.8 % in broadcast seeded plots to a high of 32.17% in raked plots. This number has since decreased to almost nothing for broadcast seeded and imprint/seeded plots to 7.7% for rake/seeded plots. Factors such as desiccation, predation, trampling (by humans and animals), and other causes have probably reduced the relatively large seed bank (after 8 days) to these low germination rates. It is also possible that the sampling procedure is biased. That is, it may not have accurately sampled the actual number of seedlings present. Observations show that seedling germination on the plots is clumped. A grid of quadrats may miss these clumps (and thus underestimate the number of seedlings/trt.) or hit the clumps (and overestimate the number of seedlings/trt.). Then again it may be very accurate. Further sampling and a comparison of sampling methods would be helpful.

Nevertheless, if on areas without harvester ants we can consistently achieve a 7% germination rate, this may be significant in terms of revegetating the site. 7.7% germination translates to 99 seedlings/m². Even if the final establishment rate is half or less of this years germination rate, this will leave 25 to 50 seedlings/m² (though these will probably be clumped in litter areas - personal observations).

Finally, at this site it appears that the raking treatment had a positive effect on seed germination compared to the other treatments and other treatments at Restoration site 1 (Frijoles Mesa).

a little more
upbeat than the
discussion for
Res 1

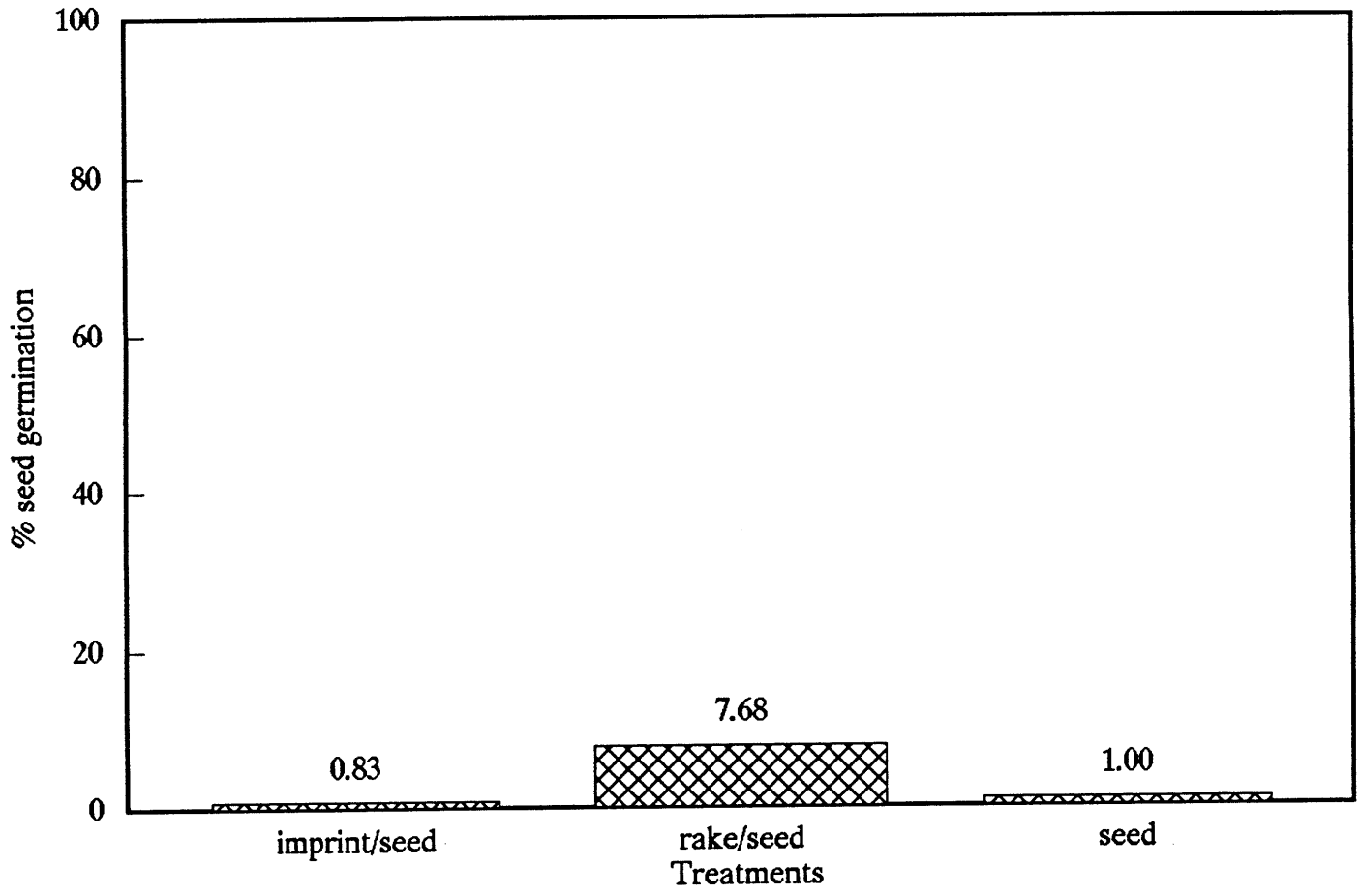
Seed Germination per m2 on Restoration Site 3 (Guaje Mesa)
Data from Quadrats - Oct. 1995



dave\seedtest\res3quad.wk3
graph: m2 germR3-quad

~~Still like to~~
would be worth
sampling w/ several
(fire belt transect) methods to see
if we're missing
a clumped distribution
w/ our current method

Percent Seed Germination – Restoration Site 3 (Guaje Mesa)
Data from Quadrats – Oct. 1995



dave\seedtest\res3quad.wk3
graph: % germR3-quad

Grass Seed Germination Data from the Quadrats
at Restoration Site 3 - Guaje Mesa
Oct. 1995 Arranged by Treatment

Sample size is 12 picture frames per plot
1 picture frame = 23.3x33.3 cm or .077589 m2
.077589 x 12 frames/plot = .931068 m2
.931068m2 x 1291 live seeds/m2 = 1202 seedlings EXPECTED!

Treatment	~~Quad~~ ^{Plot #}	Seedling count	Avg. Coun% /trt.	Germin. /trt.
control	10	0	0	N/A
	20	0		
	30	0		
imprint o	14	0	0.333333	N/A
	25	0		
	32	1		
slash onl	15	0	0	N/A
	21	0		
	35	0		
imprint/s	12	27	10	0.831947
	24	① 7		
	31	② 7		
rake/seed	11	78	92.33333	7.681642
	22	149		
	33	50		
seed	13	12	12	0.998336
	23	11		
	34	13		

~~these~~ these #'s
are hard to
believe —

Following is a summary of the above data
for graphing purposes:

	Germination/m2
control	0
imprint o	0.36
slash onl	0
imprint/s	10.74
rake/seed	99.17
seed	12.89

Graph: m2 germR3-quad

	% Germination/treatment
imprint/s	0.83
rake/seed	7.68
seed	1.00

Graph: % germR3-quad

file: dave\seedtest\res3quad.wk3

Study of the Allelopathic Effects of
Piñon Pine-Juniper Slash and Litter on the
Germination and Establishment of *Bouteloua gracilis*

October 1995

Objective:

Historical observations suggested the PJ has an allelopathic effect on native grasses. More recent work has questioned this idea. This study was designed to help determine whether the lack of *B. gracilis* under PJ overstory was due to allelopathic effects or other environmental factors.

Methods:

The overall methodology was to water *B. gracilis* seeds with 3 water treatments. One was regular tap water, the second was water soaked in PJ litter (collected daily under PJ stands) for 24 hours, and the third was a mix of fresh (collected daily) PJ slash soaked in water for 24 hours. While allelopathic effects can come from a variety of sources (bark, roots, lvs, etc...) this study investigated the possible allelopathic effects of throughfall (rainfall passing through live needles or litter underneath the trees).

1) The experiment was set up as follows:

a) Two blocks - one potting soil (as a control), one mesa top soil.

b) Each block had three treatments:

- tap water
- water soaked in PJ slash
- water soaked in PJ litter

c) Each treatment had 3 replicates with 50 seeds each.

d) Each replicated contained six 6-pack planting trays (with the 50 seeds randomly distributed over the 6 packs).

2) The 6-pack planting trays were prepared as detailed in the "7 Day Post Seeding Study" for Restoration site 1, (August 1995, pg. 2). See that study for more

details. Note that a thin layer of potting soil was added to all trays to prevent excessive desiccation.

Expected Results:

It would be expected that if throughfall extracts allelopathic chemicals from PJ litter or slash the germination and establishment of B. gracilis seeds would be reduced compared to those seeds watered with plain water.

Results:

See the attached graphs: pottingsoil.1 and mesasoil.1.

Discussion:

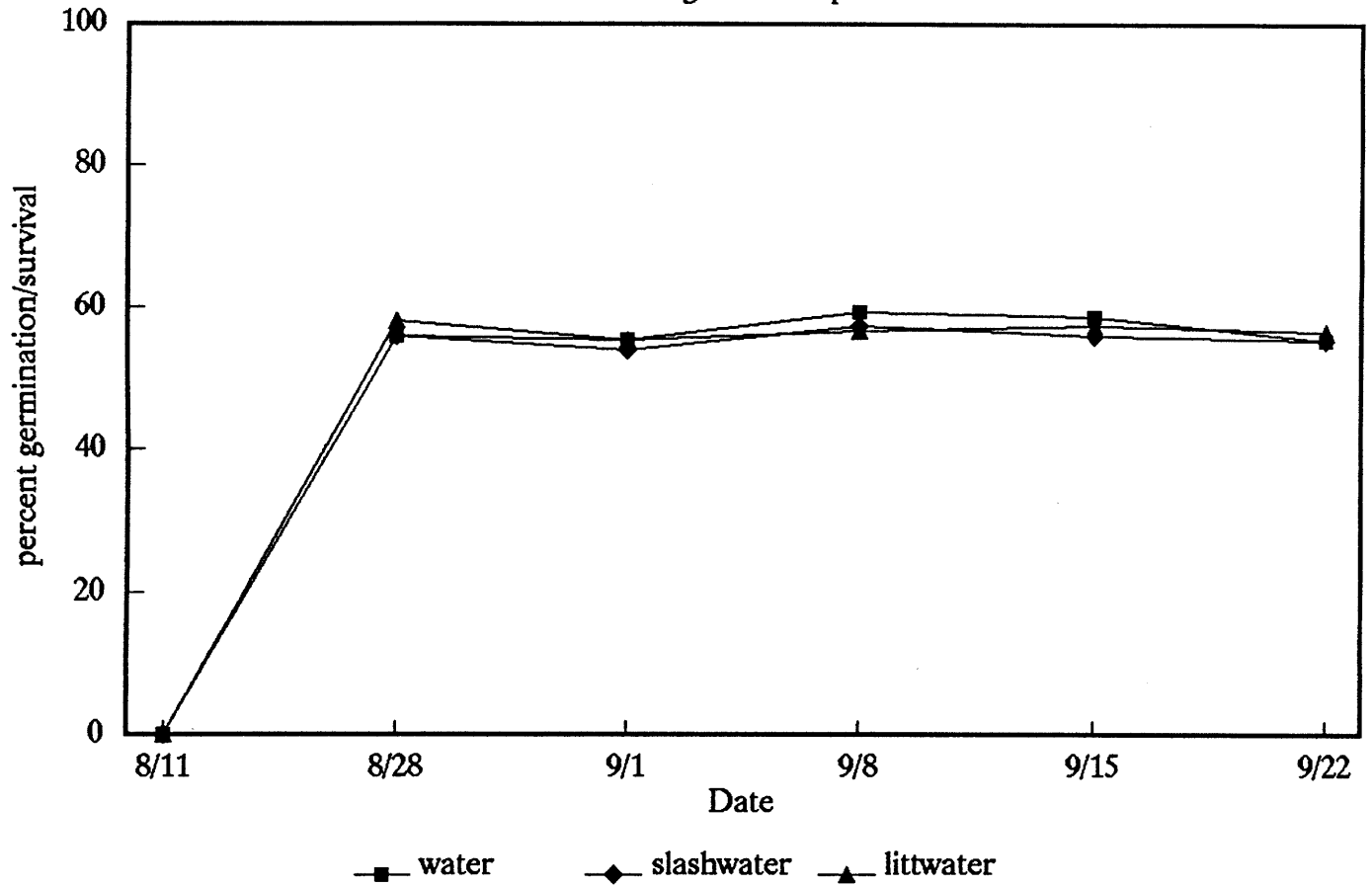
It is clear that, as tested in this study, water from slash and litter has no effect on the germination and growth of this grass species. In the potting soil (graph: pottingsoil.1) the germination and survival of the seedlings was identical for all treatments. In the mesa top soil (graph: mesasoil.1) it appears the slash and litter water may have had a beneficial effect!

This study suggests that throughfall has no negative effects on B. gracilis germination and growth. Instead it is probably other environmental conditions which restrict the growth of this species under PJ overstory. The two largest factors may be interception of precipitation by the PJ overstory and litter layer (up to 60% interception). That is, the scant rainfall that does occur does not reach seeds in the litter. Secondly, shade may play an important role. If this is true then the removal of the overstory should have a beneficial effect on this species. In addition, a study on the effects different soil surfaces (litter, bare soil, slash, etc.; see study - 1995) on the germination and growth of B. gracilis show litter is extremely beneficial to the growth of this species. This is probably due to increased soil moisture and reduced soil temperatures.

It is important to note however, that there are grass species which grow well and even exclusively under PJ stands. Oryzopsis micrantha (little seed rice grass) is always found under PJ stands and never in the open. Clearly it can establish itself under conditions of less moisture and more shade (it may require the shade for establishment). However, one must also note that established O. Micrantha also seems to do well when the overstory is removed

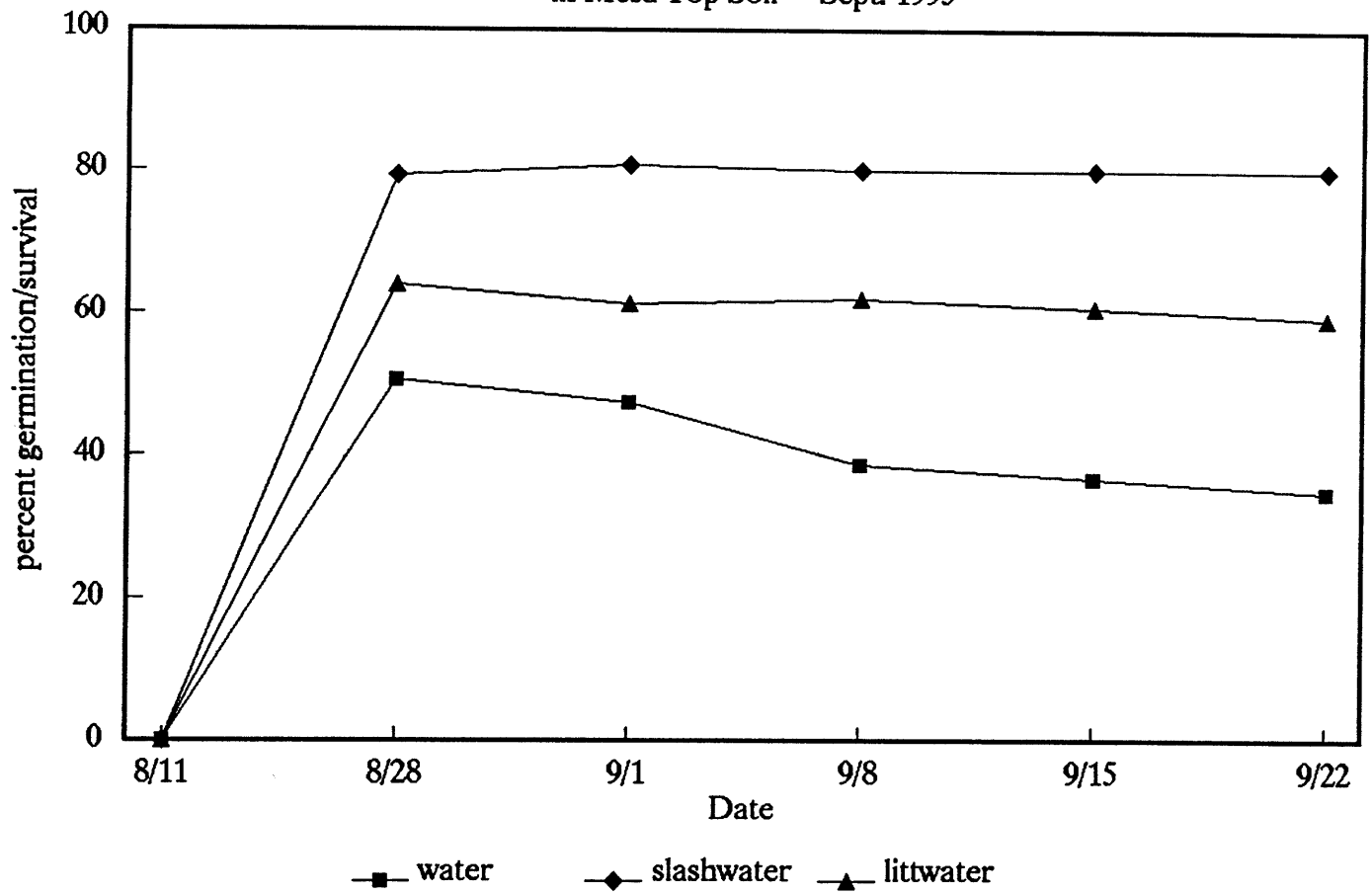
(personal observations of areas that were cut and slashed in 1995). It will be interesting to see how the removal of the overstory influences the germination, establishment, and growth of these two species in the field.

Allelopathic Effects of Water Extract Trts. on *Bouteloua gracilis*
in Potting Soil – Sept. 1995



file: dave\seedtest\allelo.wk3
graph: pottingsoil.1

Allelopathic Effects of Water Extract Trts. on *Bouteloua gracilis*
in Mesa Top Soil – Sept. 1995



file: dave\seedtest\allelo.wk3

graph: mesasoil.1

Test of Potential Allelopathic Effects of Pinon
Pine and Juniper (PJ) on Bouteloua gracilis (BOGR)
by watering bogr seeds with water, slash water, or litter water.

Aug. - Sept., 1995

Set-up (prepared 8/11/95):

1. All planting flats (6-packs) were prepared with a thin sand base
2. Mesa top soil (block 1) or potting soil (block 2) was added to fill the flats 2/3 full.
3. Six 6-packs were prepared per replicate and 3 replicates per treatment.
4. Thus there were 2 blocks (mesa soil, potting soil). Within each block there were 3 treatments: water, slash water, and litter water. Within each treatment there were three replicates on six 6-pack trays each.
5. To each replicate 50 Bogr seeds (mixed w/ soil to facilitate distribution) were added.
6. A thin layer of potting soil was added to all replicates to prevent excessive desiccation.
7. Replicates were watered daily with one of the following:
 - a. regular tap water
 - b. water that had fresh green PJ slash soaked in it for 24 hours (overnight)
 - c. water that had litter from underneath PJ soaked in it for 24 hours.

It was hypothesized that the water would extract any allelopath chemicals and the effect would be seen in the germination and/or growth of the seedlings.

RAW DATA (# of seedlings):

MESA TOP SOIL:

Date	water1	water2	water3	slashwater	slashwater	slashwater	litterwater	litterwater	litterwater
8/21	*	*	5	*	*	43	*	*	22
8/28	24	26	26	44	34	41	29	33	34
9/1	20	28	23	45	34	42	28	34	30
9/8	12	28	18	44	34	42	27	34	32
9/15	14	26	15	44	34	42	26	33	32
9/22	11	26	15	44	34	42	24	33	32

* replicates not counted separately so all data lumped under replicate #3, this data not used for analysis or graphing purposes.

POTTING SOIL:

Date	water1	water2	water3	slashwater	slashwater	slashwater	litterwater	litterwater	litterwater
8/21	*	*	78	*	*	76	*	*	66
8/28	26	28	30	23	28	33	30	27	30
9/1	24	27	32	23	28	30	28	26	29
9/8	26	29	34	23	28	35	27	28	30
9/15	26	28	34	23	27	34	27	28	31
9/22	24	27	32	23	26	34	27	28	30

* replicates not counted separately so all data lumped under replicate #3, this data not used for analysis or graphing purposes.

AVERAGE % GERMINATION OF ABOVE DATA (avg. = # rep. 1 + rep. 2 + rep. 3/150* 100):

MESA TOP SOIL - PERCENT GERMINATION:

Date	water	slashwater	litterwater
8/11	0	0	0
8/28	50.67	79.33	64.00
9/1	47.33	80.67	61.33
9/8	38.67	80.00	62.00
9/15	36.67	80.00	60.67
9/22	34.67	80.00	59.33

Graph: mesasoil.1

POTTING SOIL - % GERMINATION:

Date	water	slashwater	litterwater
8/11	0	0	0
8/28	56.00	56.00	58.00
9/1	55.33	54.00	55.33
9/8	59.33	57.33	56.67
9/15	58.67	56.00	57.33
9/22	55.33	55.33	56.67

Graph: pottinsoil.1

file:\dave\seedtest\allelo.wk3

could be adjusted for geom. asse of 77% (but not necessary since all seeds), same

Soil Surface Effects on the
Germination, Establishment, and Growth
of Bouteloua gracilis

Sept. 1995

Objective:

How does the soil surface (litter, slash, etc..) effect the germination and growth of *B. gracilis* either physically or chemically (via allelopathy)?

Methods:

The experiment was set up as follows:

- 1) Two blocks
 - sun
 - shade (30% shade cloth)
- 2) 5 treatments in each block as follows:
 - bare soil (from Frijoles Mesa)
 - potting soil
 - soil (mesa top soil) with PJ litter (1/2 to 3/4 in)
 - soil (as above) with PJ slash
 - soil (as above) with litter and slash
- 3) 5 replicates of each treatment (but note 3 replicates were done from 7/6 to 8/4 with 125 seeds in each replicate and the final 2 replicates from 8/11 to 9/22, 1995 with 50 seeds in each replicate. Data from all 5 replicates is combined in the final analysis below).
- 4) Each replicate is a 18 x 21" planting flat prepared with a layer of sand at the bottom, followed by mesa top soil (except for the potting soil treatment). The seeds distributed randomly over the top and covered with 1/4 to 1/2" soil. Treatments were then added as necessary (litter, slash, etc...)
- 5) Flats were watered (almost) daily.

Results:

See the attached graphs (4 total).

Discussion:

The results are not perfectly clearcut but there are some patterns. Results of the shade and sun treatments (graphs: allsoilsur3.sha and allsoilsur3.sun) show that the litter and slash/litter treatments consistently had the lowest germination rates (one exception: the germination rate of the slash/litter treatment in the shade shoots up from day 21 to day 28. Reason: ?? possibly an unplanned change of environmental conditions). Anyway, it appears that litter reduces the overall germination rate of B. gracilis.

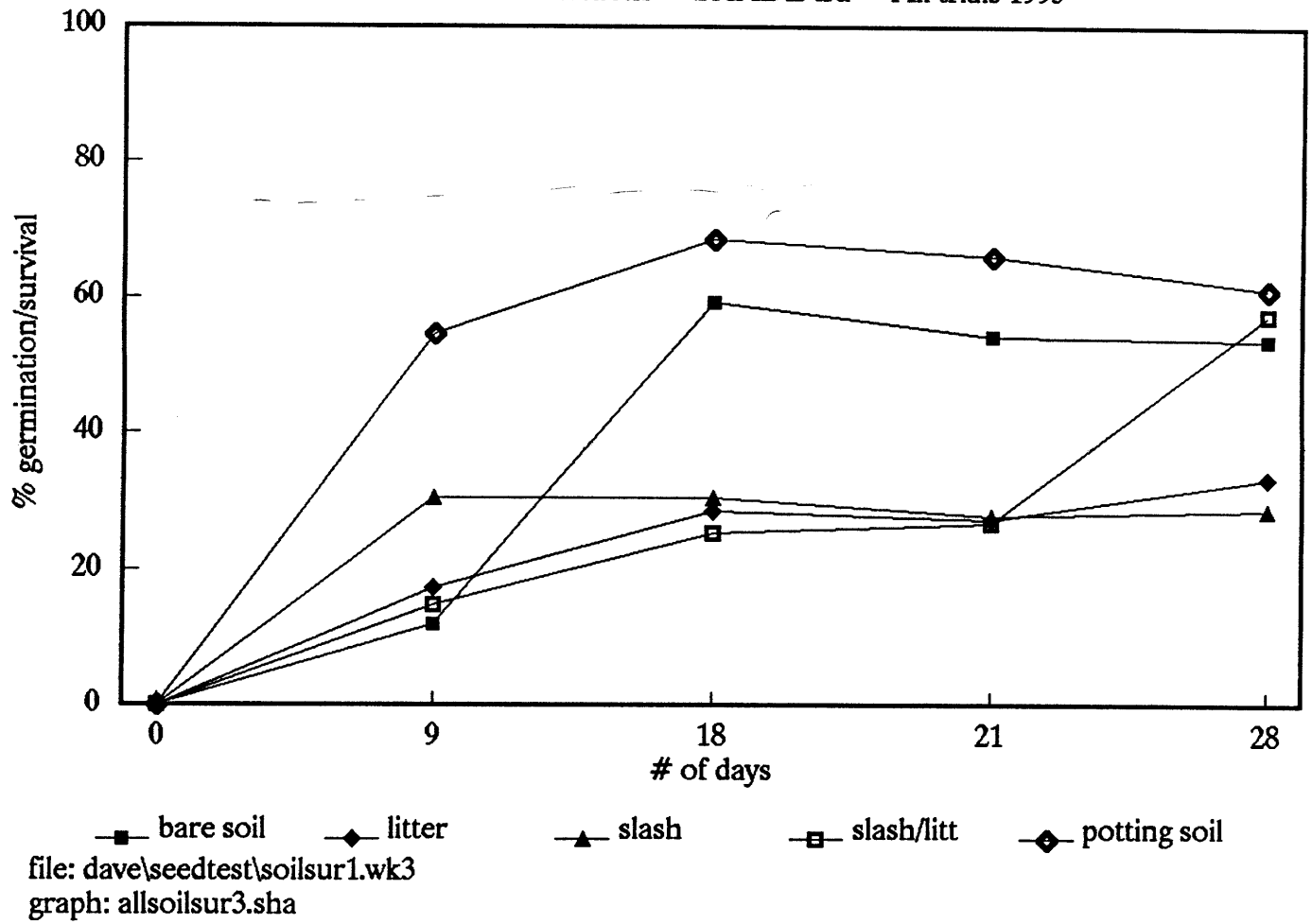
Secondly, in both the sun and shade blocks, the bare soil and potting soil had the highest germination rates.

Finally, slash (over the soil surface) had varying effects depending on the block. In the sun, the slash treatment had the highest germination rate of all treatments. In the shade block however, the slash treatment had a much lower germination rate. It was essentially equal to that of the litter and slash/litter treatments. It may be that in the sun, the slash provides enough shade and moisture retention to promote germination while in the shade the combination of the shade cloth and the slash shade is too excessive and reduces germination of the seeds.

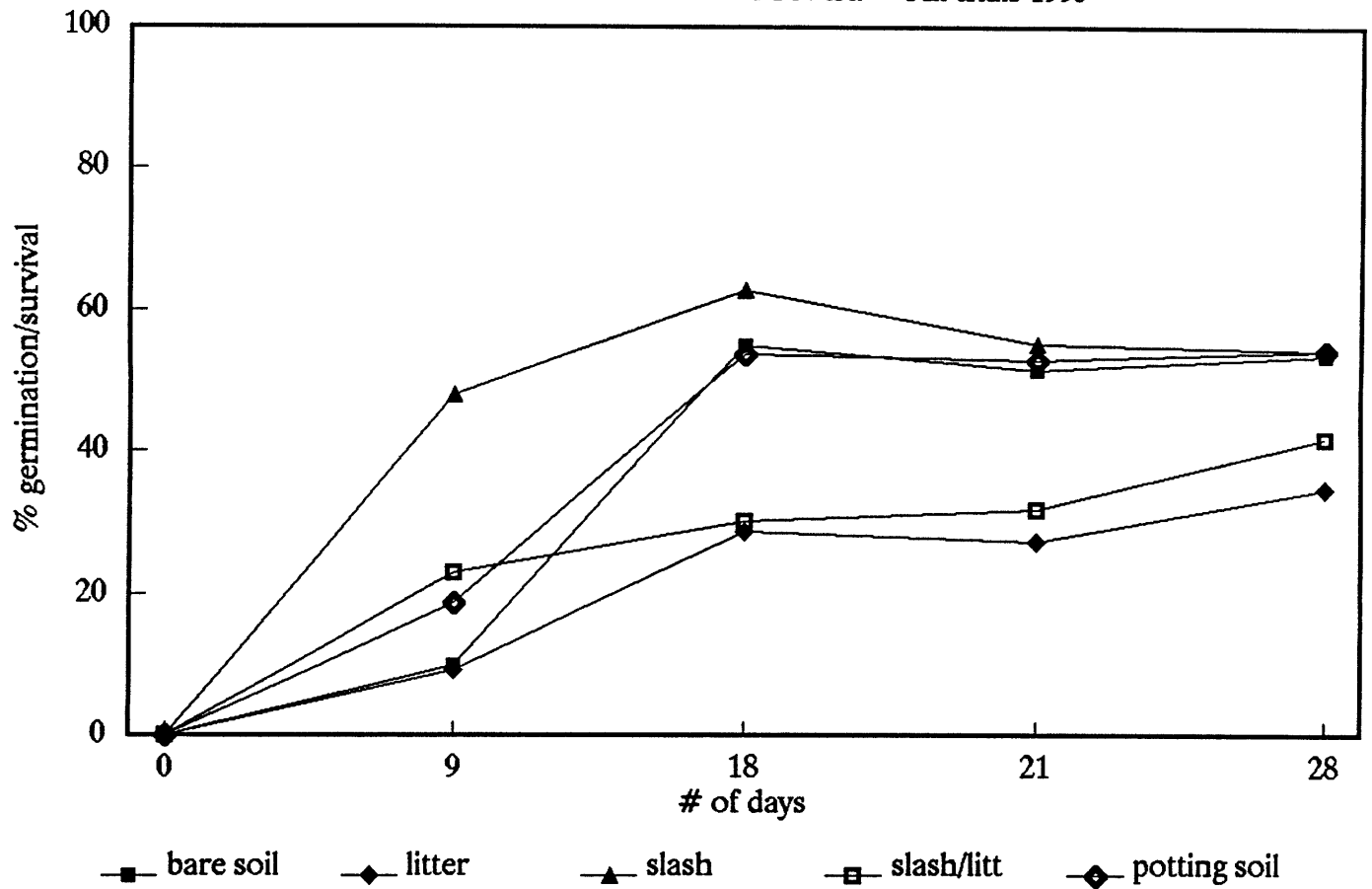
While these results seem to suggest the presence of litter, and possibly slash, can be detrimental to B. gracilis the subsequent graphs (allsur3+hgt.sha and allsur3+hgt.sun) show a different story. Despite the high germination rates of the bare soil, the growth of these plants was extremely poor. In the sun the bare soil seedlings grew only an average of 3/4", while seedlings under the slash grew to an average of 1.5" and those in the litter grew to an average of 3"! The results of the shade block are similar though the bare soil seedlings equaled the growth of the slash seedlings probably due to the modifying effects of the shade cloth. Again, the litter seedlings grew to 3" under the shade cloth.

In summary, while the bare soil treatments had the highest germination rates they had extremely poor plant growth and vigor. They certainly would not have survived long without the daily watering as the soil rapidly dried out even between waterings. The litter, however, greatly improved the environmental conditions through increased soil moisture retention and cooler soil temperatures. The soil under the litter stayed moist for many days even in the hottest weather. The addition of a mulch layer did lower initial germination but clearly benefited the establishment and growth of B. gracilis in these tests.

Germination and Survival of *Bouteloua gracilis* under various
soil surface conditions – SHADE trt. – All trials 1995



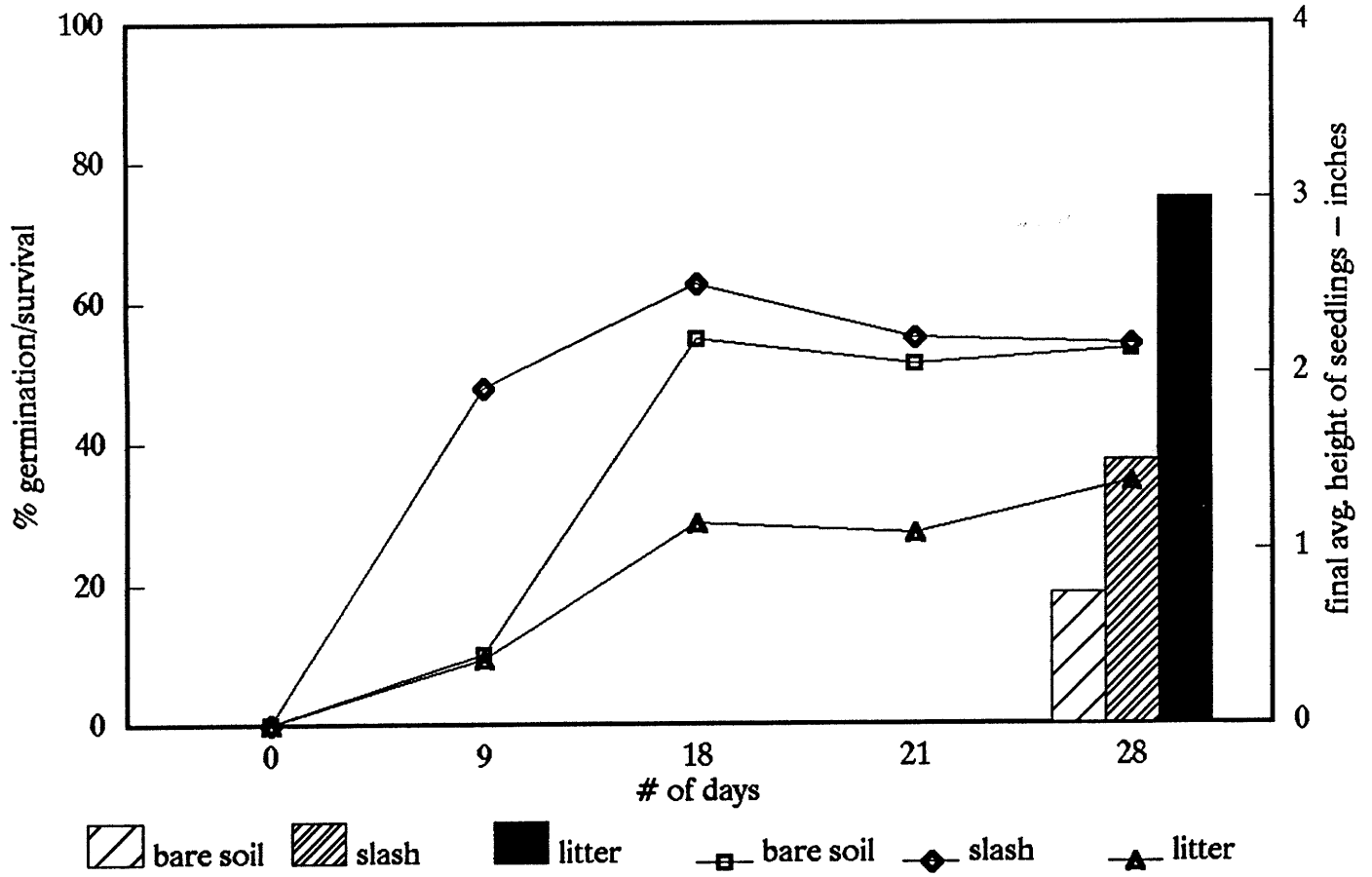
Germination and Survival of *Bouteloua gracilis* under various
soil surface conditions – SUN trt. – All trials 1995



file: dave\seedtest\soilsur1.wk3

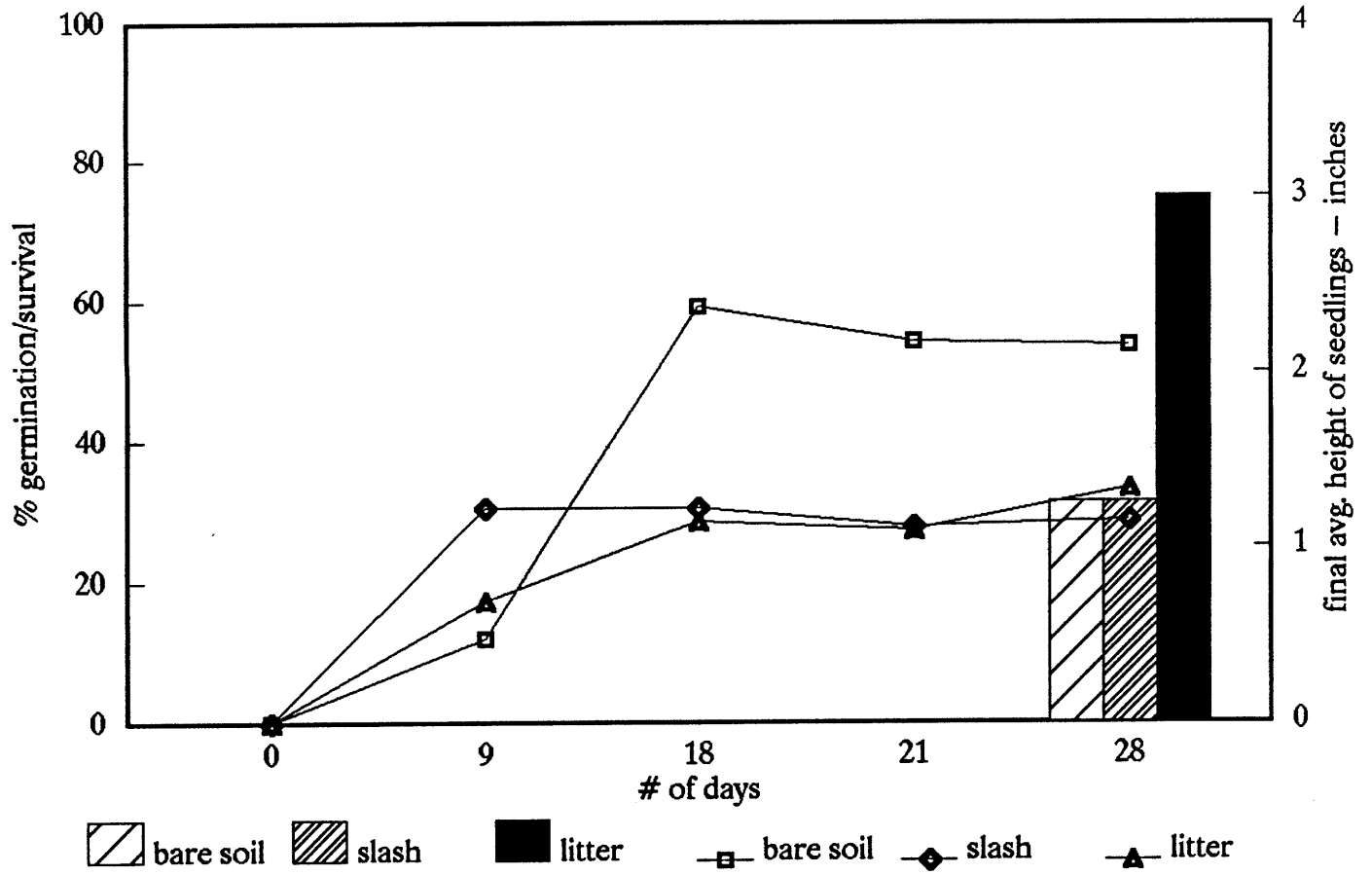
graph: allsoilsur3.sun

Germination, Survival, and Final Hgt. of BOGR under various
soil surface conditions – SUN trt. all trials – 1995



file: dave\seedtest\soilsur1.wk3
graph: allsur3+hgt.sun

Germination, Survival, and Final Hgt. of BOGR under various
soil surface conditions – SHADE trt. all trials – 1995



file: dave\seedtest\soilsur1.wk3
graph: allsur3+hgt.sha

Soil Surface effects on the germination of
Bouteloua gracilis (Bogr) - Blue grama

Bandelier National Monument
Starting date: July 6, 1995

Treatments: 2 Blocks - sun and 30% shade cloth
5 treatments/block - 3 bare soil, 3 potting soil, 3 soil with litter/duff
3 soil with slash (cut pinon-juniper branches),
3 soil with litter/duff and slash
All replicates set up in 10 x 21 inch planting flats with a layer
of sand at the bottom of the flats

Notes: litter/duff = approx. 1/2 to 3/4 inch thick
125 seeds planted per flat
Flats watered (almost) daily

THE FOLLOWING DATA IS TOTAL GERMINATION:
ORIGINAL DATA:

	7/14		7/19		7/24		7/27		8/4		in inches 8/4 gen. eyeball	
	sun	shade	sun	shade	sun	shade	sun	shade	sun	shade	sun	shade
soil	0	34	62	59	81	80	69	71	46	74	0.75	1.25
soil	0	3	35	48	55	78	49	68	40	79		
soil	0	0	51	66	69	93	55	76	45	60		
pot soil	1	44	50	61	52	72	48	67	40	62	1	1.5
pot soil	3	93	70	101	62	102	67	103	60	101		
pot soil	0	92	65	102	64	100	62	95	65	98		
slash	45	18	87	45	85	36	75	33	81	35		
slash	102	72	105	56	103	44	86	41	91	44		1.25
slash	40	53	86	48	84	50	71	45	77	45		
litter	0	15	37	23	39	33	33	23	43	38		
litter	18	19	58	22	51	26	49	34	60	31	3	3
litter	10	31	30	37	34	48	31	45	44	56		
litter/sl	47	30	42	28	48	32	48	26	51	30		
litter/sl	51	32	54	31	56	23	59	21	50	35		
litter/sl	33	8	40	9	42	13	36	15	35	19	2	2.75
pot&litter			9	20	12	26	14	24	14	27	2.5	3
pot&litter			3	11	9	15	10	14	12	17		

THE FOLLOWING DATA IS PERCENT (%) GERMINATION:

	7/14		7/19		7/24		7/27		8/4	
	sun	shade	sun	shade	sun	shade	sun	shade	sun	shade
soil	0	27.2	49.6	47.2	64.8	64	55.2	56.8	36.8	59.2
soil	0	2.4	28	38.4	44	62.4	39.2	54.4	32	63.2
soil	0	0	40.8	52.8	55.2	74.4	44	60.8	36	48
pot soil	0.8	35.2	40	48.8	41.6	57.6	38.4	53.6	32	49.6
pot soil	2.4	74.4	56	80.8	49.6	81.6	53.6	82.4	48	80.8
pot soil	0	73.6	52	81.6	51.2	80	49.6	76	52	78.4
slash	36	14.4	69.6	36	68	28.8	60	26.4	64.8	28
slash	81.6	57.6	84	44.8	82.4	35.2	68.8	32.8	72.8	35.2
slash	32	42.4	68.8	38.4	67.2	40	56.8	36	61.6	36
litter	0	12	29.6	18.4	31.2	26.4	26.4	18.4	34.4	30.4
litter	14.4	15.2	46.4	17.6	40.8	20.8	39.2	27.2	48	24.8
litter	8	24.8	24	29.6	27.2	38.4	24.8	36	35.2	44.8
litter/sl	37.6	24	33.6	22.4	38.4	25.6	38.4	20.8	40.8	24
litter/sl	40.8	25.6	43.2	24.8	44.8	18.4	47.2	16.8	40	28
litter/sl	26.4	6.4	32	7.2	33.6	10.4	28.8	12	28	15.2

STATISTICAL SUMMARY INFORMATION: AVERAGES AND SAMPLE STANDARD
DEVIATION (as calculated by 123).

DATE	# of days	Percent average germination - SUN					SUN - SAMPLE STANDARD DEVIATIONS				
		bare soil	litter	slash	litt/slas	potting soil	bare soil	litter	slash	litt/slas	pot soil
7/6	0	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
7/14	8	0.00	7.47	49.87	34.93	1.07	0.000	7.215	27.555	7.561	1.222
7/19	13	39.47	33.33	74.13	36.27	49.33	10.862	11.657	8.554	6.058	8.327
7/24	18	54.67	33.07	72.53	38.93	47.47	10.410	6.990	8.554	5.619	5.143
7/27	21	46.13	30.13	61.87	38.13	47.20	8.211	7.893	6.214	9.203	7.879
8/4	28	34.93	39.20	66.40	36.27	44.00	2.572	7.632	5.769	7.170	10.583

Graph: soilsur1-sun

THE ABOVE CONTINUED.....

SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN	SUN
slash 1	slash 2	slash 2	slash/lit	slash/lit	slash/lit	slash/lit	slash/lit	slash/lit	potting	spotting	spotting	spotting	spot soil2
0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	38	52	37.6	40.8	26.4	6	4	0.8	2.4	0	68	22	
67.2	46	50	38.4	44.8	33.6	16	18	41.6	49.6	51.2	70	56	
56.8	32	58	38.4	47.2	28.8	20	24	38.4	53.6	49.6	66	56	
61.6	38	56	40.8	40	28	24	52	32	48	52	72	58	
	42	56				28	64				64	50	
	40	56				24	74				60	52	

SHADE (1 = trial 1, 2 = trail 2 in sept.)													
Avg. Days	bare soil	bare soil	bare soil	bare soil	bare soil	bare soil	litter 1	litter 1	litter 1	litter 2	litter 2	slash 1	slash 1
0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	27.2	2.4	0	0	30	12	15.2	24.8				14.4	57.6
18	64	62.2	74.4	32	64	26.4	20.8	38.4				28.8	35.2
21	56.8	54.4	60.8	36	64	18.4	27.2	36				26.4	32.8
28	59.2	63.2	48	40	62	30.4	24.8	44.8				28	35.2
				42	64								
				42	64								

THE ABOVE CONTINUED.....

SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE	SHADE
slash 1	slash 2	slash 2	slash/lit	slash/lit	slash/lit	slash/lit	slash/lit	slash/lit	potting	spotting	spotting	spotting	spot soil2
0	0	0	0	0	0	0	0	0	0	0	0	0	0
42.2	18	20	24	25.6	6.4	6	12	35.2	74.4	73.6	52	38	
40	24	24	25.6	18.4	10.4	32	40	57.6	81.6	80	56	68	
36	12	32	20.8	16.8	12	24	60	53.6	82.4	76	54	64	
36	16	42	24	28	15.2	64	82	49.6	80.8	78.4	48	64	
	14	36				56	92				48	70	
	14	36				64	92				48	64	

AVERAGES OF THE ABOVE DATA FOR GRAPHING AND SUMMARY PURPOSES:

SUN (1 = trial 1 in July, 2 = trail 2 in SUN)					
Avg. Days	bare soil	litter	slash	slash/lit	potting soil
0	0	0	0	0	0
9	10	9.28	47.92	22.96	18.64
18	54.8	28.64	62.72	30.16	53.68
21	51.28	27.28	55.12	31.68	52.72
28	53.42222	34.62222	54.13333	41.64444	54.22222

Graph: allsoilsur3.sun

shade (1 = trial 1 in July, 2 = trail 2 in shade)					
Avg. Days	bare soil	litter	slash	slash/lit	potting soil
0	0	0	0	0	0
9	11.92	17.33333	30.44	14.8	54.64
18	59.32	28.53333	30.4	25.28	68.64
21	54.4	27.2	27.84	26.72	66
28	53.82222	33.33333	28.57778	57.46667	61.2

Graph: allsoilsur3.sha

HEIGHT DATA (day 28 only) AND SELECTED GERMINATION DATA FOR GRAPHING:

SUN

Approx. hgt. in inches at end of stuSUN

Avg. Days	bare soils	slash	litter	bare soils	slash	litter
0	0	0	0	0	0	0
9	0	0	0	10	47.92	9.28
18	0	0	0	54.8	62.72	28.64
21	0	0	0	51.28	55.12	27.28
28	0.75	1.5	3	53.42222	54.13333	34.62222

Graph: allsur3+hgt.sun

FINAL HEIGHT DATA FOR SEEDLINGS AT END OF STUDY
DATA IS EYEBALL AVERAGE ONLY (VERY APPROXIMATE)
DAYS FROM 0 TO 21 ARE FALSE DAYS AND ARE FOR
GRAPHING PURPOSES ONLY. DAY # 28 IS THE ONLY REAL DATA (i.e. data was collected
only on this day).

SHADE

Approx. hgt. in inches at end of stuSHADE

Avg. Days	bare soils	slash	litter	bare soils	slash	litter
0	0	0	0	0	0	0
9	0	0	0	11.92	30.44	17.33333
18	0	0	0	59.32	30.4	28.53333
21	0	0	0	54.4	27.84	27.2
28	1.25	1.25	3	53.82222	28.57778	33.33333

Graph: allsur3+hgt.SHA

file: dave\seedtest\soilsur1.wk3

Coated Seed Germination Study
September - October 1995

Objective:

To determine the effects of seed coatings on germination of various native grass species. The coatings are intended to protect the seed against ant predation prior to germination.

Methods:

- 1) Three native grasses were tested:

Sporobolus cryptandrus (sand dropseed)

Bouteloua gracilis (blue grama)

Schizachyrium scoparium (little bluestem).

- 2) Experimental Design for each species:

- a) There were 2 Blocks:

- surface seeds (S)
- buried seeds (B)

- b) Within each block there were 3 treatments:

- control (seeds without coatings) (C)
- 2:1 coated seeds (2)
- 5:1 coated seeds (5)

- c) Each treatment had three replicates with 30 seeds in each replicate.

The above experimental design can be summarized as follows:

<u>Surface Seeds</u>	<u>Buried Seeds</u>
1 control (30 seeds)	1 control (30 seeds)
2 control (30 seeds)	2 control (30 seeds)
3 control (30 seeds)	3 control (30 seeds)
1 2:1 coated seeds (30 seeds)	etc...
2 2:1 coated seeds (30 seeds)	
3 2:1 coated seeds (30 seeds)	

- 1 5:1 coated seeds (30 seeds) etc...
- 2 5:1 coated seeds (30 seeds)
- 3 5:1 coated seeds (30 seeds)

3) 6-pack planting trays were prepared as follows:

- a) A layer of sand, about 25% of tray height.
- b) A layer of soil from areas adjacent to research site 1, minus any rocks, roots, etc.
- c) Five seeds were placed in each cup of each tray.
- d) About 1/4 inch of soil was sprinkled over buried (B) treatments.

4) The seeds were watered daily

Expected Results:

Expected seed germination for controls (uncoated) as determined by seed viability was as follows:

Sporobolus cryptandrus = 94 % x 30 seeds per replicate = 28.2 seedlings/replicate expected.

Bouteloua gracilis = 77 % x 30 seeds/replicate = 23.1 seedlings/replicate expected.

Schizachyrium scoparium 73 % x 30 seeds/replicate = 21.9 seedlings/replicate expected.

Results:

Total germination for all 3 replicates of seeds (90 seeds total) and percent germination for seeds buried beneath soil surface was as follows:

	<u>Control</u>	<u>2:1</u>	<u>5:1</u>
<u>Sporobolus cryptandrus</u>	1 (1%)	1 (1%)	2 (2%)
<u>Bouteloua gracilis</u>	32 (35%)	39 (43%)	23 (26%)
<u>Schizachyrium scoparium</u>	3 (3%)	1 (1%)	1 (1%)

Total germination for all 3 replicates of seeds (90 seeds total) and percent germination for seeds on soil surface was as follows:

	<u>Control</u>	<u>2:1</u>	<u>5:1</u>
<u>Sporobolus cryptandrus</u>	0 (0%)	0 (0%)	1 (1%)
<u>Bouteloua gracilis</u>	9 (10%)	15 (17%)	12 (13%)
<u>Schizachyrium scoparium</u>	0 (0%)	0 (0%)	2 (2%)

SEE ATTACHED TABLES FOR THE RAW DATA.

Discussion:

1) Buried seeds vs. Surface seeds:

The data between blocks show that seeds planted in the soil fare better than those seeds on the soil surface. In the case of B. gracilis, for example, seeds in the soil had 2 to 3 times the germination rate of those seeds on the soil surface. This may be a result of more moisture retention in the soil and moderated environmental conditions than compared to conditions on the soil surface. It is also possible that seeds on the soil surface were washed away by rain or our watering. Nevertheless, this mimics what may happen to seeds broadcast on the surface in our seeding trials.

2) Within Experimental Blocks:

Within each block (buried or surface) it appears that the vegetable coatings had no major negative impact on germination rates of the three native grass species in this study. In fact, there is a slight trend of higher germination rates with the 2:1 coating in both the surface and buried trials. This may be due to the coating holding moisture for the seed.

Overall, the germination tests showed lower germination rates (regardless of treatment) than expected. This is possibly because of the late season in which the study was conducted. These are all warm summer grasses and this study was not done until the fall (Sept. and Oct.). While the first 2 to 3 weeks of the study were fairly warm (though not approaching July and Aug. summer heat), the rest of study had only warm days and cool to cold nights. This may have affected the germination rates. A similar study should be done next Summer to confirm these results. In addition, the number of replicates and seeds used in these tests was small. Data was taken at rather long intervals on the germination study. As mentioned above the study should be repeated next year in order to obtain more reliable data.

Finally, it is important to note that the dissolution of the seed coatings is not a prerequisite for germination.

Germination Data for Bouteloua gracilis
Seed Coat Tests - September 1995
(part 1 of 2 part table)

	09/12/95	09/15/95	09/22/95	09/25/95	09/29/95
C/B 1		1	3	2	4
C/B 2	1	2	4	3	5
C/B 3		1	9	5	3
C/S 1	1	1		1	1
C/S 2	1	1		1	1
C/S 3	2	1	1	1	1
2/B 1			2	7	8
2/B 2			8	8	8
2/B 3			11	10	10
2/S 1	1	4	3	3	2
2/S 2	1	1			
2/S 3	2	2		1	3
5/B 1				3	3
5/B 2	1	1	1	2	
5/B 3				6	3
5/S 1	2	2		4	5
5/S 2	1	3		4	4
5/S 3	1	1			2

Continued Germination Data for Bouteloua gracilis
Seed Coat Test Data - October 1995
(part 2 of 2 part table)

	10/04	10/10	10/14	10/19	10/22	Total 1995 Germinants
C/B 1	8	3	3	3	3	9
C/B 2	11	6	6	5	4	12
C/B 3	5	4	3	3	3	11
C/S 1	1	1	1	1	1	2
C/S 2	2	1	1	2	1	4
C/S 3	2	2	2	1	1	3
2/B 1	14	6	6	5	3	14
2/B 2	14	9	10	9	9	14
2/B 3	9	7	7	7	7	11
2/S 1	3	3	2	2	2	5
2/S 2	1					2
2/S 3	6	4	5	3	3	8
5/B 1	7	1				7
5/B 2	6	1	1			8
5/B 3	5	1	1	1	1	8
5/S 1	5	5	4	3	3	5
5/S 2	4	4	4	4	4	4
5/S 3	2	1				3

Germination Data for Schizachyrium scoparium
Seed Coat Test Data - September-October 1995

	09/22	09/25	09/29	10/04	10/10	10/14	10/19	10/22	Total
C/B 1									
C/B 2			1	1					1
C/B 3					2				2
C/S 1									
C/S 2									
C/S 3									
2/B 1									
2/B 2									
2/B 3	1								1
2/S 1									
2/S 2									
2/S 3									
5/B 1									
5/B 2		1	1	1	1	1	1	1	1
5/B 3									
5/S 1									
5/S 2	1								1
5/S 3		1	1	1	1	1	1	1	1

Germination data for Sporobolus cryptandrus
Seed Coat Test data - September 1995
(part 1 of 2 part table)

	09/12/95	09/15/95	09/22/95	09/25/95	09/29/95
C/B 1					
C/B 2					
C/B 3		1			
C/S 1					
C/S 2					
C/S 3					
2/B 1					
2/B 2	1	1	1	1	
2/B 3					
2/S 1					
2/S 2					
2/S 3					
5/B 1			1	1	1
5/B 2					
5/B 3					
5/S 1					
5/S 2					
5/S 3			1		

Germination Data for Sporobolus cryptandrus
Seed Coat Test Data - October 1995
(part 2 of 2 part table)

	10/04/95	10/10/95	10/14/95	10/19/95	10/22/95	Total 1995 Germination
C/B 1						
C/B 2						
C/B 3						1
C/S 1						
C/S 2						
C/S 3						
2/B 1						
2/B 2						1
2/B 3						
2/S 1						
2/S 2						
2/S 3						
5/B 1						1
5/B 2	1	1	1	1	1	1
5/B 3						
5/S 1						
5/S 2						
5/S 3						1