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Field Evaluation of Big Sacaton (*Sporobolus wrightii*)

Study Number: NMPMC-P-9801-RA

Abstract
Evaluate selected parents and progeny for potential release.

Introduction

Big Sacaton (*Sporobolus wrightii* Monro, plant symbol SPWR2) is a native, robust, perennial, warm-season bunchgrass that begins growth in early spring. It is distributed from southeastern Arizona to central Texas and south into the northern Mexican states. However stand development is greatest in southeastern Arizona. Big sacaton is usually found on low alluvial flats and flood plains. Big sacaton is useful for forage and hay.

Over 1,000 irrigated big sacaton plants were maintained for ten years at the Los Lunas Plant Materials Center. Only a few seedlings have become established from the seed falling from these plants. Therefore, we think there is a low chance of an invasion of cultivated land by big sacaton seedlings derived from windbreak plants. Under irrigation, these big sacaton plants reached heights in excess of 2 meters. This size combined with little spread by seed onto adjacent land, makes big sacaton useful as a windbreak on irrigated land.

Materials and Methods

Prior Work: Bulk seed was collected from 37 locations in New Mexico. Seedlings were transplanted from a greenhouse to a field into non-replicated accession rows. One superior appearing plant was selected from each of 10 superior appearing accessions, based on visual evaluation of vigor and height. Lineage numbers were assigned to these selected Parent accession plants and their Progeny (Appendix A). Clonal shoots of each selected plant were transplanted into a testcross block, with one of the 10 selected accessions as a male tester (Appendix 2). Big sacaton is thought to be out-breeding and cross-pollinated.

Current Work: In 1999 progeny seeds from the 10 selected lineage female plants were collected from the testcross block. Seedlings were greenhouse grown from progeny seed. Progeny seedlings and clonal shoots of the 10 Parents were planted in a semi-random complete block in 8 replicated rows with parent and progeny plants in alternating positions, but not paired by lineage (Appendix 3). This design gave a total of 160 plants - 16 of each lineage with 8 clonal parents and 8 progeny from seed. The field is flood irrigated as needed, typically five times per year at 3 inches. Nitrogen and phosphorus were each applied in three split treatments to achieve the rate of 100 lbs. per acre per year. Weeds are controlled by herbicide, mechanical cultivation, and manually as needed. Each fall, after dormancy, the plants are mowed to approximately 12 inches to reduce litter.

After six years of growth the plants were evaluated for long term vigor. Data were collected at two times during 2005. The first data collection was during the second week of July for vegetative growth. Most vegetative leaf growth was complete at that time and seed culm growth was just beginning. Data collected on each plant included leaf height (**Lht**) and leaf perimeter (**Lp**). In addition, an index was computed to be proportional to vegetative volume, named Volume Index (**Vi**). Volume Index was calculated as **Vi** = (**Lht***Lp**^2)/10.

A second data collection was done in the fourth week of September. At that time little further vegetative growth had occurred since mid-summer, but seed production was complete. Each plant was visually rated for seed production (**Sp**) on a three-point scale relative to the overall field.

3	Above average
2	Average
1	Below average

Data were analyzed using SAS 9.1. The General Linear Models (GLM) was used to perform Factorial ANOVA for Row (replicates), Lineage, and Generation as main effects without interaction. Type III tests examined each factor corrected for the influence of the other factors. Post-hoc comparison tests between factor levels were performed using both Fisher's LSD and Scheffé criteria. Fisher's LSD is the most liberal comparison test between levels but does not control experiment-wise error rate. On the other hand, Scheffé is very conservative in controlling experiment-wise error, sacrificing discrimination power in multiple comparisons. Row (Replicate) is included as a legitimate fixed effect because of known soil moisture variation across the field due to variation in irrigation between the test field and adjacent fields.

Results

Summary results of the Factorial ANOVA are presented in Table 1. Several observations can be made:

First the overall predictive power of the complete models (replicate, lineage, generation) was limited to R-square values between 0.17 and 0.26. R-square represents the fraction of the observed variation of the data which is explained by the chosen experimental factors.

The remaining fraction of the variation (.74 to .83) is due to random variation among the plants or due to uncontrolled factors. In spite of the limited R-square values, the model was statistically significant on all dependent variables.

Each of the independent variables will be examined individually.

Table 1: ANOVA Statistical Summary

Population Mean	Dependent Variable	Independent Variable	R-square	Pr > F	Significant at p<.05 (•)
1.32 meter	Leaf Height (Lht)	Model	.26	.0003	•
		Row/Replicate Lineage Generation	– – –	.0020 .0062 .3832	• • N.S.
7.84 meter	Leaf Perimeter (Lp)	Model	.20	.0119	•
		Row/Replicate Lineage Generation	– – –	0191 .0510 .9365	• (borderline) N.S.
—	Volume Index (Vi)	Model	.22	.0037	•
		Row/Replicate Lineage Generation	– – –	.0202 .0149 .3727	• • N.S.
—	Seed Production (Sp)	Model	.17	.0402	•
		Row/Replicate Lineage Generation	– – –	.8468 .0060 .1626	N.S. • N.S.

Generation–The Parent/Progeny factor was non-significant by all measures. Pr>F values for vegetative vigor measures (**Lht**, **Lp**, **Vi**) ranged from 0.37 to .93. This gives an extremely strong conclusion of no hybrid effect – either to hybrid vigor or hybrid depression, especially when related to the statistical significance of the other factors. Similarly, seed production (**Sp**) was non-significant with respect to Generation.

Row/Replicate–East-West row position in the field was significant for **Lht**, **Lp**, and **Vi**. This was expected due to the irrigation effects of adjacent fields. Row number is not in itself a factor of interest but is important to the statistical model to remove its known variation from other factors and the error terms.

Lineage–The lineage factor was significant for **Lht** (p=0.0020), **Vi** (p=0.0149, and **Sp** (p=0.0060). For **Lp** the significance was borderline (0.051), and is taken as significant given the significance of the other measures. The lineage effects are shown in Figure 1 (**Lht**), Figure 2 (**Lp**), Figure 3 (**Vi**) and Figure 4 (**Sp**). Figures 1–3 display individual data points. Figure 4 (**Sp**) displays Mean and Std. Dev. as a plot of the categorical measures (1,2,3) of would be unclear.

Figure 1: Leaf Height

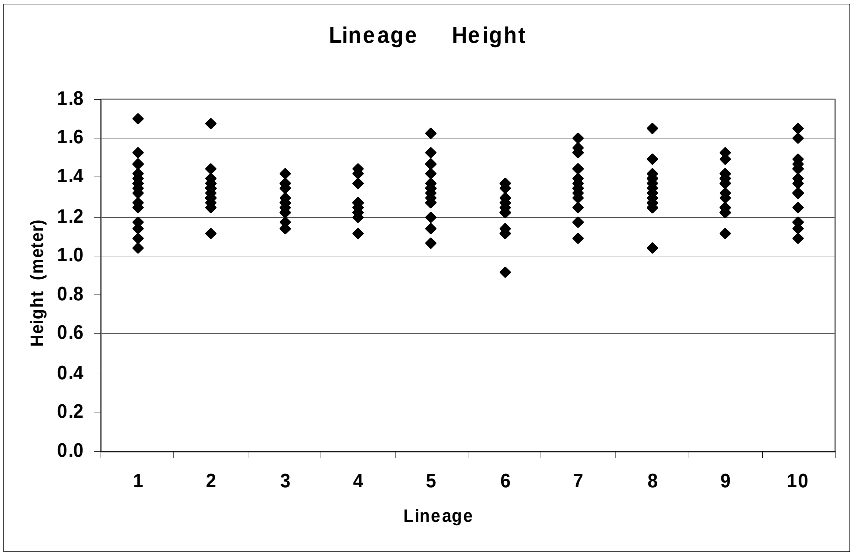


Figure 2: Leaf Perimeter

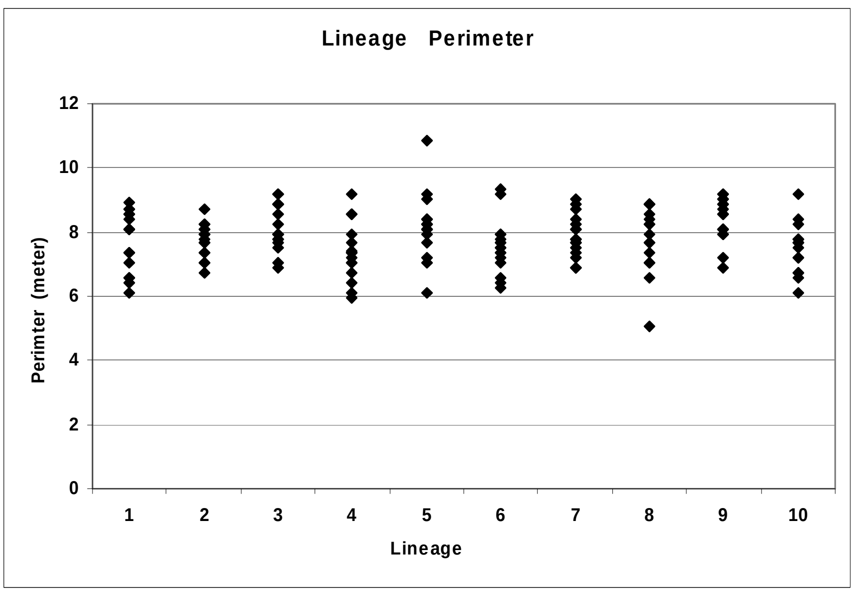


Figure 3: Volume Index

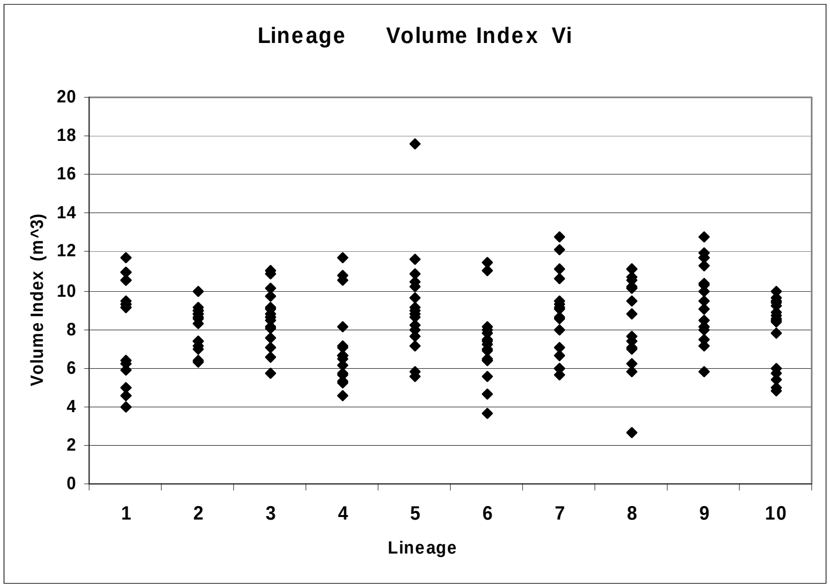
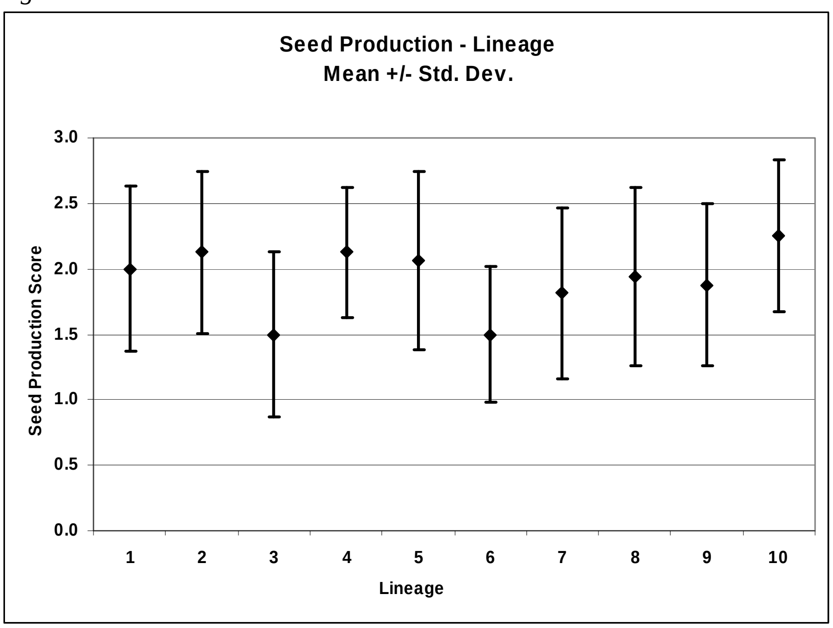


Figure 4: Seed Production



As can be seen in the Figures 1-4, within level variability is quite high relative to the between level variability. However, because of the statistical significance of the Lineage factor on each of the dependent variables, a post-hoc comparison-wise analysis also was made. The more liberal Fisher LSD method indicates significant differences between lineages as shown in Appendix 5. However the more conservative Sheffé method as shown in Appendix 6 indicates no significant differences between lineages. Further examination of the data revealed that while the test block was controlled for east-west variation by replicated rows, north-south was uncontrolled and confounded the Lineage factor. Visual observation showed a north-south moisture gradient after irrigation.

Lineages that tend towards more vigor by the Fisher LSD test were also weighted towards the south end of the field which probably had greater moisture. Given the non-significant Sheffé tests and the possible confounding effect of uneven north-south distribution, all lineages are concluded to be equivalent by all measures: **Lht**, **Lp**, **Vi**, and **Sp.**

Discussion

While the selected accessions failed to demonstrate hybrid vigor in the first generation cross (F1), each accession was itself originally selected as superior, and a superior plant from within each superior accession had been chosen for crossing. Equally important, the F1 plants show no hybrid depression, indicating the ability to use the parent plants to cross and produce vigorous progeny from seed. All selected accessions showed excellent long term vigor and would be suitable for general use where vigorous growth is desired, such as for wind-stripping. Seed propagation from all 10 lineages would be expected to maintain greater genetic diversity in future generations than select hybrid seed propagation.

Further, wide variation was seen among individual plants in shape, blade width, and color, though no statistical relationship was found with lineage or generation. If particular appearance traits are desired, individual plants could be selected for vegetative propagation.

Recommendations

Vegetatively propagate parent plants of all ten lineages from the test field into a randomized seed production field. The produced seed can be harvested and used directly for planting, or if planting for windstripping, seed from the production plot should be grown as seedlings. These seedlings can then be transplanted to remote sites in a planned and controlled manner. Windstrip planting should be done in multiple diagonally offset rows such that the failure one, two, or even three adjacent plants will not allow a clear path for wind and dust. On irrigated land, plant spacing of 3 to 6 feet in 4 or more rows should provide complete coverage even with multiple individual plant failures.

Casual observation of various big sacaton plants at the NMPMC suggests that growth can be vigorous on nonirrigated buffer strips that are adjacent to flood irrigated fields. Determination of guidelines for non-irrigated plantings adjacent to flood irrigated lands would provide an avenue to the establishment of lower cost, lower water demand windstrips for control of blowing dust. A non-irrigated test field should be planted from seedling adjacent to a flood irrigated field on dry land mesa. First year and long term growth should be measured and related to distance from the irrigated land, depth of seeding roots, and deep level soil moisture.

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Field Evaluation of Little Bluestem (*Schizachyrium scoparium*)

Study Number: NMPMC-P-9101-RA

Abstract
Evaluate little bluestem for vigor and seed production to select accessions for polycross.

Introduction

Little bluestem (*Schizachyrium scoparium*) is a perennial warm-season bunchgrass found throughout the U.S., except for Nevada and the Pacific Coast states (Voight and MacLauchlan, 1985). Little bluestem produces good quality forage when immature, but it is not well accepted by livestock when it becomes mature. It is more drought resistant and can persist under grazing in drier climates better than big bluestem, indiangrass, or switchgrass (Voight and MacLauchlan, 1985).

Little bluestem has the following attributes:

- Both rhizomatous and non-rizomatous (Stubbendieck et al., 1992
- It is outbreeding and cross-pollinated (Anderson and Aldous, 1938).
- The culms are 1.6 – 6.5 feet
- Leaves can be green or glaucous
- Sheaths are strongly keeled and laterally flattened, and as broad as .4 inches
- Ligules are firm and .04 – .12 inches long
- Rachis joints and pedicels have long silvery hairs at least on the upper two-thirds (Gould, 1968)
- Fine-rooted to a depth of 5 feet
- Spikelets are paired, sessile perfect, and pedicellate sterile (Hitchcock, 1951).

Cornelius (1947) studied flowering dates of little bluestem with different origins at Manhattan, Kansas. Plants from North Dakota flowered an average of 5 days after June15 compared to 64 days for Manhattan, KS plants, and 87 days for Vernon, TX plants. He also found that little bluestem plants increased in plant height from North to South, with the exception of plants from higher elevations.

Seed matures in late September to October. If grown in cultivated and irrigated fields, yields of 200 pounds per acre may be expected. A pound of clean seed contains 254,000 to 263,000 seeds (Hoover et. al., 1948).

Little bluestem was found to have 12 to 15 very short, basal nodes aggregating no more than one inch in total length. Most of these short nodes are below ground level. Thus the growing point is not pushed above ground until after the first 12 – 15 short nodes are mature, which may be mid-growing season. There are also about seven elongated nodes above ground. Because Indiangrass and switchgrass have fewer short basal nodes, they have only a few nodes from which buds can develop into new shoots. Therefore they are less able to spread or even maintain growth under intense grazing conditions when compared to little bluestem (Rechenthin, 1956)

In tall-grass prairie regions, little bluestem is a dominant on upland sites. Considered a climax species, it occupies as much as 90% of the steep, drier, loess hills on deep soils, and 50 – 75% in drier soils, including level uplands (Weaver, 1968). In the mixed prairie, little bluestem occurs mainly on sandy soils or on weakly developed soils, and especially along ridges or steep slopes (Johnson and Nichols, 1970).

Cattle graze mostly on the leaves of little bluestem until late August. After that date, they graze mostly on the seed stalks (Jameson and Huss, 1959). Weaver (1958) reported that little bluestem is readily eaten in spring and early summer, but it is often avoided after its woody stems are produced. A moderately grazed little bluestem pasture provides palatable and nutritious forage throughout the growing season. Grazing preference studies show that cattle preference to little bluestem was equal to big bluestem on rangeland in fair condition, but decreased on good to excellent condition rangeland.

In the Nebraska sandhills, little bluestem should be defoliated a single time in June or July. A single July defoliation was the optimum treatment for the total digestible matter (DM) yield, tiller weight and number, and bud number. To insure restoration of plant vigor, plants grazed late in the growing season should not be grazed closely every year, and multiple defoliations should not be repeated in consecutive years (Mullahey et. al., 1990). Control of broadleaf weeds increased DM yield by an average of 22% (Reardon, 1964).

Ecotypes are quite variable in characteristics such as leafiness, time of maturity, plant height, and seed set (Anderson and Aldous, 1938). Several cultivars have been developed:

Blaze	1967	Nebraska
Camper	1973	Nebraska
Aldous	1966	Kansas
Cimmarron	1970	Kansas
Pastura	1963	New Mexico

Pastura was developed from seed collected near Rowe, New Mexico in western San Miguel County. It is well-suited for range plantings on light-textured soils of the foothills and plains in central and eastern New Mexico and eastern Colorado. In these areas, little bluestem has produced more seed and forage than native collections originating further east. It is well adapted to adverse climatic conditions, particularly extremes of temperature and precipitation. At the Los Lunas Plant Materials Center, seed production has averaged 100 pounds pls/per acre. Seedling vigor is very good, especially under adverse range conditions. However, forage production is only average for little bluestem. It is hoped that a cultivar may be developed to maintain the desirable climatic adaptation and seed production of Pastura, but with an increased forage production.

Materials and Methods

During 1989, bulk seed collections of little bluestem were made from 111 locations throughout New Mexico and the Texas Panhandle. These collections encompassed a greater geographic range and number of accessions than the original Pastura development collection. Seedlings of the 111 accessions plus 'Pastura' were transplanted from a greenhouse into a space-planted (1 m spacing) field nursery during 1991. The experimental design was a randomized complete block with three replications (two plots/replication for Pastura), with accessions/cultivars as entries. Each plot contained eight plants for a total of 2712 plants in the nursery. The soil type is a sandy loam, and the field was maintained with minimal irrigation (20 – 30 day intervals) to simulate southwestern rangeland conditions. Weed control was accomplished with machine cultivation, broad leaf herbicide, and manual hoeing.

In 1993 (two years after transplanting), first flowering dates of each plant was recorded as the number of days after June 1. Flowering was defined as the appearance of stigma on two racemes. Means of all plants of each treatment across one replicate were computed.

In 2005 an evaluation was completed for long-term vigor and seed head production. Both objective and subjective measures were used. Subjective measures were plot vigor, plot uniformity, and plot seed stem production – each plot comprised of eight plants. A five point subjective scale was used (1=minimal, 5= exceptional). Objective measures were mean basal diameter and mean maximum seed stem height of an individual plant selected as representative of each plot. A composite score for each treatment (accessions or cultivar) was developed by ranking each treatment by each measure with tie breaking by alternate measures. For example, when treatments were ranked for 'vigor,' ties were broken first by 'uniformity,' then if necessary by the product of 'diameter' and 'height.' A composite treatment rank was formed by averaging the treatment ranks across all measures, then re-ranking on the mean rank. In this manner all treatments were ranked from one (best) to 111. To achieve a high composite rank a treatment needed to score well by all measures.

Results

Mean data of all treatments is displayed in Table 3. The top ten of the 111 accessions are listed in Table 2. Of these, the top five can be segregated from the second five on the combination of two criteria. First, the ratings by all individual measures were above the median of the 111 accessions. Second, the flowering dates fall within nine days of each other. Two additional accessions had all measures above the median, but their flowering dates are 20 and 26 days later than the latest flowering date of the top five group of accessions. Similar flowering dates are desirable for a polycross and earlier dates may also be desirable for higher elevation plantings. Details of the top five accessions as well as the Pastura and the means of all 111 accessions are described in Table 3. A means comparison is also presented in Figure 5.

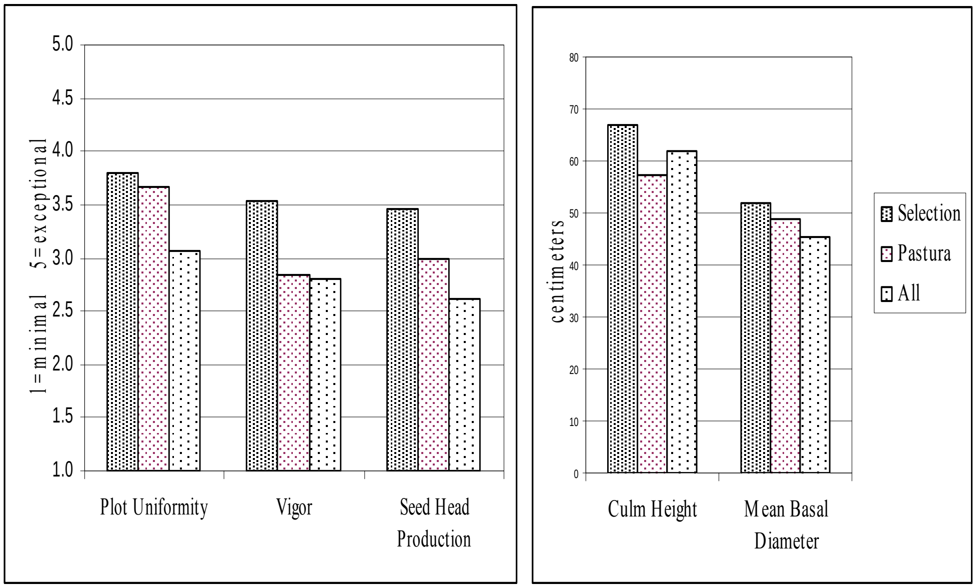
Table 2: Top Ten Accession Rank Summary

Composite Rank	Mean Rank	Flower Days After June 1	All rankings > median	Best Rank	Worst Rank	Rank Range	Treatment	Accession	County
1	8	35	Y	1	23	22	47	9052954	San Miguel, NM
2	9	36	Y	1	26	25	4	9052908	Santa Fe, NM
3	13	36	Y	2	48	46	70	9062462	Colfax, NM
4	13	30	Y	6	32	26	76	9061657	Union, NM
5	15	27	Y	3	41	38	51	9052963	Union, NM
6	15	48	N	1	38	37	23	9061695	Quay, NM
7	19	57	N	9	42	33	15	9052944	Rio Arriba, NM
8	20	56	Y	1	47	46	32	9062469	Roosevelt, NM
9	21	62	Y	11	42	31	110	9061693	Hartley, TX
10	21	44	N	5	39	34	77	9061658	Dallam, TX

Table 3: Selected Accessions, Details, and Comparisons

Growth Characteristics					Rankings							
Plot Uniformity	Vigor	Seed Head Protection	Culm Height (cm)	Mean Basal Diameter (cm)	Mean Rank	Best Rank	Worst Rank	Rank Range	Composite Rank	Days to Flower After June 1	Accession	County
3.3	4.0	3.7	73	54	8	1	23	22	1	35	9052954	San Miguel, NM
4.0	3.7	3.3	68	52	9	1	26	25	2	36	9052908	Santa Fe, NM
4.0	3.3	3.3	64	53	13	2	48	46	3	36	9062462	Colfax, NM
3.7	3.3	3.3	66	52	13	6	32	26	4	30	9061657	Union, NM
4.0	3.3	3.7	64	50	15	3	41	38	5	27	9052963	Union, NM
3.8	3.5	3.5	67	52	12	3	34	31	3	33	Mean – Top five selection	
3.7	2.8	3.0	57	49	37	16	74	58	22	29	Pastura	
3.1	2.8	2.6	62	45	56	27	84	57	56	44	Mean – All accessions	

Figure 5: Means Comparison



Discussion

Pastura, as expected of a cultivar, ranked above the overall average, but was out ranked by 22 accessions. This indicates the potential for significant improvement in a new cultivar. The top five cultivars scored better than Pastura by all five measures, especially in vigor and seed head production.

Recommendations

Develop a true-breeding, hybrid cultivar having superior growth qualities to Pastura, particularly forage production. Polycross the top five accessions in a 5x5 latin square design with four replications arranged in a square pattern. This results in a 10x10 planting. The two outside rows will be treated as border rows, and seed will be collected from the interior 6x6 plants.

Propagate polycross seed and compare to Pastura foundation seed on the basis of vigor and digestible matter. Establish test plots both on-site and in an irrigated field, and off-site in various climatic/soil environments.

Pastura is currently grown for sustained production of foundation seed. The accession evaluation field will also be maintained until final cultivar development.

Table 4: Pastura Evaluation Field

Treatment	Uniformity	Vigor	Height (in)	Mean Width (in)	Seed Head Production	Unif AND Vig>median	Ht & Wd & Seed > Median	All > median	Flowering Days after June 1
1	3.7	2.8	22.5	19.3	3.0	1	0	0	29
2	2.3	2.7	21.3	18.0	2.7	0	0	0	38
3	2.0	2.7	21.3	17.2	2.3	0	0	0	45
4	4.0	3.7	26.7	20.3	3.3	1	1	1	36
5	3.0	3.3	28.7	16.7	2.7	0	0	0	50
6	3.0	3.3	26.0	18.0	3.3	0	1	0	28
7	2.3	2.7	24.7	17.7	3.0	0	0	0	21
8	3.3	3.0	25.3	18.5	2.7	1	0	0	50
9	3.7	2.0	22.7	16.3	3.0	0	0	0	32
10	3.3	2.0	22.0	18.3	3.0	0	0	0	18
11	3.7	2.7	21.7	19.3	3.3	0	0	0	15
12	3.0	2.7	22.0	15.3	3.0	0	0	0	36
13	3.3	3.0	23.3	18.5	3.7	1	0	0	29
14	3.7	3.3	26.7	19.3	2.3	1	0	0	49
15	3.7	3.3	30.0	19.2	2.7	1	0	0	57
16	2.3	3.0	29.3	15.5	2.7	0	0	0	60
17	2.3	2.0	17.0	20.8	2.3	0	0	0	29
18	3.0	3.0	27.7	17.0	2.7	0	0	0	47
19	4.0	3.3	25.7	19.3	2.7	1	0	0	26
20	3.7	2.7	24.7	18.0	2.7	0	0	0	24
21	3.0	3.0	24.3	18.0	3.0	0	1	0	29
22	3.7	2.7	20.0	18.3	2.7	0	0	0	31
23	3.3	3.7	30.0	21.5	2.7	1	0	0	48
24	3.0	3.3	31.3	17.8	2.7	0	0	0	59
25	2.7	2.7	25.7	17.5	2.3	0	0	0	43
26	3.3	2.3	23.3	17.5	2.0	0	0	0	35
28	2.7	2.7	25.0	16.0	3.0	0	0	0	29
29	2.7	2.3	22.7	16.0	2.7	0	0	0	23
30	2.7	2.7	28.0	17.0	3.0	0	0	0	57
31	3.0	2.3	26.7	15.2	2.3	0	0	0	52
32	3.3	3.7	35.3	18.0	3.0	1	1	1	56
33	3.3	3.3	29.0	18.8	2.7	1	0	0	49
34	2.7	2.3	19.3	16.8	2.7	0	0	0	41
35	3.0	3.0	32.7	15.3	2.7	0	0	0	50
36	3.7	3.7	35.0	16.3	2.7	1	0	0	74
37	3.3	3.7	28.0	16.5	2.3	1	0	0	78
38	3.3	3.3	22.0	17.2	3.0	1	0	0	36

Treatment	Uniformity	Vigor	Height (in)	Mean Width (in)	Seed Head Production	Unif AND Vig>median	Ht & Wd & Seed > Median	All > median	Flowering Days after June 1
39	3.0	2.7	24.3	18.7	3.0	0	1	0	27
40	4.0	2.7	14.3	16.3	1.3	0	0	0	73
41	2.7	3.0	25.3	16.0	3.0	0	0	0	32
42	4.0	2.7	18.3	18.5	2.0	0	0	0	73
43	3.7	2.7	21.0	17.8	2.7	0	0	0	25
44	3.0	3.0	25.7	16.3	1.7	0	0	0	89
45	3.3	2.7	24.0	17.8	3.0	0	0	0	34
46	2.7	3.3	23.7	19.0	3.3	0	0	0	38
47	3.3	4.0	28.7	21.3	3.7	1	1	1	35
48	3.3	3.0	25.0	18.3	2.7	1	0	0	33
49	3.3	2.7	21.3	20.2	3.0	0	0	0	36
50	3.3	2.7	20.0	19.2	3.7	0	0	0	30
51	4.0	3.3	25.3	19.5	3.7	1	1	1	27
52	3.0	3.0	21.0	19.7	3.3	0	0	0	31
53	3.3	2.7	20.3	17.8	2.0	0	0	0	32
54	3.0	2.7	21.7	18.8	2.3	0	0	0	40
55	3.3	3.0	27.3	19.8	2.7	1	0	0	40
56	2.7	3.0	25.3	17.3	2.7	0	0	0	30
57	3.3	2.3	22.0	19.7	3.0	0	0	0	40
58	2.7	3.7	27.0	17.0	3.0	0	0	0	40
59	3.7	2.7	25.7	19.7	3.3	0	1	0	36
60	2.0	2.7	25.3	15.8	2.0	0	0	0	50
61	3.0	3.0	29.3	16.2	2.0	0	0	0	63
62	2.7	2.7	19.0	18.3	2.3	0	0	0	39
63	3.0	3.0	31.0	16.5	3.3	0	0	0	34
64	3.0	2.7	23.3	15.7	2.3	0	0	0	47
65	3.7	3.0	23.7	18.0	2.7	1	0	0	32
66	3.3	2.7	22.0	19.2	3.3	0	0	0	27
67	2.7	2.0	18.0	18.5	2.7	0	0	0	30
68	3.0	2.0	18.3	16.2	3.0	0	0	0	22
69	3.7	3.3	23.3	20.0	3.7	1	0	0	30
70	4.0	3.3	25.0	20.8	3.3	1	1	1	36
71	3.0	2.3	24.7	18.5	2.0	0	0	0	39
72	2.7	3.3	31.0	19.0	3.0	0	1	0	44
73	2.7	2.7	25.7	18.7	2.7	0	0	0	64
74	3.3	3.3	19.3	18.8	3.3	1	0	0	36
75	2.0	2.3	18.0	18.8	2.7	0	0	0	28
76	3.7	3.3	26.0	20.5	3.3	1	1	1	30
77	3.3	3.3	28.0	20.5	2.7	1	0	0	44

Treatment	Uniformity	Vigor	Height (in)	Mean Width (in)	Seed Head Production	Unif AND Vig>median	Ht & Wd & Seed > Median	All > median	Flowering Days after June 1
78	3.0	3.0	27.0	19.2	2.3	0	0	0	54
79	2.3	2.7	25.7	17.0	2.0	0	0	0	58
80	3.3	3.0	19.3	18.8	1.7	1	0	0	63
81	3.3	3.0	27.3	17.5	2.7	1	0	0	55
82	3.3	3.0	24.7	18.0	2.3	1	0	0	56
83	4.0	2.7	22.3	20.3	2.0	0	0	0	62
84	3.0	2.7	22.3	19.5	2.3	0	0	0	51
85	3.0	2.0	21.0	17.2	1.7	0	0	0	51
86	3.7	3.0	28.0	17.5	2.0	1	0	0	54
87	2.3	3.3	26.3	17.8	2.3	0	0	0	58
88	2.7	1.3	22.7	17.3	1.7	0	0	0	62
89	2.7	3.0	24.0	17.8	2.7	0	0	0	44
90	2.7	2.0	22.3	17.0	2.0	0	0	0	56
91	2.7	2.0	22.0	16.8	1.3	0	0	0	59
92	2.7	2.7	25.3	17.8	3.0	0	1	0	54
93	3.0	3.0	26.3	17.8	2.7	0	0	0	47
94	2.7	3.3	26.0	17.2	2.7	0	0	0	54
95	2.3	3.0	24.7	16.5	3.0	0	0	0	58
96	2.7	3.3	24.0	17.3	2.7	0	0	0	48
97	2.3	2.0	26.3	15.8	1.7	0	0	0	55
98	3.0	3.0	30.3	16.5	2.7	0	0	0	53
99	2.7	3.0	24.3	17.2	2.0	0	0	0	57
100	3.0	2.7	24.3	15.0	1.7	0	0	0	55
101	2.3	2.3	22.3	16.5	1.7	0	0	0	66
102	3.0	2.3	21.7	17.5	2.3	0	0	0	45
103	3.0	2.7	25.3	17.3	2.3	0	0	0	56
104	3.0	2.0	21.0	16.3	2.0	0	0	0	55
105	3.0	2.3	22.7	17.5	2.3	0	0	0	62
106	2.7	2.3	22.0	18.5	2.0	0	0	0	63
107	3.3	1.3	19.0	16.5	1.3	0	0	0	52
108	3.0	2.3	19.3	20.0	2.3	0	0	0	26
109	3.0	2.7	23.7	18.7	2.3	0	0	0	52
110	3.7	3.3	28.7	18.3	3.0	1	1	1	62
111	2.7	2.0	21.3	16.0	2.3	0	0	0	60
112	2.7	3.0	29.0	15.3	2.7	0	0	0	56

Example 1: Factorial ANOVA Statistical Results

08:18 Tuesday, November 15, 2005
The GLM Procedure
Class Level Information

	Class	Levels	Values
Row/Replicate	R	8	1 2 3 4 5 6 7 8
Lineage	Ln	10	1 2 3 4 5 6 7 8 9 10
Generation	G	2	1 2

Number of Observations Read 160

Number of Observations Used 160

Dependent Variable: Lp (perimeter of leaf foliage - meters)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	30.1814794	1.7753811	2.89	0.0003
Error	142	87.0856216	0.6132790		
Corrected Total	159	117.2671010			

R-Square	Coeff Var	Root MSE	**Lp Mean**
0.257374	9.997795	0.783121	7.832941

Source	DF	Type III SS	Mean Square	F Value	**Pr > F**
R	7	14.78432725	2.11204675	3.44	**0.0020**
Ln	9	14.92794236	1.65866026	2.70	**0.0062**
G	1	0.46920975	0.46920975	0.77	**0.3832**

Dependent Variable: Lht (height of leaf foliage – meters)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	0.55942577	0.03290740	2.05	0.0119
Error	142	2.27617375	0.01602939		
Corrected Total	159	2.83559952			

R-Square	Coeff Var	Root MSE	**Lht Mean**
0.197287	9.605311	0.126607	1.318096

Source	DF	Type III SS	Mean Square	F Value	**Pr > F**
R	7	0.27965660	0.03995094	2.49	**0.0191**
Ln	9	0.27966709	0.03107412	1.94	**0.0510**
G	1	0.00010208	0.00010208	0.01	**0.9365**

Dependent Variable: Vi (index of total volume of leaf foliage = (Lht*Lp^2)/10)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	162.1709034	9.5394649	2.33	0.0037
Error	142	581.3510786	4.0940217		
Corrected Total	159	743.5219820			

R-Square	Coeff Var	Root MSE	**Vi Mean**
0.218112	24.24453	2.023369	8.345673

Table 5: Little Bluestem

Treatments Selected for Polycross **Field 8**

	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	
NW																			NE
19	22	86	52	62	66	39	44	88	102	67	10	33							78
18	7	29	9	20	63	108	48	34	46	35	94	77	109	96	36	68	**27**	21	74
17	26	17	41	32	16	3	**1**	11	61	105	99	37	83	43	80	25	75	24	70
16	31	71	112	93	56	98	30	28	5	60	110	57	89	54	85	14	97	74	66
15	100	90	73	2	13	58	104	59	64	**51**	103	107	38	**4**	92	12	19	50	62
14	91	**70**	81	82	79	69	**47**	87	6	42	8	55	49	45	[76]	23	40	101	58
13	104	85	80	112	10	34	26	99	111	84	18	65	72	53	15	78	106	95	54
12	40	22	18	64	45	90	38	61	69	63	48	3	42	95	57	108	54	68	50
11	107	9	88	30	97	6	50	96	44	56	55	62	75	46	91	74	67	81	46
10	7	43	111	31	79	98	21	29	39	93	84	60	59	16	32	5	**27**	89	42
9	71	28	**1**	103	110	109	101	100	**4**	58	**47**	36	14	52	11	82	19	37	38
8	92	20	25	102	53	24	23	41	106	94	72	77	105	12	17	78	83	**70**	34
7	101	91	99	45	87	35	65	33	66	8	15	**51**	**76**	73	13	86	49	2	30
6	107	97	35	32	49	**76**	40	20	78	94	103	98	89	83	64	30	85	24	26
5	31	34	81	18	86	43	56	11	95	26	52	79	108	19	80	2	9	63	22
4	37	17	61	60	10	6	46	55	**51**	22	50	**70**	71	62	28	110	77	69	18
3	73	36	68	104	5	29	38	67	15	109	23	74	8	25	87	**1**	84	54	14
2	72	82	111	105	88	21	41	33	**47**	16	14	7	92	96	66	**4**	59	65	10
1	48	106	90	100	93	112	53	**27**	13	102	58	44	12	3	39	57	42	75	6
SW	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	SE

Bold Yellow are top ranked for polycross

Bold Red (#1, #27) is Pastura

Top Five Treatments 47, 4, 70, 76, 51

Northwest Plant of plot flagged white.

[76] Boxed treatment has Filler plants. Filler plants flagged red.

(Plant 4 of treatment 76 at row 58, column 29)

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Fragrant Ash (*Fraxinus cuspidata* Torr.)

Study Number: NMPMC-P-9901-UR

Seed of fragrant ash (Accession No. 9066495) were collected near Grants in Cibola County of northwest New Mexico. Seedlings of this accession were propagated and planted in one row in Field 26S at the LLPMC in 2000. Fragrant ash occurs in much of western New Mexico (Martin and Hutchins 1980) and is found from Texas to Nevada. This species is usually found as a small tree or large shrub on rocky slopes at elevations from 5,000 to 7,000 ft in New Mexico (Carter 1997). The presence of fragrant flowers and delicate drooping leaves distinguish this species from other native ashes (Carter 1997).

In September 2005, 18 plants were evaluated; two plants of the original 20 were dead. Limited amounts of seed were found on some plants in 2005. The plants were measured for height and canopy width, seed collected from each plant, and canopy form was noted. Height/width ratios were calculated as an indication of plant form. Table 6 presents data collected on each plant as well as means, standard error of the means, maximum values, and minimum values.

Table 6: Data Collected

Field Location	Plant No.	Height (m)	Canopy Width (m)	Seed Production (g)	Notes on Appearance and Plant Form	Height to Width Ratio
North end	1	2.26	1.98	4	Globose	1.14
	2	2.78	2.40	26		1.16
	3	2.76	2.66	8		1.04
	4	2.78	2.50	54	Densely branched	1.11
	5	2.64	1.70	24		1.55
	6	2.34	2.18	13	Globose	1.07
	7	3.00	2.32	8	Open habit	1.29
	8	2.60	2.50	19	Open habit	1.04
	9	2.16	1.92	0		1.13
	10	1.68	1.30	0		1.29
	11	3.55	2.82	0	Globose	1.26
	12	1.75	1.40	0		1.27
	13	2.44	1.64	17	Open habit	1.49
	14	2.02	1.66	6	Globose	1.22
	15				Dead	
	16				Dead	
	17	2.52	2.34	0	Open habit, upright	1.08
	18	2.50	1.48	2	Globese	1.69
	19	2.24	1.78	4		1.26
South end	20	1.96	1.59	0		
	Mean	2.45	2.01	10.28		1.24

Table 6: Data Collected

Field Location	Plant No.	Height (m)	Canopy Width (m)	Seed Production (g)	Notes on Appearance and Plant Form	Height to Width Ratio
	Maximum	3.55	2.82	54.00		1.69
	Minimum	1.68	1.30	0.00		1.04
	SE of the Mean	0.44	0.45	13.51		0.18

Fragrant ash heights ranged form 1.68 to 3.55 m and widths from 1.30 to 2.82 m. Plant form observations indicate 30% of the plants have somewhat globose forms and about 20% have an open branching habit. The mean height/width ratio of 1.24 shows a general suggestion of a fairly globose habit. Five plants yielded substantial (>15g) amounts of seed, but many plants produced little or no seed. Seed collected in mid-September 2004 was split into 2 batches, one kept moist (M) and the other air dried for 2 weeks (D). Then these 2 batches were treated by 2 methods: one treatment was warm stratification for 6 weeks followed by cold stratification for 4 months (WS/CS) and the other treatment was cold stratification for 4 months (CS). The greatest germination was achieved with dry seed treated by warm stratification followed by cold stratification (D-WS/CS). Assigning a relative germination percentage of 100% to the D-WS/CS treatment, the other seed treatments had lower germination percentages: 57% M-WS/CS, 39% M-CS, and 15% D- CS. Although prolonged dry storage might reduce total germination, a limited air drying immediately after seed collection had an uncertain influence on germination. Definitely warm stratification before cold stratification was beneficial.

After the fragrant ash plants are more fully mature, the individuals with the best flowering, seed production, and growth form could remain in the field for seed production while those without ornamental attributes could be removed. The anticipated difficulty of vegetative propagation probably precludes the development of clonal stock.

Figure 6: Fragrant ash individual #8, 2.60 m high x 2.50 m wide (8.5 feet high x 8.2 feet wide), height/width ratio 1.04, most floriferous individual (photo taken 5/2/2006).

Literature Cited

Carter, J.L. 1997. Trees and shrubs of New Mexico. Johnson Books, Boulder, CO. 533 p.

Martin, W.C. and C.R. Hutchins. 1980. A flora of New Mexico. A.R. Gantner Verlag K.G., Germany. 2591 p.

Singleleaf Ash (*Fraxinus anomala* Torr. Ex S. Wats.)

Study Number: NMPMC-P-9804-UR

Seed of singleleaf ash (Accession No. 9066184) were collected from Hogback Mountain (a monocline along the west edge of the San Juan Basin) in San Juan County of northwest New Mexico. Seedlings of this accession were propagated and planted in 2 rows in Field 26S at the LLPMC in 2000. Singleleaf ash occurs only in San Juan and Catron Counties of western New Mexico (Martin and Hutchins 1980) but is widely distributed throughout the Colorado Plateau. This species is usually found as a small tree or large shrub on rocky slopes or adjacent to streams at elevations from 4,400 to 6,000 ft (Carter 1997).

In September 2005, all 40 plants planted were evaluated – there was no mortality. No seed was found on any plants in 2005, but in the spring of 2006 several plants have produced seed. The plants were measured for height and canopy width and were evaluated for canopy form, foliage color, and apparent plant vigor. Height/width ratios were calculated as an indication of plant form. Table 7 presents data collected on each plant as well as row means, grand means, standard errors, maximum values, and minimum values.

Table 7: Data Collected

Field Location	Plant No.	Height (m)	Width (m)	Form	Foliage Color[1]	Vigor	Height/ Width
North End	1	2.72	1.86	Vase	G	3	1.46
East Row	2	2.86	2.42	Globose	DG	4	1.18
	3	2.62	1.81	Upright	VDG	4	1.45
	4	2.02	1.3	Vase	DG	3	1.55
	5	2.56	2.06	Globose	VDG	4	1.24
	6	3.28	1.72	Columnar	VDG	5	1.91
	7	2.64	2.26	Globose	DG	4	1.17
	8	2.98	2.02	Upright	DG	4	1.48
	9	2.18	1.74	Vase	G	3	1.25
	10	2.64	1.6	Upright	G	3	1.65
	11	3.06	2.06	Vase	Y	2	1.49
	12	1.26	0.38	Upright	YG	1	3.32
	13	2.4	1.64	Upright	G	3	1.46
	14	0.96	0.28	Upright	YG	1	3.43
	15	2.28	1.84	Globose	G	4	1.24
	16	2.1	1.1	Columnar	G	2	1.91
	17	2.96	2.54	Globose	DG	4	1.17
	18	3.08	2.36	Upright	G	4	1.31

[1] VDG = very dark green, DG = dark green, G = green, YG = yellow-green, YE = yellow

Table 7: Data Collected

Field Location	Plant No.	Height (m)	Width (m)	Form	Foliage Color[1]	Vigor	Height/ Width
South End	19	2.28	1.68	Upright	VDG	5	1.36
East Row	20	3.58	2.98	Globose	G	4	1.20
East Row	Mean	2.52	1.78			3.35	1.61
North End							
West Row	1	1.96	1.12	Upright	G	3	1.75
	2	3	2.24	Upright	DG	4	1.34
	3	2.5	1.52	Columnar	G	3	1.64
	4	2.82	1.58	Columnar	DG	4	1.78
	5	2.18	0.91	Upright	YG	2	2.40
	6	1.87	0.88	Columnar	G	2	2.13
	7	2.93	1.88	Vase	DG	4	1.56
	8	2.74	1.54	Columnar	G	3	1.78
	9	2.12	1.36	Upright	DG	3	1.56
	10	2.62	1.86	Upright	DG	4	1.41
	11	2.58	0.98	Columnar	DG	3	2.63
	12	2.36	0.78	Columnar	YG	2	3.03
	13	2.11	1.12	Columnar	G	2	1.88
	14	2.31	1.08	Columnar	YG	1	2.14
	15	2.37	1.05	Columnar	VDG	3	2.26
	16	2.3	1.66	Globose	VDG	4	1.39
	17	3.5	3.17	Other	G	3	1.10
	18	3.35	2.19	Vase	VDG	5	1.53
South End	19	1.89	0.96	Upright	G	3	1.97
West Row	20	1.4	0.78	Upright	G	4	1.79
West Row	Mean	2.45	1.43			3.10	1.85
	Grand Mean	2.48	1.61			3.23	1.73
	Standard Error	0.56	0.64			1.04	0.56
	Maximum	3.58	3.17				3.43
	Minimum	0.96	0.28				1.10

Singleleaf ash heights ranged form 0.96 to 3.58 m and widths from 0.28 to 3.17 m. Observations of plant form indicate a predominance of columnar (37%) and upright (27%) forms with globose (17%) and vase (15%) making up about a third of the plants. The dark green and green foliage categories make up 67% with very dark green and yellow/yellow green classes each accounting for 17 and 15%, respectively. When foliage color was assigned numeric values (5 for very dark green to 1 for yellow) there was a strong correlation with vigor. However, a correlation of height and vigor was only slightly positively correlated, indicating that vigor ratings were based more on foliage color than growth.

If height/width ratios are used as an objective measure of plant form, 4 categories can be developed and assigned to the forms: h/w > 2.5 as columnar, 2.0 – 2.5 as upright, 1.5 – 2.0 as vase, and < 1.5 as globose. Using these height/width ratios, it becomes apparent that globose and vase are the most common forms (45% and 35%) with columnar and upright accounting for only 10% and 7%, respectively. As with vigor, the observations of plant form are not substantiated by measurements.

Of the 40 plants, 11 plants are dark to very dark green with height/width ratios of less than 1.5 (globose) and 5 plants have similar foliage colors with height/width ratios between 1.5 and 2 (vase). For landscape horticulture use, this group of 16 plants might represent those with most ornamental appeal. Vegetative propagation of many ashes requires grafting, so clonal production would be very involved if rooting of stem cuttings can not be accomplished. If and when this species sets viable seed, those plants with the least ornamental value could be removed from the planting with the intent of producing seed plants with the greater ornamental attributes such as globose form and dark green foliage.

Figure 7: Singleleaf ash individual #18, West row, 3.35 m high x 2.19 m wide (11 feet high x 7 feet wide), height/width ratio is 1.53, very dark green foliage (photo taken 5/2/2006)

Literature Cited

Carter, J.L. 1997. Trees and shrubs of New Mexico. Johnson Books, Boulder, CO. 533 p.

Martin, W.C. and C.R. Hutchins. 1980. A flora of New Mexico. A.R. Gantner Verlag K.G., Germany. 2591 p.

Blue Grama Variety Trial

Study Number: NMPMC-T-0401-RA

Grazing competition between elk and livestock has become a concern for landowner Carl Smith. Elk graze on his forage pasture during the spring which decreases the available forage for livestock during the summer-grazing season. The elk herd in the area eats the cool-season grass forage prior to the introduction of livestock in the summer months. Without the cool-season species forage and because of the low production rate of warm-season species forage (which is the indigenous forage species at the ranch), the livestock end up with an insufficient amount of forage during the summer grazing period. Additionally, Mr. Smith's ranch is located at an elevation of 8,200 feet which adds an extra complication because of the short growing season.

In an attempt to solve this problem, the USDA-NRCS Espanola Field Office and the LLPMC agreed to plant and test improved varieties of blue grama at Mr. Smith's ranch. Blue grama (*Bouteloua gracilis)* is a component of the warm-season forage species indigenous to the ranch.

The native blue grama exhibits a low rate of forage production and does not contribute much to the total forage produced during the warmer summer months. By planting the improved varieties of blue grama, it could provide a greater forage potential at this 8,200-foot elevation.
On July 27, 2004, the LLPMC installed the following improved varieties of blue grama on Mr. Smith's ranch:

- Hachita
- Lovington
- Alma
- Bad River Ecotype

Hachita, Alma and Lovington were developed by the LLPMC. Bad River Ecotype is an ecotype release from the Bismarck Plant Materials Center in North Dakota. By including the Bad River Ecotype in the trial planting, it allowed us the opportunity to evaluate an accession from a northern climate. The trial planting covers 0.10 acres in 16 replicated plots. The seed was installed using a plot drill, and it was evaluated on 10/01/2004. None of the blue grama seed had germinated. However, because we did not plant until late July, it may have been too late in the season for germination to occur at this elevation.

In the spring of 2005, Mr. Smith removed the 2004 blue grama trial planting to prepare the area for a new trial planting. On June 6, 2005, the staffs from the Espanola USDA-NRCS Field Office and the LLPMC installed the same four improved varieties of blue grama and, except for the earlier planting date, used the same installation procedures as used in 2004. The 2005 seeding was installed at an earlier date in order to provide a longer growing season for any seed that may germinate. This longer growing period compensates for the shorter growing period at this elevation.

On September 28, 2005 germination of the seeding had occurred. The replicated plots of the four improved varieties of blue grama had seedling emergence, and the plots, as a whole, had from 10 to 50 percent germination. All of the seedlings looked healthy and vigorous and were approximately two inches high. These plants should have a sufficient amount of growth to survive the upcoming winter dormant period. No disturbance by wildlife or livestock was observed on any of the plots.

We are concerned that at this time, the plots have not been fenced for protection from livestock and wildlife. The landowner is aware of this concern, and he stated he will fence the area as soon as possible.

An evaluation of the planting is scheduled for 2006.

Forage Triticale Planting Trial

Study Number: NMPMC-T-0001-RA

In 2000, Mr. Glen of Jeff Glenn Farm approached the USDA-NRCS Silver City Field Office to inquire about improved selections of triticale that might be available commercially. Mr. Glenn has been planting triticale as winter forage irrigated pasture on his farm for several years, and he wanted to find out if other varieties would produce more forage than his existing variety of triticale. The field office then contacted the LLPMC in 2001 to see if a field trial of different triticale varieties could be installed on Mr. Glenn's property.

In the fall of 2001, a trial planting of other varieties of triticale was installed by the LLPMC, and during the winter-grazing period forage data was taken by the field office staff. The tested varieties did not perform any better than the triticale Mr. Glenn had been using previously.
No action of any kind was taken in 2005 on Mr. Glenn's trial planting. Pending a decision by the field office and Mr. Glenn, additional testing of other irrigated species could be part of the project in 2006. The LLPMC will be contact with the Silver City Field Office in 2006 to determine the outcome of this study.

New Mexico Department of Transportation 2005 Cooperative Seeding Project Agreement

Study Number**:** NMPMC-T-0502-OT

In 2005, a cooperative agreement was developed between the New Mexico Department of Transportation (NMDOT) and the Natural Resources Conservation Service's Los Lunas Plant Materials Center (LLPMC). The new agreement begins a three-year project between the two agencies to evaluate the revegetation technology currently being used by the NMDOT. The NMDOT has had difficulty meeting the national vegetation requirements following the completion of road construction projects. The proposed work in the new 2005 agreement will study the current revegetation technology and determine its effectiveness.

In 1992 (as a result of a similar agreement), the LLPMC produced a Handbook of Roadside Vegetation Management that contained the necessary information to successfully revegetate areas that were disturbed by roadside construction. Species selection for seed mixes in this handbook was based upon species identified in the Natural Resources Conservation Service range site descriptions for a particular location. The NMDOT would like a more simplified procedure based on only three standard seed mixes for Region 6 (northwest New Mexico): one for desert regions, one for the foothill pinyon-juniper region, and one for all of Region 6 that consists of a cool-season, xeric mixture than can be successfully seeded in the fall.

Beginning in 2006, the NMDOT and the LLPMC will identify the study sites, select the plant species, select different mulching treatments, and apply the treatments on road construction projects. Mulching treatments will include using pinyon wood chips. These treatments will be evaluated for three years and consider cover, density, and species composition.

The new agreement allows the LLPMC an opportunity to investigate new mulching treatments and new plant materials that have been made available since 1992 and were not evaluated in the first NMDOT revegetation study by the LLPMC. The outcome of this agreement will provide useful information about revegetation technology for both the NMDOT and the LLPMC.

Evaluation of Giant Sacaton for Use in Field Windstrip Plantings

Study Number: NMPMC-P-9801-CP

NRCS Field Offices continue to be very interested in using the giant sacaton native species for windstrip plantings. In 2005, the Los Lunas Plant Materials Center (LLPMC) evaluated giant sacaton plantings at several locations in New Mexico: Clayton, Columbus, Deming, Isleta Reservation, Lovington, McIntosh, Tatum, and Tucumcari. The distribution and planting of giant sacaton continues to promote the utility of this species for use as a windstrip, and it additionally defines its range of adaptability.

Clayton, NM–Ken Dellinger Property

In June of 2004, a giant sacaton windstrip was installed on the Ken Dellinger property in Clayton, New Mexico using transplants from the Los Lunas Plant Materials Center. The planting was installed to provide wind protection and landscaping at Mr. Dellinger's livestock sales yard. The windstrip will provide wind protection for Highway 64 located adjacent to the livestock yard. The sacaton planting will also provide a visual screen from the livestock yard for traffic along the highway. A drip irrigation system provides water to the windstrip.

On September 21, 2005 the windstrip was evaluated for survival and growth. All plants are established with a 100-percent survival rate. The planting looks healthy and vigorous, and all plants have produced seedheads. The sacaton plants averaged 30 inches in height and 18 inches in width and are receiving adequate water for optimum growth.

An evaluation is scheduled for 2006.

Columbus, NM–Rancho La Frontera

The Rancho La Frontera located in Columbus, New Mexico, has had two, separate giant sacaton windstrip plantings. The first planting was installed in 1999-2000, and the second planting was installed in 2001. Both of these plantings were evaluated in 2005. All of the plants in the 1999-2000 windstrip planting appear to be vigorous and have produced seed heads. These plants average 8 feet in height and 48 inches in width. The 2001 windstrip planting also appears healthy, and the surviving plants are vigorous and have produced seed heads. These plants averaged 8 feet in height and 48 inches in width. The plants that originally died in the 2001 planting have been replaced with new transplants, and these plants appear to be healthy.

An evaluation is scheduled for 2006.

Deming, NM–Turner Ranch

This giant sacaton windstrip planting is located on the Turner ranch approximately 15 miles northwest of Deming, New Mexico. The planting was installed in July 2002 using transplants grown at the LLPMC. The windstrip is adjacent to irrigated cropland and will provide wind erosion protection for the cropland during the windy season (February–May). This planting will provide evaluation data on the suitability of giant sacaton as a windstrip species in this part of New Mexico. The planting was evaluated in November of 2004 for survival and growth. The plants had averaged 7 feet in height and 38 inches in width, and all of the plants had produced seed heads. No plants have been lost since the 2003 evaluation. The plants appeared to be healthy, vigorous, and well established.

On September 19, 2005 the giant sacaton windstrip was evaluated for growth and survival. The planting did not receive adequate moisture in 2005. Plants averaged 52 inches in height and 32 inches in width and all had produced seedheads. The planting was not mowed during the dormant period and weeds were not controlled in 2005. The irrigated cropland next to the windstrip was not irrigated during 2005. This windstrip evaluation may be discontinued if the adjacent cropland has been abandoned.

An evaluation is scheduled for 2006.

Deming, NM–Keeler Farm

This giant sacaton windstrip planting is located in Deming, New Mexico on Keeler Farms. The planting was installed in July 2002 using transplants grown at the LLPMC. The windstrip is located on the west side of an irrigated field and will protect the cropland from wind erosion during the windy season (February–May). The planting will provide evaluation data on giant sacaton for use in windstrips in this area of New Mexico. The planting was evaluated in November of 2004 for survival and growth. The plants had averaged 7 feet in height and 38 inches in width, and all of the plants had produced seed heads. Survival has remained constant since the last evaluation, and all of the plants appear to be healthy and vigorous. However, this planting does have a serious weed problem. African rue is growing in the windstrip and must be controlled to prevent damage to the planting, and also to keep it from spreading to the adjacent cropland. Mr. Keeler is aware of this problem and has initiated a chemical control program.

On September 19, 2005 the windstrip was evaluated for growth and survival. The plants look healthy, vigorous and all have produced seedheads. The plants averaged 6 feet in height and 30 inches in width. The windstrip still contains the noxious weed African Rue and is being chemically treated by the landowner in an attempt to eradicate it. No plants have been lost since the last evaluation and this planting provides excellent protection for the adjacent cropland.

An evaluation is scheduled in 2006.

Isleta Reservation, NM–Bernard Lujan

This giant sacaton windstrip was installed in July 2004 on the Bernard Lujan Farm in Isleta, New Mexico located in Valencia County. This windstrip will provide protection during the windy season for Mr. Lujan’s homestead. The planting consists of a single row of giant sacaton planted 5 feet apart; it is located on the west side of the homestead next to an irrigated alfalfa field. The giant sacaton transplants used in the windstrip were grown at the LLPMC. This planting is part of the adaptability trial of this native grass species for use in windstrips and will enable us to evaluate giant sacaton as a windstrip species in this area of New Mexico. The planting showed a 100 percent survival rate at the October 2004 evaluation. The plants had averaged 12 inches in height and 10 inches in width.

On September 30, 2005 the planting was evaluated for survival and growth of the plants. Five plants were destroyed by gophers in 2005 and will be replaced in 2006. The remaining plants are healthy, vigorous and all have produced seedheads. The plants averaged 40 inches in height and 20 inches in width.

An evaluation is scheduled for 2006.

Lovington, NM–USDA-NRCS Service Center

This giant sacaton windstrip planting is located at the USDA-NRCS Service Center in Lovington, New Mexico. The giant sacaton was planted in 2003 using transplants grown by the LLPMC. The sacaton was planted along the edge of the service center parking lot and along the north side of the service center office building. This planting is an evaluation for the use of giant sacaton as wind protection in this area of New Mexico.

On September 20, 2005 the planting was evaluated for growth and survival. The plants averaged 58 inches in height and 28 inches in width and all had produced seedheads. The planting is being irrigated by a drip irrigation system and all are established and look healthy and vigorous. A few of the plants on the west side of the building were destroyed by gophers during the first season after transplanting. These missing plants may be replaced in 2006.

An evaluation of the planting is scheduled for 2006.

McIntosh, NM–Schwebach Farm

This giant sacaton windstrip planting is located in McIntosh, New Mexico. The planting was installed in August of 2004 using transplants grown at the LLPMC. The windstrip was installed along the west side of a farm road adjacent to irrigated cropland. The planting will protect cropland from wind erosion during the windy season (February–May) and will be irrigated using water from an existing underground irrigation pipeline. Plants were planted in two staggered rows and spaced 6-feet apart. At the October 2004 evaluation, the plants had averaged 10 inches in height and 6 inches in width with 100 percent survival. The plants appear to be healthy and vigorous, and they have received abundant moisture due to heavy rains in the area. This planting will help us to evaluate the suitability for this species to be used as a windstrip in this part of New Mexico.

On September 21, 2005 the planting was evaluated for growth and survival. All plants were alive and in good condition. The planting was not watered regularly in 2005, due to problems with the farm irrigation system. The plants averaged 28 inches in height and 14 inches in width. With adequate water in the 2006 growing season, this windstrip should provide good protection to the adjacent cropland during the 2007 windy season.

An evaluation is scheduled for 2006.

Tatum, NM–Tatum Memorial Cemetery

On May 23, 2002 a giant sacaton windstrip was installed at the Tatum Memorial Cemetery in Tatum, New Mexico. The windstrip is a joint project between the town of Tatum, the Lea Soil and Water Conservation District and the Sureste Resource Conservation and Development office. The planting provides wind protection for the cemetery and tests the adaptability of giant sacaton in this part of New Mexico for use in windstrips.

The planting consists of 172 giant sacaton transplants, planted along the east and west sides of a new section of the cemetery. The grass windstrip is providing wind erosion protection from the adjacent rangeland. The windstrip receives irrigation from the existing sprinkler system used to water the lawn grass in the cemetery.

On September 20, 2005 the windstrip was evaluated for survival and growth. The plants are healthy and vigorous and all had produced seedheads. No plants have been lost since the last evaluation. The plants averaged 64 inches in height and 32 inches in width. The planting continues to be irrigated using the existing cemetery sprinkler system.

An evaluation of the planting is scheduled for 2006.

Tatum, NM–Tatum Town Park

On June 12, 2003 a giant sacaton windstrip planting was installed at the Tatum Town Park in Tatum, New Mexico. The windstrip is a joint project of the Town of Tatum, the Sureste Resource and Conservation Area and the Lea Soil and Water Conservation District. The planting was installed for wind protection at the park and is testing the adaptability of giant sacaton for wind protection and use as a landscape plant in this part of New Mexico.

The planting consists of 300 giant sacaton transplants, planted along the north, west and east sides of the town park in Tatum. The grass windstrip will receive irrigation from the existing sprinkler system that waters the grass lawn and trees in the park.

On September 20, 2005 the windstrip was evaluated for growth and survival. Several plants have been mowed recently and have minimal growth. Competition between the existing vegetation of the park appears to be causing the sacaton to have less growth than would be expected. No plants have been lost since the last evaluation. The plants that were not mowed averaged 38 inches in height and 20 inches in width and all have produced seedheads. The planting continues to receive irrigation from the existing park sprinkler system.

An evaluation is scheduled for 2006.

Tucumcari, NM–Outdoor Classroom

The giant sacaton planting at the Tucumcari outdoor classroom appears to be healthy; all of the plants are vigorous and have produced seed heads in 2005. The plants have averaged 5 feet in height and 36 inches in width. These plants are not receiving any additional watering; they have done well with just rainfall moisture. The plants do receive runoff from an adjacent paved road and parking lot during rainfall events. Additional plants maybe installed in 2006 to expand the windstrip area.

An evaluation is scheduled for 2006.

Habitat Restoration Project

Study Number: NMPMC-T-0404-RI

Abstract

Due to the construction of silvery minnow egg retention ponds, the Los Lunas Plant Materials Center (LLPMC) was contracted to restore 1.2 miles of the Rio Grande river bank in Los Lunas, New Mexico. The LLPMC planted native vegetation on approximately 16 acres of a disturbed area of the bosque. The LLPMC implemented planting techniques that involved getting the plants' roots or the cut end of the pole cuttings into the soil where subsurface water is naturally present. This technique takes advantage of natural irrigation.

Currently, most of the plants are healthy even though they have not received any supplemental irrigation. However, the plantings were inundated for 50 or more continuous days in May, June and July 2005, killing many of the transplants and pole cuttings. The rate of survival was affected by plant species and container type.

The plantings included four acres of grass and penstemon seeding, 1200 transplants of three shrub species grown in tall pots, 100 New Mexico olive transplants grown in tree pots, 780 cottonwoods pole cuttings, and 865 black willow pole cuttings.

The survival rate of skunkbush sumac transplants grown in tall pots (8%), New Mexico olive transplants grown in tree pots (14 %), and newly planted cottonwood pole cuttings (27%) were severely impacted by the 50 plus days of continuous inundation. The survival rate of transplants of wolfberry grown in tall pots (50%) was also reduced by the inundation. The wolfberry plants that were planted in low areas and were inundated for the longest period of time had typically died. However, survival of second-year planting of cottonwood pole cuttings (76%) and New Mexico olive grown in tall pots (93 %) was not affected by the 50 plus days of continuous inundation. Survival of the newly planted black willow pole cuttings (67%) did not seem to affected by inundation if they were planted in sandy top soils. When planted on sandy top soils, nearly 100 % of the plants survived. On clay top soils, most had died.

Moist soil along riparian areas in the arid southwest is very conducive to growing vegetation, including competitive weeds species. Once the soil of a riparian area is disturbed, it is common for annual and perennial weeds to establish quickly. New plantings and seedings will find it difficult to compete with fast-growing weeds for light, water, and nutrients. Applying a surface layer 4-6 inches of wood chips will reduce weed emergence and allow desired plants to grow. Surface mulch was not applied in this planting, and resulted in a continual application of weed control methods to protect the desired plants.

Currently, the four-acre seeding on the high-flow berm has not become established. It is competing with a dense population of annual weeds. The LLPMC will continue mowing this seeding to reduce the weed competition.

In addition, dense stands of salt cedar seedlings and salt cedar root sprouts are becoming established on the planting areas along the high-flow berm. These stands of salt cedar need to be

controlled while they are small and can be killed easily by herbicide applications. If the salt cedar stands are not controlled, they will be more competitive and reduce the density of the desired vegetation.

Introduction

The USDA-NRCS Los Lunas Plant Materials Center (LLPMC) participated in an interagency project designed to restore the hydrology of an area of the Rio Grande in Los Lunas to its natural condition where spring overbank flooding occurs. In an effort to protect the survival of the Silvery Minnow, egg retention ponds were constructed inside a 1.2 mile high flow channel on the river. In the process of building these structures, some of the native and non-native vegetation had to be cleared away. To restore this area to its natural vegetative state, the LLPMC implemented some unique planting methods which will require little or no irrigation. These planting methods were either developed or refined by the LLPMC, and they were used on this project to measure their effectiveness.

Developing a successful transplanting system that requires minimal follow-up irrigation is critical for bosque restoration in the droughty Southwest. These areas receive less than 10 inches of annual precipitation. The selection of tall pots (containers 30-inches in length and 4-inches in diameter) coupled with embedded irrigation tubes (40-inches in length and 1-inch in diameter) were tested at this site. Pole cuttings of cotton woods and western black willows were also tested.

Both planting systems rely on getting roots or pole cuttings into the soil where subsurface water is present to provide the irrigation needs for the plants.

The participants in this project consisted of the Los Lunas Plant Materials Center (LLPMC), the Albuquerque District of the U.S. Army Corps of Engineers, the Albuquerque office of the U.S. Bureau of Reclamation (USBR), and the Middle Grande Conservancy District (MRGCD).

Background

In the area of the minnow ponds, the cottonwood gallery was destroyed in a wildfire in the spring of 2000. The scorched, 50-foot mature cottonwood trees appeared to be dead, but by late summer of 2000 they were starting to re-sprout at their base. In order to start the construction of the egg retention ponds in 2002, all of the wood debris had to be removed.

At the request of the LLPMC, the fine branches of the cottonwoods and small trees were chipped and transported to an off-site location. Traditionally the wood chips are used as a mulching layer and spread on the planting site, but the LLPMC thought it would be easier to establish cottonwood pole cuttings, shrub transplants, and grass seedings if the mineral soil was exposed and not covered by a layer of mulch. This would prove to be a costly mistake because of the prolific weed emergence as described in the results section of this document. The larger material, such as the main stems of the mature trees, were also removed and transported to an off-site location. Some standing dead trees were left intact to provide for woodpecker and raptor habitat.

Planting Preparation and Installation

The planting area consisted of two sites totaling approximately 16 acres and 1.2 miles in length (Figure 8). There are approximately eight acres along the MRGCD drain ditch road and approximately eight acres along the high-flow berm adjacent to the Rio Grande. The MRGCD requested us to leave a 30-foot open area along the berm for access to the site.

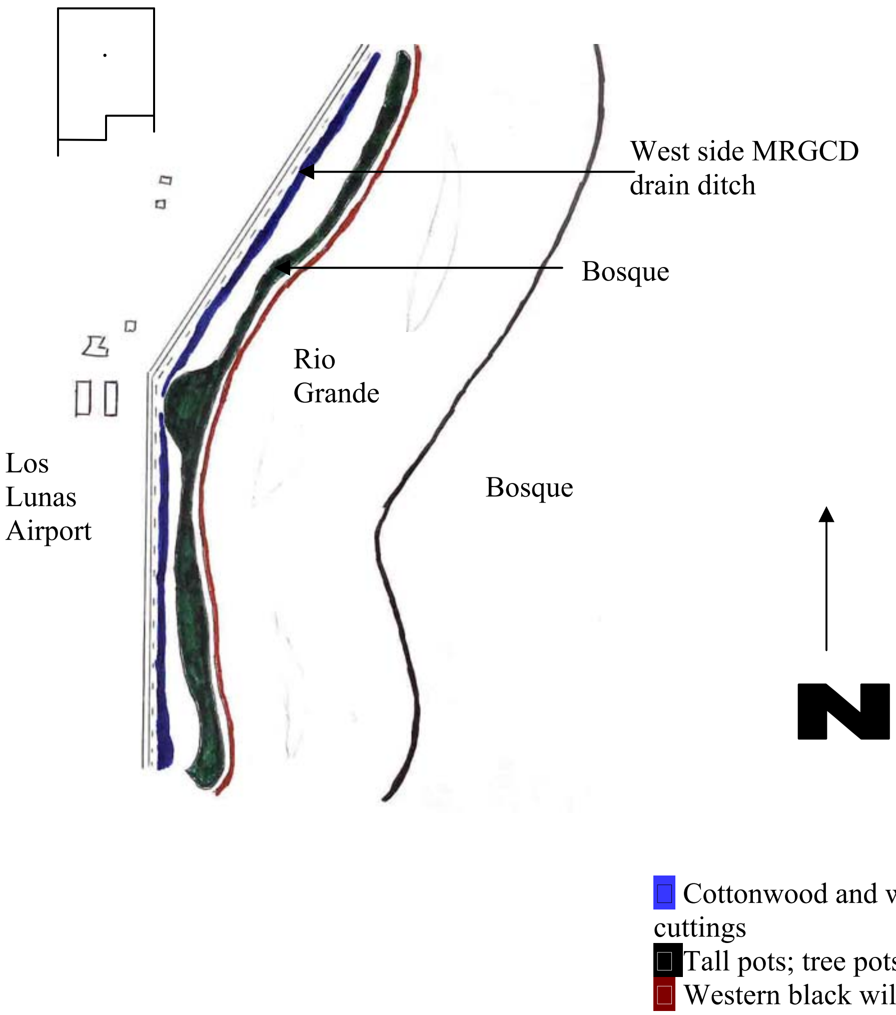


Figure 8: Map detail of the Los Lunas Habitat Restoration Project

April 2004

Location: North of the river access road between the existing bosque and the MRGCD drain ditch road.

The LLPMC staff planted 580 cottonwood (*Populus eltoids*) pole cuttings and 20 western black willow (*Salix gooddingii)* pole cuttings. The original source of the poles was taken from the Bosque del Apache Wildlife Refuge, but the poles that were cut and planted were grown and harvested from production fields at the LLPMC. We prepared the poles by pruning all but two or three terminal branches. The cut poles were then kept hydrated by placing their cut ends in water tanks until they could be planted.

The planting holes were dug using a 65-hp farm tractor with a front-end mounted auger that was 9-inches in diameter and 8-foot in length (see Figure 9). We planted the poles on 15–30 foot centers. After planting the poles we placed a poultry-wire tree guard (5-foot in height and 10-inches in diameter) around each pole to control beaver predation.

Figure 9: Planting cottonwood poles in April 2005

May 2004

By May of 2004, several mature cottonwoods had fallen over the access road that parallels the high-flow berm. The LLPMC staff used chain saws to cut up the debris, and then removed it from the planting site.

May, June, July 2004

Location: 1.2 mile high-flow berm along the river and the access road parallel to the high-flow berm (see map).

To prepare for the seeding, we sprayed this area once in May, once in June, and once in July with the herbicide glyphosate ('Rodeo') at the rate of one-gallon per acre to control common annual weeds. The site was kept fairly clean with this treatment. To apply the herbicide, we used a 50-hp farm tractor outfitted with a power take off (PTO), 10 ft. boom spray system. The entire seeding area is approximately 4 acres in size.

Because the access road had been driven over regularly by vehicles resulting in compacted soil, we disked the access road that had been sprayed prior to the seeding.

August 2004

During the first week of August 2004, the prepared site was seeded by hand-broadcasting the seed. The seed then was incorporated into the soil by harrowing with a farm tractor which covered the seed with approximately ¼-inch of soil.

The seed mix was composed of sand dropseed (*Sporobolus cryptandrus*), Indian ricegrass (*Achnatherum hymenoides*), alkali sacaton (*Sporobolus airoides*), blue grama (*Bouteloua gracilis*), galleta (*Pleuraphis jamesii*), and narrowleaf penstemon (*Penstemon angustifolius)* (see Table 8).

Table 8: Seed mix for the Los Lunas Restoration Project

Common Name	Scientific Name	% Composition	Seeds/lb	Seeds /sq ft	PLS lbs/acre
Blue grama	Bouteloua gracilis	10	825,000	4	0.21
Galleta	Pleuraphis jamesii	20	470,000	8	0.74
Indian ricegrass	Achnatherum hymenoides	40	141,000	16	4.94
Alkali sacaton	Sporobolus airoides	15	1,758,000	6	0.15
Sand dropseed	Sporobolus cryptandrus	10	5,298,000	4	0.03
Narrowleaf penstemon	Penstemon angustifolius	5	313,000	2	0.28

September 2004, July and August 2005

The seeding was mowed with a brush hog once in September 2004, once in July 2005, and once again in August 2005 to control annual weeds (Figures 10 and 11).

Figure 10: The grass seeding on high flow berm before mowing in July 2005 (looking north). The weeds are mainly Russian thistle and Kochia.

Figure 11: The grass seeding on high-flow berm after mowing in July 2005 (looking south).

November 2004

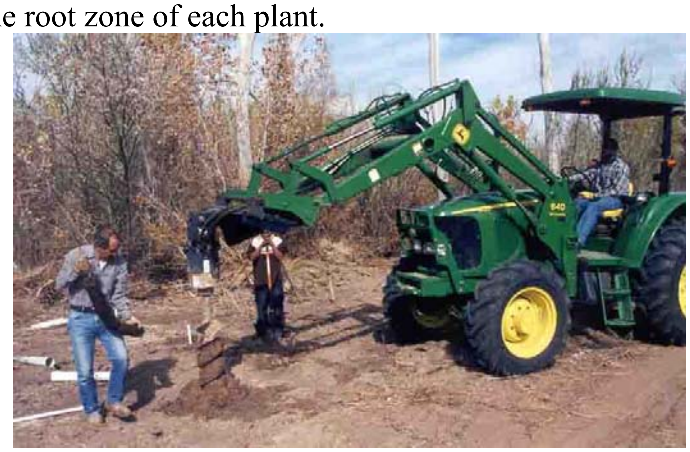
To prepare the site for the containerized transplants, the soil surface of the planting area, located between the access road along the high flow-berm and the bosque, was scraped with the blade of a small dozer to remove the thick annual weed cover (mainly sunflowers and kochia with some approaching 12-foot in height). The weeds were piled outside the planting areas.

In mid-November, we planted 1,100 tall pots and 100 tree pots in the cleared areas:

- 700 New Mexico Olive (*Forestiera neomexicana*) tall pots
- 100 New Mexico olive tree pots
- 300 wolfberry (*Lycium torreyii*) tall pots
- 100 skunkbush sumac (*Rhus trilobata*) tall pots

The plants were planted to the depth of subsurface moisture, approximately 3- to 6-feet (Figure 12). Paired plantings of 100 New Mexico olive tall pot and 100 New Mexico olive tree pot transplants were planted within 8-feet from each other to test the effectiveness of the pot size on plant survival. An irrigation tube measuring 40-inches long and 1-inch in diameter was embedded with each transplant for future irrigation treatments. The lower ⅓ portion of the tube was perforated to enhance water dispersion in the root zone of each plant.

Figure 12: Planting New Mexico olive tall pot transplants with sub-irrigation tubes in November 2004.



February 2005

The area between the MRGCD road on the west side of the river, and the bosque north of the pond access was mowed in preparation for the March 2005 planting of cottonwood pole cuttings.

March 2005

In early March, the area was planted with 300 cottonwood pole cuttings. The cuttings were planted on approximately 30–40 foot centers. Each pole had a poultry wire tree guard installed using the same methodology as previously discussed.

April 2005

Location: East side of the high-flow berm

To reduce stream flow velocity protecting the berm, we planted 845 western black willow and 1,425 coyote willow. So that the new planting would not have to be irrigated, both species were planted in 8-foot augured holes that reach subsurface moisture. The coyote willows were planted in group of four willows per hole, about 10 feet from the berm; no tree guards were installed. The western black willows were planted individually along the toe of the berm with tree guards. The areas that had been previously planted with tall pot containerized shrubs were sparsely planted with 110 cottonwood pole cuttings with tree guards to provide an overstory structural component.

Planting Maintenance

The areas planted in tall pot transplants and cottonwood pole cuttings near the river along the west side of the high-flow berm were spot treated once in April with a mixture containing a post-emergent and pre-emergent herbicide which were respectively 2% glyphosate (Roundup at 47.6 %) and 2% pendimethalin (Pendulum at 37.4 %).

In May 2005, only the post-emergent herbicide was applied. In both April and May, glyphosate (‘Pondmaster’) was applied around the edge of the pond to control mainly sunflower and kochia. By mid-May most of the treated areas were under water due to the rise in groundwater; a consequence of the extremely high flow of the Rio Grande. This high flow of water was due to twice the normal amount of snow-pack in the watershed compounded by extremely warm air temperatures. This area remained under water until mid-July.

When the soil surface dried out enough for a vehicle to enter the site (late July 2005), the perimeters of the tall pot transplants were sprayed with glyphosate (Roundup at 47.6%) to control annual weeds so plants could be located for irrigation and evaluated. Unfortunately, there was no control of annual weed emergence by the pendimethalin which had been previously sprayed. The chemical was probably diluted past the state of effectiveness by the long standing surface water.

As of August 26, 2005, there has been no irrigation treatments applied to any of the plantings. Subsurface moisture at this time was found to be approximately 18 inches below the surface. The plantings were evaluated for survival August 22–23, 2005. Survival results for the treatments of the parried plot trial were analyzed using the SAS Statistical analysis procedure GLM (see Attachment A).

Results and Discussion

The construction of the silvery minnow egg retention ponds resulted in massive soil surface disturbance. With the mixing of subsurface and surface soil, new weed seed was positioned on the surface ready to germinate and establish with the addition of water. Because of the high flows of the Rio Grande, water was ponded on the soil surface for more than 50 days (Figure 13). In addition to providing anaerobic conditions for the planted shrubs and pole cuttings, a surplus supply of water was available for weeds to germinate, establish and grow. Consequently, during the entire period of this planting, the LLPMC has had to control weeds using both mechanical and chemical treatments. Otherwise the planting easily could fail because of the blanket shading and other impacts that would occur.

Figure 13: A typical inundated area of the planting with New Mexico olive tall pot transplants in the foreground in June of 2005.

Leaving a 4- to 6-inch chip layer on the soil surface would have reduced the continued need for weed control. A mulch layer similar to this was left where the mulch piles once stood and after two years it is still controlling weed emergence (Figure 14). These sites are highly productive because of the presence of surface water and need to be protected from annual and new perennial weed emergence once they are disturbed.

Figure 14: The second growing season for cottonwood pole cuttings planted at the side between the existing bosque and the MRGCD drain ditch road covered with a 4- to 6-inch surface mulch layer of wood chips. In the background where no surface mulching occurred, exists a dense ground cover of annual weeds in August 2005.

The berm grass and penstemon seeding began emerging in late August of 2004 after several rainstorms. Emerging seedlings of galleta and Indian ricegrass were the most common (Figure 15). Desert salt grass was also volunteering on the site. However, the seed bed was dominated by high densities of Russian thistle (*Salsola kali*) and kochia (*Kochia scoparia*) seedlings. Both plants are more competitive for light, water, and nutrients than grass seedlings. In retrospect, the site should have had weed control applied for at least two years prior to seeding to reduce this competition. As of August 2005, the berm is still dominated by weeds with some grass plants present. Unlike the other species seeded, New Indian ricegrass and penstemon seedlings will continue to emerge for the next two years.

Figure 15: Grass emergence on the berm seeding in September 2004. The grass in the foreground is desert saltgrass, other grasses are mainly galleta and Indian ricegrass.

Of the 600 pole cuttings planted in the April of 2004 (580 cottonwood and 20 western black willow), only 384 cottonwood and 17 western black willow were found, approximately 67 percent of the plants (Figure 16). The others are in a dense forest of 10–12 foot kochia, sunflowers, coyote willow and other vegetation. Of the plants that were located, the cottonwoods averaged 84 percent survival and the western black willow averaged 76 percent survival. The 50 days of inundation did not seem to have an effect on the survival of the poles that had already rooted one year earlier.

Figure 16: Cottowoods poles cuttings in their second year planted along the MRGCD drain ditch road in August 2005.

However, of the 410 cottonwood pole cuttings planted in March and April 2005, the survival rate averaged only 27 percent. The trees were affected by the 50 day plus inundation which occurred from May to July of 2005. The pole cuttings leafed out in May as they typically do, but they began to show signs of chlorosis by mid-June, and by July (Figure 17) they had dropped their leaves. Those plants that did survive were located on slightly higher ground within the planting. Similar survival results occurred on a new planting of cottonwood poles about 15 miles south of this planting. This similar planting was also inundated, and most of these pole cuttings also died except for those that were planted on higher ground.

Figure 17: In July 2005 three months after planting, these cottonwood pole cuttings had dropped their leaves and are probably dead.

Survival of the western black willow planted on the toe of the berm averaged 53 percent as a consequence of inundation (Figure 18). Those planted in sandy top soil seemed to have a higher survival rate (Figure 19). Their were areas within the planting that had 30 or more consecutive dead willows that seemed to correlate to clay soil surface texture which may provide less air for root respiration under saturated conditions. Traditionally, survival averages above 70 percent when conditions are ideal and the plants are not inundated. Survival of the coyote willow averaged about 75 percent even though they were planted in a slightly lower area than the western black willow (Figure 20). They appear to display a better tolerance to inundation than the western black willow. Some of the coyote willows were damaged by beaver. However the stems that were cut all had new growth. The western black willows with the beaver guards were left intact.

Figure 18: Western black willow pole cuttings planted on the toe of the high-flow berm are inundated in June 2005.

Figure 19: Western black willow pole cuttings five months after planting on sandy topsoil in August 2005.

Of the 700 New Mexico olive tall pot transplants, 609 plants were found. The plants averaged a 93% survival rate Figure 21). The inundation did not have a significant impact on New Mexico olive tall pot survival. These plants can tolerate this extended period of inundation.

Figure 20: Coyote willow pole cuttings (center) four months after planting in the high-flow channel in August 2005.

Of the 100 skunkbush sumac that was planted, 90 plants were located. Skunkbush sumac tall pot transplants averaged an 8 percent survival. Every plant that was inundated for the extended period died. Only those plants that were planted on high ground survived.
Of the 300 wolfberry planted, 193 plants were located. Wolfberry tall pot transplants averaged a 51 percent survival. These plants were also impacted by inundation but not as severely as skunkbush sumac.

Figure 21: New Mexico olive tall pot transplants in foreground 8 months after planting in August 2005.

Survival of the New Mexico olive tallpots (89 %) was significantly greater (.0001) than survival of the treepots (14 %) in the paired plot trial (see Figure 22). The tree pot transplants broke dormancy in May and dropped their leaves in June and then died while the soil was still inundated. These plants have smaller root system (10–12 inches in length) compared to the root system of plants grown in tallpots (25–27 inches in length). The larger root systems of plants grown in tall pots may have allowed the plants to tolerate inundation for a longer period of time. The buried stem of the tree pot plants would be less tolerant of inundation.

Figure 22: Survival test of New Mexico olive tall pots (white tubes) compared to New Mexico olive tree pots (red tubes) planted next to each other in paired plots in July 2005.

In addition, dense stands of salt cedar seedlings and salt cedar root sprouts are becoming established on the planting areas along the high-flow berm. These stands of salt cedar need to be controlled while they are small and can be killed easily by herbicide applications. If the salt cedar stands are not controlled, they will be more competitive and reduce the density of the desired vegetation.

Table 9: Los Lunas Habitat Restoration Plantings and Survival Rates

Species/Container Type	November 2004 Planting	April 2004 Planting	Planting Survival Rate	March 2005 Planting	Planting Survival Rate
New Mexico olive tree pot	100		14%		
Skunkbush sumac tall pot	100		8%		
Wolfberry tall pot	300		51%		
Cottonwood pole cuttings		580	84%	410	27%
Western black willow pole cuttings		20	76%	845	53%
Coyote pole cuttings				1,425	
New Mexico olive tall pot		700	93%		

Summary

In summary, the success of the Los Lunas Habitat Restoration Project was impacted by the following major factors:

- The 50 or more days of inundation had the following effects:
    1. No effect on the survival rate of New Mexico olive transplants grown in tall pots and cottonwood pole cuttings in their second year of establishment.
    2. Significantly reduced the survival rate of Wolfberry transplants grown in tall-pots, skunkbush sumac transplants grown in tall-pots, New Mexico olive transplants grown in tree-pots, and first-year planted cottonwood pole cuttings.
- Controlling the emergence of competing weeds is critical for the establishment of native vegetation in a newly disturbed riparian ecosystem. Control can be accomplished by applying a surface layer of wood chips 4 to 6 inches in depth.

Attachment 1

The GLM Procedure

Class Level Information

Class	Levels	Values
Pot	2	0 1
Location	76	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76

Number of Observations Read	152
Number of Observations Used	152

13:02 Wednesday, October 19, 2005

The GLM Procedure

Dependent Variable: Survival

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	76	28.81578947	0.37915512	3.12	<.0001
Error	75	9.12500000	0.12166667		
Corrected Total	151	37.94078947			

R-Square	Coeff Var	Root MSE	Survival Mean
0.759494	67.11233	0.348807	0.519737

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Pot	1	21.37500000	21.37500000	175.68	<.0001
Location	75	7.44078947	0.09921053	0.82	0.8105

13:02 Wednesday, October 19, 2005

The GLM Procedure

Bonferroni (Dunn) t Tests for Survival

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	75
Error Mean Square	0.121667
Critical Value of t	1.99210
Minimum Significant Difference	0.1127

Means with the same letter are not significantly different.

Bon Grouping	Mean	N	Pot
A	0.89474	76	1 tall-pot
B	0.14474	76	0 treepot

* (significantly greater @ alpha .05)

Revegetation Treatment Results for the Middle Rio Grande Fuels Reduction Study

Study Number: NMPMC-T-0302-RI

Introduction

The Los Lunas Plant Materials Center (LLPMC) is involved in a study to reduce the amount of fuel load at 12 study sites in the Middle Rio Grande area. The LLPMC is partnering with the following interagency group:

- USFS Rocky Mountain Research Station in Albuquerque
- Bosque del Apache National Wildlife Refuge
- Middle Rio Grande Conservancy District
- City of Albuquerque Open Space
- US Bureau of Land Management
- New Mexico Department of Environment

This study was designed to evaluate the response of groundwater, soil, vegetation, and animal populations to three different types of treatments. These treatments were designed to reduce the amount of fuel load (see Figure 23) or provide restoration by:

1. Mechanically removing or burning (prescribed burns) the dead and downed wood
2. Applying herbicide to control exotic woody species
3. Revegetating three study areas with native plants

Figure 23: Typical appearance a study site before treatment. This is the north edge of the Bosque study site.

The study sites consisted of twelve, 30–50 acre plots that begin at the north-end of Albuquerque and continue south to the Bosque del Apache National Wildlife Refuge. Three of these study sites received revegetation treatments provided by the LLPMC:

- Bosque – Approximately a half mile south of the State Highway 346 Bridge on the west side of the Rio Grande, approximately 10 miles south of Belen
- Rio Bravo – Approximately one mile south of the Rio Bravo Bridge on the east side of the Rio Grande in south Albuquerque.
- Lemitar – Approximately one mile north of Escondida Bridge on the east side of the Rio Grande, approximately 10 miles north of Socorro.

Figure 24 shows the graphical location of the three study sites.

Figure 24: Map showing the locations of the three study sites (shown in red).

The revegetation study included developing the planting methodologies, installing the plant materials, and performing the follow-up irrigation on plant materials as necessary to maintain their survival during the first two years of establishment.

The goal of the revegetation treatments was to bring the combined shrub and tree density of a site to at least 100 units per acre; the ideal density for maximum diversity and populations for wildlife species in the Middle Rio Grande Bosque (per the late John Taylor, a biologist for the Bosque del Apache National Wildlife Refuge).

In December 2004, the LLPMC conducted a limited pilot study at the request of the Middle Rio Grande Conservancy District (MRGCD) to determine the number of plants to be installed at each site. This study involved subjectively selecting representative sampling points at each of the three study sites. Stakes were driven into the ground and a 117 ½-foot tape was rotated from this stake. All of the stems of shrubs and trees were counted inside the radius of this one acre, circular plot. At the Bosque and Rio Bravo sites, six plots were read. At Lemitar, only four plots were read because this site already had a significantly higher density than the project goal of 100 units per acre (see Figure 25). The pilot study showed the stems-per-acre at each site: 82 at Bosque, 120 at Rio Bravo, and 1,360 at Lemitar. The MRCGD considered these density results and had the LLPMC plant 1,600 shrubs at the Rio Bravo study site, 1,701 shrubs a the Bosque study site, and 400 shrubs at the Lemitar study site. The planting goal was to have more than 100 shrubs per acre at each site.

Figure 25: Typical NM olive understory stand density on both sides of the Lemitar study site road (looking south).

Shrubs and Low-Growing Trees

Methods

Seed from riparian shrub and low-growing tree species was generally collected near the three study sites (within 100 miles). Collected species included: New Mexico olive (*Forestiera pubescens*), indigo bush (*Amorpha fruticosa*), netleaf hackberry (*Celtis reticulata*), willow baccharis (*Baccharis salicina*), golden currant (*Ribes aureum*), screwbean mesquite (*Prosopis pubescens*), and skunkbush sumac (*Rhus trilobata*). The origin of the seed used for skunkbush sumac was from the PMC cultivar release 'Big Horn' which was originally collected in Montana. The transplants were grown in 30x4-inch PVC pipe tall pots (see Appendix A) or 14-inch deep tree pots. At time of installation, the transplants ranged in age from two–four years, depending upon the time required to produce a mature root ball.

All three sites had adequate stands of cottonwoods and herbaceous understory (see Figure 26). Therefore only native shrubs and low growing trees were planted. Selected species for the three sites was based on the existing species in that area. Each study had its own unique understory shrub composition. For example, screwbean mesquite occurred in the Lemitar area, but it was not found in the Albuquerque area. As a result, screwbean mesquite was planted at Lemitar but not in Albuquerque. On the contrary, golden currant occurred in Albuquerque, but not at Lemitar.

Figure 26: Cottonwoods and herbaceous understory with no shrub component at the Bosque study site; similar vegetation was present at the Rio Bravo study site.

The deep planting technique utilized on the three sites requires little or no follow–up irrigation. The roots of these transplants are planted to the depth of the capillary fringe of the water table (typically 4–7 feet deep). Because the root system is placed into moist soil, it is not necessary to irrigate these plants unless the capillary fringe of the water table drops below the root zone.

Most species of plants would not survive this treatment because the root crown is being buried several feet below the surface. Riparian shrub species may tolerate burial by sediments because they have evolved in flood-prone environments.

The plants typically were planted on bare soil in random clusters where the exotic species had been removed. Areas that had dense stands of grass such as alkali muhly (*Muhlenbergia asperifolia*) and forbs such as yerba manza (*Anemopsis californica*) were generally not planted to avoid the competition for water and nutrients from these already dense, established stands (see Figure 27). However there was limited planting in some of these areas with more open stands of herbaceous species. Our intent was to simulate how wood understory species commonly occur in the bosque.

Figure 27: Transplants were not planted in the dense stands of the herbaceous broadleaf understory yerba manza (*Anemopsis californica)* which dominates at this location in the Bosque study site.

At the Rio Bravo site, 800 tall pot transplants were installed from October 27 through November 14, 2003. An additional 800 tall pots were planted at Rio Bravo from October 24 through November 4, 2005. See Table 10.

Table 10: Rio Bravo Study Site Planting

Species	Planting Dates	Container Type	Total Planted
NM olive	10/27/2003 to 11/14/2003	Tall Pot	497
	October 2005	Tall Pot	620

Table 10: Rio Bravo Study Site Planting

Species	Planting Dates	Container Type	Total Planted
Skunkbush sumac	10/27/2003 to 11/14/2003	Tall Pot	165
	October 200	Tall Pot	105

Table 10: Rio Bravo Study Site Planting

Species	Planting Dates	Container Type	Total Planted
	5		
Wolfberry	10/27/2003 to 11/14/2003	Tall Pot	97
	October 20	Tall Pot	0

Table 10: Rio Bravo Study Site Planting

Species	Planting Dates	Container Type	Total Planted
	05		
Golden currant	10/27/2003 to 11/14/2003	Tall Pot	41
	October 2	Tall Pot	75

Table 10: Rio Bravo Study Site Planting

Species	Planting Dates	Container Type	Total Planted
	005		
Grand Total			**1,600**

At the Bosque site, 558 tall pots and 388 tree pots were planted in January 2005, and 805 additional tree pots were planted in November 2005. See Table 11.

Table 11: Bosque Study Site Planting

Species	Planting Dates	Container Type	Total Planted
NM	01	Ta	22

Species	Planting Dates	Container Type	Total Planted
olive	/18/2005 to 01/27/2005	ll PotTree Pot	6213
	11/07/2005 to	Tree Pot	269

Species	Planting Dates	Container Type	Total Planted
	11/11/2005		
Indigo bush	01/18/2005 to 01/27/2005	Tall Pot Tree Pot	6814
	11	Tr	26

Species	**Planting Dates**	**Container Type**	**Total Planted**
	/07/2005 to 11/11/2005	ee Pot	8
Netleaf hackbe	01/18/2005 to	Tall Pot Tree P	1520

Species	Planting Dates	Container Type	Total Planted
rry	01/27/2005	ot	
	11/07/2005 to 11/11/2005	Tree Pot	0
Wi	01	Ta	01

Species	Planting Dates	Container Type	Total Planted
llow baccharis	/18/2005 to 01/27/200	ll PotTree Pot	11
	11/07/2005 to	Tree Pot	268

Species	Planting Dates	Container Type	Total Planted
	11/11/2005		
Screwbean mesquite	01/18/2005 to 01/27/2005	Tall Pot Tree Pot	032
	11	Tr	0

Species	Planting Dates	Container Type	Total Planted
	/07/2005 to 11/11/2005	ee Pot	
Wolfberry	01/18/2005 to	Tall PotTree P	018

Species	**Planting Dates**	**Container Type**	**Total Planted**
	01/27/2005	ot	
	11/07/2005 to 11/11/2005	Tree Pot	0
Go	01	Ta	11

Species	**Planting Dates**	**Container Type**	**Total Planted**
lden currant	/18/2005 to 01/27/2005	ll PotTree Pot	20
	11/07/2005 to	Tree Pot	0

Species	**Planting Dates**	**Container Type**	**Total Planted**
	11/11/2005		
Grand Total			**1,751**

At the Lemitar site, 400 tall pots were installed December 1–4, 2003. See Table 12.

Table 12: Lemitar Study Site Planting

Species	**Planting Dates**	**Container Type**	**Total Planted**
NM olive	12/01/2003 to 12/04/2003	Tall Pot	112
Willow bacch	12/01/2003 t	Tall Pot	110

Species	**Planting Dates**	**Container Type**	**Total Planted**
aris	o 12/04/2003		
Screwbean mesquite	12/01/2003 to 12/04/2003	Tall Pot	90

Species	**Planting Dates**	**Container Type**	**Total Planted**
Wolfberry	12/01/2003 to 12/04/2003	Tall Pot	88
Grand Total			**400**

A 65-horsepower farm tractor with an 8-foot auger mounted on the front end was used to dig the holes for the tall pots (see Figure 28). Plants were placed to the depth of the capillary fringe of the water table, and the holes were backfilled by hand with shovels. The plants at all three sites were planted in random clusters and as individuals. Before backfilling, a PVC pipe (40-inches in length and 1-inch in diameter with perforations on the bottom third of the pipe) was placed in each hole for future irrigation applications. These irrigation pipes rise approximately 10 inches above the ground, making it easier to locate the transplants. Even though the soil was moist at the time of planting, the plants were irrigated after planting primarily to collapse any air-pockets and achieve good root-to-soil contact.

Figure 28: Planting holes being dug by a 65-horsepower tractor with an 8-foot auger mounted to the front end. The plants were installed by hand as deep as 7 feet to reach sub-surface moisture.

By applying irrigation water through the PVC pipes, water flows near and below the root tips to encourage the root system to continue to grow towards the water table (see Figure 29). Another benefit to irrigating through the plastic pipes is that the soil surface remains dry. If the soil surface is irrigated on these highly productive riparian sites, it often promotes weed seed germination, emergence, and growth. These weeds are generally more competitive for light, nutrients, and water than the desired plants, and as a result may reduce the plants' survival or growth rate.

The shrubs, planted in 2003 at the Rio Bravo and Lemitar study sites, were irrigated three times during the dry conditions of 2004, once in June, once in July, and once again in September. Each application consisted of approximately 4–5 gallons of water. Irrigation water was applied with a 300-gallon tank located in the bed of a pickup. Water was pumped from the tank with a 4-horespower, high-pressure (70 psi) pump. It typically takes about three days using two irrigation trucks operated by four technicians to irrigate 800 plants.

Other than watering in newly planted plants, the 2005 irrigation at the three study sites only occurred once in August at the Lemitar site because the water table had dropped below the reach of the plants' roots. At the Rio Bravo and Bosque study sites, the water table never dropped below 5 feet, allowing for continuous, natural sub-irrigation of the plants. This high water table was unusual for this area and only occurred because the watershed of the Rio Grande in southern Colorado and northern New Mexico received about twice the amount of normal snow pack (approximately 150 inches by spring). As a result, the high volume of run-off from snow melt kept flows in the Rio Grande high all summer. These high flows provided for lateral seepage in the river bank that resulted in recharging shallow ground water along the river corridor.

Figure 29: Irrigating transplants through the PVC pipes keeps the soil surface dry and allows water to flow near and below the root tips to encourage the root system to grow towards the water table.

Results and Discussion

Survival results for all three study sites were based on the amount of live and dead plants found. Both the dead plants and the live plants were easy to locate because they were flagged by the 10-inch, above ground portion of the irrigation tube.

Rio Bravo – The survival rate at the Rio Bravo study site averaged 92 percent by September 2005 (see Table 13 and Figure 30). In July 2004, a wild fire on the south side of this site may have killed about 100 of the transplants which we were unable to find. The fire destroyed the irrigation tubes so resprouting shrubs could not be positively identified as transplants. In some areas, this site also had become overgrown with root sprouts of tree of heaven, Russian olive and several species of annual weeds. This made it difficult to locate the transplants in this dense underbrush. Of the 800 transplants that were installed in October 2003, only 565 were found. The survival rate of New Mexico olive was at 99 percent, skunkbush sumac at 90 percent, wolfberry at 97 percent, and golden currant at 81 percent. New Mexico olive seemed to be the most vigorous, with some of them doubling in size (up to 8 feet in height) by the fall of 2005. The wolfberry lacked vigor from growing in the dense shade and their leaves were etiolated and sparse.

Table 13: Rio Bravo Study Site Survival Rates From the October/November 2003 Planting

Species						
NM olive						
Skunkbush						

Species						
sumac						
Wolfberry						
Gold						

Species						
en currant						
Grand Tot						

Species						
al						
Average Survival						

S p e c i e s						
R a t e						

Figure 30: Typical transplant shrub density and growth in October of the second growing season at the Rio Bravo study site.

Bosque – The survival rate at the Bosque study site for all species of transplants averaged 91 percent (see Table 14 and Figure 31). All of the transplants were found at this site. The site remained open with only native grass generally occupying ground level so the transplants could be located easily. The survival rate of New Mexico olive was at 99 percent, indigo bush was at 100 percent, netleaf hackberry was at 91 percent, willow baccharis was at 100 percent, golden currant was at 100 percent, screwbean mesquite was at 94 percent, and wolfberry was at 67 percent. All of the species of transplants were doing excellent at this site except for the wolfberry. This location has a fairly dense cottonwood canopy which may not allow for adequate sunlight to allow vigorous growth of wolfberry (similar to the Rio Bravo site).

Most of the transplants that died were planted in surface depressions where there was standing water for a period of 60 days or longer. This occurred in May, June, and July of 2005. This standing water was caused by unusually high flows in the river, and as a result, significantly raised the water table at this site. Because of the high water table, low surface depressions became shallow ponds. None of the transplants that were planted in the depressions survived (no matter what the species).

Table 14: Bosque Study Site Survival Rates From the January 2005 Planting

Species						
NM olive						
Indigo bush						

Species						
Netleaf hackberry						
Sc						

Species						
rewbean mesquite						
Wol						

Species						
fberry						
Golden curran						

Species						
t						
Willow baccharis						
Gr						

Species						
and Total						
Average Su						

Species						
rvival Rate						

Figure 31: Typical transplant shrub density and growth in October of the first growing season at the Bosque study site.

Lemitar – The survival rate at the Lemitar study site for all species of transplants averaged 83 percent for all those that were found (see Table 15 and Figure 32). Of the 400 transplants installed, 285 were found. This site already had dense stands of native shrubs before the planting that made it difficult to find some transplants. This site also had continuous grazing by approximately 20-head of cattle that often browsed the transplants. Most transplants had browse damage, but it seemed the cattle preferred willow baccharis, with many of these plants being browsed more than 50 percent. Survival of New Mexico olive was at 95 percent, willow baccharis at 94 percent, wolfberry at 73 percent, and screwbean mesquite at 70 percent. Willow baccharis appeared to display the highest vigor of the four species. Many might have doubled in size if they had not been browsed regularly. A few isolated plants were huge. The screwbean mesquite generally defoliated in mid-summer of 2004; however most plants leafed-out in the spring of 2005 and put on about 12 inches of new growth. Wolfberry also defoliated in mid-summer of 2004, but so did the local, on-site wolfberry. The plants appeared to have acquired a foliar fungal disease that turned the leaves to a gold/black color and defoliated; however most of these plants appeared to be healthy again by the Spring of 2005 and through the Fall of 2005.

Table 15: Lemitar Study Site Survival Rates From the December 2003 Planting

Species						
NM olive						
Willow bacc						

Species						
haris						
Wolfberry						
Screw						

Species						
bean mesquite						
Grand						

Species						
Total						
Average Surviv						

Species						
al Rate						

Figure 32: Typical transplant shrub density and growth situated between a natural stand of NM olive and wolfberry in October of the second growing season. The transplants are easily identified by their irrigation tubes.

Pole Cuttings

Methods

Dormant, understory pole cuttings of western black willow (*Salix goodingii*), indigobush, willow baccharis, and New Mexico olive were planted primarily close to the Rio Grande (within 100 feet) at the Rio Bravo and Bosque study sites. The origin of the pole cuttings were from locations within 100 miles or less from the study sites. Poles cuttings were grown in production plantations at the LLPMC where they were irrigated and fertilized to maintain a vigorous stock (see Figure 33). The day before planting, three-to-five year-old sapling shrubs (8–15 feet tall) were cut using a chainsaw. Side limbs of these cuttings were removed with hand pruners, but the branch collars on the pole cuttings were left intact. The terminal end and about two side limbs were left on each cutting. After harvest, the cuttings were placed in water baths to maintain hydration.

Four random soil samples were taken at a 12-inch depth at the Rio Bravo and Bosque study sites where poles had been planted. A soil saturation paste was prepared for each sample and measured for electrical conductivity (EC) using a Hanna HI 991300 field meter. A commercially prepared standard (1.413 dS/m) of potassium chloride was used to develop a standard curve. The meter consistently read a lower value, of about 0.1 dS/m, which was corrected in the individual soil sample EC measurements.

Figure 33: A pole cutting plantation of willow baccharis at the Los Lunas Plant Materials Center. This plantation is in its tenth growing season; the longer stems are approaching 12 feet in height.

At the study sites, the pole cuttings were planted into 8-foot holes that were 10-inches in diameter. The holes were drilled using an auger mounted to the front-end loader of a 65 horsepower farm tractor (see Figure 34). Then the holes were backfilled by hand and compacted to remove air pockets to achieve good soil-to-stem contact. Cuttings were planted only in holes that exposed the water table at a depth of 4 feet or more. Dry holes were backfilled without planting.

Figure 34: Los Lunas Plant Materials Center crew members are planting understory pole cuttings on the east bank of the Rio Grande at the Bosque study site.

Results

At the Rio Bravo study site, 543 pole cuttings were planted; half were planted in March 2004 and the other half planted in March 2005 (see Table 16 and Figure 35).

Table 16: Rio Bravo Study Site Pole Cuttings Survival Rate

Species						
NM olive						
Indigobush						

Species						
Willow baccharis						
Western bl						

Species						
ack willow						
Grand Total						
Avera						

Species						
ge Survival Rate						

Figure 35: Established indigobush pole cutting (center) by the end of the second growing season in October 2005.

At the Bosque study site, 1,004 pole cuttings were planted in March of 2005 (see Table 17 and Figure 36).

Table 17: Bosque Study Site Pole Cuttings Survival Rate

Species	Number Planted	Planting Date	Number Alive	Survival Percentage Rate
NM olive	73	March 2005	1	1%
Indigobush	324	March 2005	91	28%
Willow baccharis	213	March 2005	1	0.5%
Western black willow	394	March 2005	69	18%
Grand Total	1004		162	
Average Survival Rate				**12%**

Figure 36: Established indigobush (foreground, left) and western black willow (center) with several dead pole cuttings in the background (right).

No cuttings were planted at the Lemitar study site because the water table depth was greater than the 8-foot depth of the planting equipment used by the LLPMC.

Rio Bravo – The survival rate of the pole cuttings at the Rio Bravo study site averaged 21 percent. The survival rate of western black willow was at 45 percent, indigo bush at 28 percent, NM olive at 11 percent, and willow baccharis at 1 percent.

Bosque – The survival of pole cuttings at the Bosque study site averaged 12 percent. Survival of indigo bush was at 28 percent, western black willow at 18 percent, New Mexico olive at 1 percent, and willow baccharis at 0.5 percent.

At the Rio Bravo study site, soil EC measurements were 0.2 dS/m, 0.6 dS/m, 0.5 dS/m and 0.7 dS/m. At the Bosque study site soil EC measurements were 1.8 dS/m, 0.6 dS/m, 1.0 dS/m, and 0.5 dS/m. All of these measurements for both study sites are in the acceptable range where salt concentration in the soil should not be detrimental to root formation of the understory pole cutting species planted.

The survival rate of pole cuttings at Rio Bravo and Bosque was lower than anticipated. Both sites had a dense over-story canopy of cottonwoods, limiting the amount of light which reduced the establishment of the pole cuttings. Additionally, the pole cutting production plantations at the LLPMC for all species are now older than 10 years, and they seem to be less vigorous which may limit field establishment. Even when the production plantations were new, it was unusual to achieve a survival rate of greater than 50 percent for these species.

Summary

The LLPMC continues to develop or refine planting methodologies and plant materials that require little or no follow-up irrigation. Riparian areas are unique in the dry climate of the Southwest because they typically have shallow water tables due to the lateral seepage of water from a source, such as a river. The planting methods developed by the LLPMC usually involve strategies designed to tap into this moisture. Demonstration plantings like this study provide the LLPMC an opportunity to measure the effectiveness of these methods before they are released to cooperators and the general public.

The survival rate of riparian shrub transplants with limited or no follow-up irrigation averaged 90% or greater for the three study sites. These study sites are located in the desert where they receive less than 10 inches of annual precipitation. By digging holes in a riparian zone deep enough to reach the capillary fringe of the water table, we were able to place the transplants' roots into the subsurface moisture. To achieve this depth, the root crowns of the transplants were buried up to 6 feet below the soil surface. This did not seem to have an effect on their survival or vigor.

Because this planting technique of riparian shrub transplants has worked so well at the three study sites, the LLPMC will no longer encourage the planting of unrooted, understory pole cuttings; however, the pole cutting methodology is still an excellent planting technique to establish cottonwoods and willow trees without follow-up irrigation.

Field Maintenance at the Los Lunas Plant Materials Center

Alkali Muhly

Study Number: NMPMC-P-8301-RA

Introduction

This accession of alkali muhly has been released as Westwater germplasm from the LLPMC. Alkali muhly[2], sometimes known as scratchgrass, is a common riparian grass species found throughout the U.S. except for the Southeast. Alkali muhly is a native, warm-season, perennial sod grass, that has a prostrate or an erect growth form. Alkali muhly is an excellent soil stabilizer because it is strongly rhizomatous and grows in moist-to-wet, sand-to-clay and neutral-to-alkali soils.

Westwater germplasm alkali muhly was first collected in 1993 near Westwater Spring in San Juan County located in northwestern New Mexico. This site is 5,200 feet in elevation, receives approximately seven inches of annual precipitation, and is located in Zone 6 of the USDA plant hardiness zones. The Westwater germplasm release will be beneficial in the restoration of riparian sites along drainages located in the LLPMC service area. Alkali muhly will be one of the plant materials used to control the introduction or reintroduction of invasive species along riparian corridors.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and promote vigorous growth of the planting.

Action	2005 Date
Field 11 Irrigation 3" application Field 12 Irrigation 3" application	 4/14, 5/11, 5/26, 6/23, 7/22, 8/19 4/14, 5/11, 5/26, 6/23, 7/22, 8/19
Field 12 burned	3/3
Field 11, 12 Herbicide Pre-emergent	 4/4
Fertilizer Field 11 80 pounds Nitrogen 70 pounds Phosphorus Field 12 120 pounds Nitrogen 40 pounds Phosphorous	 4/14, 5/10 1/19, 5/10 4/14, 5/10, 8/22 8/22

[2] This species is not tolerant to 2,4-D types of herbicide. Sever die-back of foliage has been observed after applying this herbicidal group.

Action	2005 Date
Field 11 Harvest Completed	 9/29

National Arboretum American Elm Selections

Study Number: NMPMC-F-0201-OT

Introduction

In the spring of 2002, two varieties of American elm were sent to the LLPMC from the National Arboretum. They sent six rooted plants (three each of the two varieties) for evaluation in the Los Lunas hardiness zone: Valley Forge and New Harmony. On August 15, 2002, the six trees were transplanted into Field 26S at the LLPMC.

The six plants have had a 100 % survival rate. The amount of growth is fair, but it appears to be limited by the climate in this area. The New Harmony variety averaged 103 inches in total height, and the Valley Forge variety averaged 102 inches in total height. Both varieties had good foliage color, but they did not produce very many new branches in 2005. It is too early in the growth of both varieties to judge how they will perform in the Los Lunas area.

The planting will be evaluated for growth and survival in 2006.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and promote vigorous growth of the planting.

Action	2005 Date
Irrigation 3" application	4/15, 5/18, 6/1, 6/23, 7/19, 8/3, 8/11, 9/6
Fertilizer 40 pounds Nitrogen 40 pounds Phosphorus	 1/14 5/18

Autumn Amber

Study Number: NMPMC-P-9803-UR

Introduction

Evaluation of propagation techniques will be performed in 2005 as required.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

Action	2005 Date
Irrigation 3" application	5/10, 6/23, 7/25, 8/11, 9/6
Herbicide	

Action	2005 Date
Pre-emergent	3/10

Hope Desert Willow Stock Plant Production

Study Number: NMPMC-P-0102-UR

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

Seed was not harvested in 2005 from this planting.

Action	2005 Date
Irrigation 3" application	4/4, 4/18, 5/18, 6/9, 6/28, 7/21, 8/5, 9/6, 9/23
Herbicide Pre-emergent	 3/11
Fertilizer 50 pounds Nitrogen 50 pounds Phosphorous	 8/22 8/22

Regal Desert Willow Stock Plant Production

Study Number: NMPMC-P-0101-UR

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

Seed was not harvested in 2005 from this planting.

Action	2005 Date
Irrigation 3" application	4/4, 4/18, 5/18, 6/9, 6/28, 7/21, 8/5, 9/6, 9/23
Fertilizer 50 pounds Nitrogen 50 pounds Phosphorous	 8/22 8/22

Species from Four Corners Region

Study Number: NMPMC-P-9505-CR

Introduction

These plantings of different species collected in the Four Corners region of New Mexico were not evaluated in 2005.

Evaluations will be completed in 2006 to work towards a possible release of selected species.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the fields clean and to promote vigorous growth of the plantings.

Action	2005 Date
Shrub collections	
Irrigations 3" water application	4/19, 8/3
Desert needlegrass and Slender wheatgrass	
Irrigations 3" water application	4/1, 4/14, 5/3, 6/9, 7/25, 9/9, 10/31
Herbicide 2,4-D Pre-emergent	 1/26 3/22
Fertilizer	
30 pounds Nitrogen 40 pounds Phosphorus	1/24 1/19
Mexican whitesage, Buckwheat and White prairieclover	
Irrigation 3" water application Fertilizer 30 pounds Nitrogen 40 pounds Phosphorous Herbicide Pre-emergent	4/19, 6/15, 8/16 1/24 1/19 3/10

Little Bluestem Initial Evaluation Planting

Study Number: NMPMC-P-9101-RA

Introduction

In 2005, evaluations were completed in preparation for a possible release of this species. Five accessions were selected from the planting and will be placed in a polycross environment in 2006. Seed from this polycross will be used to start a production field, and the resulting plants will be evaluated against the LLPMC release 'Pastura.'

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

There was no seed harvested in 2005.

Action	2005 Date
Irrigation 3" application	4/21, 6/9, 7/6, 8/12, 9/16
Herbicide 2,4-D	 7/22
Swath	11/25

Mexican Whitesage

Study Number: NMPMC-9801-WL

Introduction

This Mexican whitesage collection is being evaluated for its potential as a variety release.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

No viable seed was found on the plants in 2005. Seed harvest will be attempted in 2006.

Action	**2005 Date**
Irrigation (3" application)	4/18, 5/18, 6/1, 6/27, 7/7, 7/21, 8/11, 9/6, 9/27
Fertilizer 50 pounds Nitrogen	 3/4
Mow	12/22

Sandhill Muhly

Study Number: **NMPMC-P-9601**

Introduction

This collection of Sandhill muhly is being evaluated for its potential as a variety release. Evaluation of this collection of Sandhill muhly will be completed in 2006.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

Action	**2005 Date**
Irrigation (3" applications)	4/18, 5/19, 6/17, 6/22, 7/8, 8/3, 9/6, 9/27
Herbicide Pre-emergent	 3/3/2004
Fertilizer 40 pounds Phosphorous	 1/14

Single Leaf Ash and Fragrant Ash

Study Number: NMPMC-P-9804-UR

Introduction

Evaluation of these accessions of ash will continue in 2006 for possible release.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

Action	2005 Date
Irrigation 3" application	4/4, 4/18, 5/18, 6/9, 6/28, 7/21, 8/5, 9/6, 9/23
Fertilizer 40 pounds Nitrogen	 5/18

IE Tobosa Planting

Study Number: NMPMC-P-8301-RA

Introduction

The culms transplanted in 2004 did not survive during 2005. In 2006, culms of the six selected accessions will be put into transplant containers. The transplants grown in 2006 will be placed into a polycross block at the LLPMC. Seed produced from this block will then be used to complete the planting of a production field at the LLPMC. Work will progress on releasing tobosa as a conservation plant during the next few years.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and promote vigorous growth of the planting.

Action – Field 6	2005 Date
Irrigation 3" application	8/16
Mow	8/15

Advanced Planting of Needle and Thread Grass

Study Number: NMPMC-S-9503-RA

Introduction

These accessions of needle and thread grass are being evaluated for a possible variety release by the LLPMC. No evaluations were made in 2005.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

Action – Field 12	2005 Date
Irrigation 3" application	4/15, 5/10, 6/23, 8/3, 9/1
Fertilizer 115 pounds Nitrogen 70 pounds Phosphorous	 4/14, 5/10, 10/5 3/21, 10/3
Herbicide 2,4-D	 1/25, 10/18

Action – Field 12	2005 Date
Pre-emergent	4/13

Initial Evaluation Planting of Blowout Grass

Study Number: NMPMC-P-85019503-RA

Introduction

These accessions of blowout grass are being evaluated for a possible variety release by the LLPMC. No evaluations were made in 2005.

2005 Treatment and Harvest

Weed control was performed throughout the growing season to keep the field clean and to promote vigorous growth of the planting.

Action – Field 20N	2005 Date
Irrigation 3" application	5/3, 5/27, 6/15, 8/2, 9/1
Fertilizer 80 pounds Nitrogen	 5/18, 6/9
Herbicide 2,4-D Pre-emergent	 1/25, 8/19 3/22

2005 Annual Seed Production Report

Project Number/Name	Field #	Acres	Planting Date	Fertilizer Applications	Irrigation Dates (3" Application)	Harvest Date	Harvest (Cleaned Wt. lbs.)
NMPMC-S-8801-RA Alma Blue grama Foundation seed field	7 and 8	2.7	1983 and 1988	70 lbs. Nitrogen 80 lbs. Phosphorous	5/19, 6/16, 7/1, 7/26, 8/25, 9/27	11/2	N/A
NMPMC-S-9701-RA Nogal Black grama Foundation seed field	21N	1.3	1997	110 lbs. Nitrogen 40 lbs. Phosphorous	5/26, 6/9, 6/30, 7/22, 8/23, 9/15	11/7	N/A
NMPMC-S-9803-RA San Juan Narrowleaf Penstemon Foundation seed field	34S	0.85	1998	30 lbs. Nitrogen 40lbs. Phosphorous		7/14	17.10
NMPMC-S-8803-RA Elida Sand bluestem Breeder seed field	31S	0.14	1988	40 lbs. Nitrogen 40 lbs. Phosphorous	5/20, 6/13, 7/7, 8/2, 9/1	11/22	N/A
NMPMC-S-RA Grant Cane bluestem Foundation seed field	9	1.75	1999 and 2000	80 lbs. Nitrogen 80 lbs. Phosphorous	5/20, 6/20, 7/12, 8/12	9/21, 27	N/A
NMPMC-S-7801-RA Hachita Blue grama Foundation seed field	16	2.0	1963	80 lbs. Nitrogen 80 lbs. Phosphorous	5/25, 6/24, 8/4, 8/29	10/28	N/A
NMPMC-S-6501-RA Jose Tall wheatgrass Foundation seed field	16	1.0	1965	155 lbs. Nitrogen 30 lbs. Phosphorous	4/15, 5/18, 6/23, 7/26, 8/30, 10/26	9/9	N/A
NMPMC-S-9902-RA Largo Tall wheatgrass Foundation seed field	12	0.45	5/3/1999	115 lbs. Nitrogen 70 lbs. Phosphorous	4/14, 5/11, 5/27, 6/23, 7/22, 8/31, 10/25	9/6	N/A
NMPMC-S-9401-RA Paloma Indian ricegrass Foundation seed field	25N	0.89	2000	135 lbs. Nitrogen 70 lbs. Phosphorous	3/31, 4/21, 5/18, 6/13, 7/7, 7/20, 8/22, 10/28	5/27, 6/17	161.12
NMPMC-S-8802-RA Pastura Little bluestem Breeder seed field	31S	0.14	1988	40 lbs. Nitrogen 40 lbs. Phosphorous	5/20, 6/13, 7/7, 8/2	9/23	N/A
NMPMC-S-0403-RA Carlsbad Caverns NP Blue grama seed production	13	0.50	7/6/2005	35 lbs. Nitrogen 30 lbs. Phosphorous	7/6, 7/12, 7/22, 7/29, 8/11, 8/25, 9/1, 9/15, 10/31		No harvest
NMPMC-S-0404-RA	23S	0.25	8/4/2005	35 lbs. Nitrogen	8/4, 8/8, 8/25, 9/2, 9/9, 9/22,		No harvest

Project Number/Name	Field #	Acres	Planting Date	Fertilizer Applications	Irrigation Dates (3" Application)	Harvest Date	Harvest (Cleaned Wt. lbs.)
Capulin National Monument Blue grama seed production				30 lbs. Phosphorous	10/28, 11/30		
NMPMC-S-0404-RA Capulin National Monument Western wheatgrass seed production	14	0.14	10/14/2005		10/14, 10/21, 11/14, 12/1		No harvest
NMPMC-S-0404-RA Capulin National Monument Little bluestem seed production	23S	0.50	7/21/2005	35 lbs. Nitrogen 30 lbs. Phosphorous	7/21, 7/25, 7/29, 8/5, 8/12, 8/18, 8/25, 9/2, 9/9, 9/22, 10/28, 12/1		No harvest
NMPMC-S-0404-RA Capulin National Monument Mountain muhly seed production	27N	0.50	9/15/2005		9/15, 9/20, 9/26, 10/21, 11/30		No harvest
NMPMC-S-0403-RA Carlsbad Caverns National Park Three-awn seed production	24S	0.25	6/2/2005	40 lbs. Nitrogen 40 lbs. Phosphorous	6/2, 6/7, 6/13, 6/23, 6/30, 7/8, 7/15, 7/28, 8/9, 8/25, 9/8, 9/22, 10/31	9/21	4.88
NMPMC-S-0403-RA Carlsbad Caverns National Park Sideoats grama	23N	0.25	6/8/2005	40 lbs. Nitrogen 40 lbs. Phosphorous	6/8, 6/10, 6/17, 6/24, 6/30, 7/8, 7/15, 7/28, 8/9, 8/25, 9/9, 9/22, 10/31	11/7	88.66
NMPMC-S-0301-WO Zion National Park Muttongrass seed production	35S	0.50	4/19/2005	115 lbs. Nitrogen 110 lbs. Phosphorous	4/19, 4/29, 5/6, 5/19, 5/31, 6/8, 6/17, 7/1, 7/15, 7/22, 8/2, 8/16, 9/2, 9/13, 9/27, 10/31, 11/30		No harvest
NMPMC-S-0302-WO Pipe Spring Bottlebrush squirreltail seed production	23N	0.20	10/4/2005		10/4, 10/21, 10/31, 11/30		No harvest
NMPMC-S-9401-RA Vaughn sideoats grama Foundation seed field	25N, 19	1.55	5/26/1992, 2004	115 lbs. Nitrogen 70 lbs. Phosphorous	4/15, 5/12, 5/18, 5/31, 6/9, 6/28, 7/19, 7/29, 8/11, 9/1, 10/25	9/21,22,23	348.32
NMPMC-S-9902-RI Seed Increase of Alkali Muhly	12	0.25	1999	120 lbs. Nitrogen 40 lbs. Phosphorous	4/14, 5/11, 5/26, 6/23, 7/22, 8/19		No harvest
NMPMC-S-0403-WO Grand Canyon National Park Muttongrass seed production	25S	0.90	2003	200 lbs. Nitrogen 60 lbs. Phosphorous	3/30, 4/15, 5/5, 5/20, 6/10, 7/1, 7/19, 8/8, 9/1, 10/28, 12/2	5/16	
NMPMC-S-0307-RA Salado Alkali Sacaton Foundation seed field	11 and 19	1.0 and 0.72	2003	80 lbs. Nitrogen 30 lbs. Phosphorous	4/15, 5/10, 5/18, 5/27, 6/20, 7/12, 8/9, 9/16		No harvest
NMPMC-S-0301-RA Viva Galleta Foundation seed field	19	2.4	2003	80 lbs. Nitrogen 100 lbs. Phosphorous	5/12, 6/1, 6/30, 8/2, 10/25	6/24, 8/30	92.30
NMPMC-S-0004-WO Grand Canyon NP Muttongrass seed production	20N	1.0	2000 and 2002	205 lbs. Nitrogen 70 lbs. Phosphorous	3/30, 4/14, 5/3, 5/24, 6/10, 7/1, 7/19, 8/8, 9/1, 12/2	5/12	30.58

Project Number/Name	Field #	Acres	Planting Date	Fertilizer Applications	Irrigation Dates (3" Application)	Harvest Date	Harvest (Cleaned Wt. lbs.)
NMPMC-S-0003-RA Grand Canyon NP Blue grama seed production	20N	0.50	2000	120 lbs. Nitrogen 40 lbs. Phosphorous	5/3, 5/27, 6/15, 7/7, 8/2, 9/1	10/13	8.26
NMPMC-S-0301-WO Zion NP Sand bluestem seed production	25S, 27N	0.50	2003, 8/23/2005	110 lbs. Nitrogen 40 lbs. Phosphorous	4/15, 5/18, 6/9, 6/30, 7/20, 8/23, 8/25, 9/1, 9/20, 9/26, 10/21, 11/30	9/15, 9/26	5.84
NMPMC-S-0301-WO Zion NP Indian ricegrass seed production	35N	0.25	2004	65 lbs. Nitrogen 60 lbs. Phosphorous	4/4, 4/14, 5/6, 5/25, 6/21, 7/8, 8/2, 9/7, 10/31, 12/16		No harvest
NMPMC-S-0302-WO Pipe Spring National Monument Indian ricegrass seed production	8	0.25	2004	70 lbs. Nitrogen 100 lbs. Phosphorous	4/4, 4/14, 5/10, 5/25, 6/23, 7/7, 8/4, 9/6		No harvest
NMPMC-S-0302-WO Pipe Spring National Monument Galleta seed production	26S	0.10	2004	40 lbs. Nitrogen 40 lbs. Phosphorous	4/14, 5/18, 6/23, 7/19, 8/3, 9/6	9/23	N/A
NMPMC-S-0301-WO Zion NP Galleta seed production	35N, 24S	0.35	2004, 6/2/2005	70 lbs. Nitrogen 40 lbs. Phosphorous	4/14, 5/18, 5/26, 6/2, 6/7, 6/13, 6/23, 6/30, 7/8, 7/15, 7/28, 8/9, 8/25, 9/8, 9/22, 10/31	9/23, 10/31	0.42
NMPMC-S-0401-RA Pastura Little bluestem Foundation seed field	19	0.41	2004	30 lbs. Nitrogen 30 lbs. Phosphorous	3/31, 4/21, 5/12, 5/26, 5/31, 6/17, 6/29, 7/29, 8/25, 9/16	10/5	140.62
NMPMC-S-0402-RI Westwater germplasm Alkali muhly Foundation seed field	11	1.0	2004	80 lbs. Nitrogen 70 lbs. Phosphorous	4/14, 5/11, 5/26, 6/23, 7/22, 8/19	9/29, 10/3	84.50
NMPMC-S-0301-WO Zion NP Bottlebrush squirreltail seed production	19	041	2004	95 lbs. Nitrogen 110 lbs. Phosphorous	4/4, 4/21, 5/12, 5/27, 6/23, 7/29, 9/1, 10/4, 10/14, 12/1	6/7, 6/13, 6/27	65.54
NMPMC-S-0501-RA Llano Indiangrass Foundation seed field	24N	0.25	9/8/2005		9/8, 9/12, 9/16, 9/22, 10/5, 10/21, 10/31, 11/30		No harvest

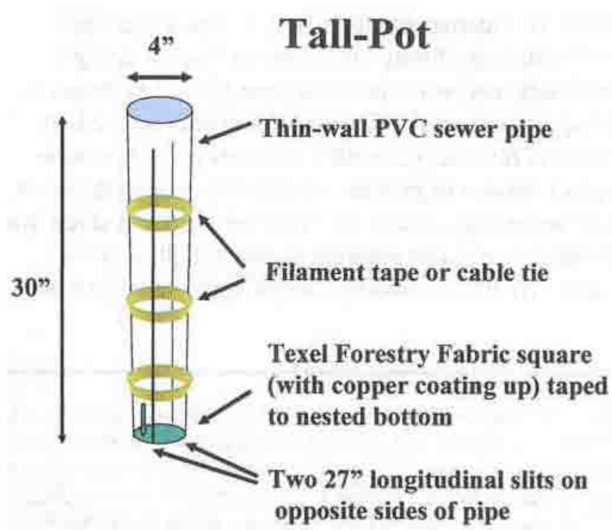
Appendix A
Tall-Pots

Tall-pots are being used by the USDA-NRCS Los Lunas Plant Materials Center for revegetation of disturbed xeric sites which would require appreciable irrigation if conventional woody plant establishment methods were used. Pilot studies investigating tall-pot technology have been conducted on highway medians and along right-of-ways in semi-arid pinon-juniper zones, in disturbed riparian areas with deep (greater than four feet) water tables, and at other critical area planting sites where conventional irrigation is not technically or economically feasible.

Tall-pots allow the development of deep root systems capable of using subsurface soil moisture occurring in two contrasting situations:

1. arid sites with thick soil profiles and deep soil moisture (i.e., not subject to loss by surface evaporation) or
2. riparian areas where soil moisture is present in the capillary fringe above a relatively deep water table (e.g., the fringe extends from the water table to about three to four feet below the soil surface).

The LLPMC has modified traditional tall pot designs to reduce pot costs and improve plant growth in the nursery. Inexpensive thin wall four-inch diameter PVC sewer pipe is split lengthwise to provide a tapered pot for easy root-ball removal and to discourage root spiraling. The bottom of a tall-pot is covered with copper hydroxide coated spun-bonded fabric to control root egress and allow drainage. The LLPMC tall-pots are typically 30” long (or four pots from a 10-foot pipe section).



The LLPMC is investigating methods to enhance transplant survival in the arid Southwest while minimizing the expense of providing sufficient supplemental water to assure establishment. Beyond the benefits of a long root ball to access soil moisture deep in the soil profile, the use of a limited number of subsurface water applications has provided high survival rates of shrubs planted on and sites. In pilot projects on sites disturbed by highway construction near Santa Fe, New Mexico, thousands of native shrubs (including New Mexico olive, skunkbush sumac, and wavyleaf oak) were grown in tall pots and were planted with perforated watering tubes to allow the application of water deep into the soil profile. Several years after planting, the survival rates for well-adapted species during the current drought exceed 95 percent.

A watering tube is placed adjacent to the root ball in an augered hole, which is two to five inches greater in diameter than the four inch mot ball. The goal of watering tubes is to apply sufficient water to produce a store of deep subsurface moisture not subject to surface evaporation. The bottom of the tube reaches the bottom of the planting hole. Perforations along the lower half of the tube allow water to move into the lower soil profile and result in minimal wetting of the soil surface to minimize weed growth and evaporation losses.

The planting hole containing the 30" root ball and watering tube needs to be backfilled with care. Voids in the backfill can be minimized by surface watering to wash soil into the void space, if irrigation water is readily available immediately after planting. Since fall plantings are generally preferred, the application of this surface water will not generally encourage troublesome weed growth except occasionally some winter annual weeds.

Larger diameter watering tubes (three to four inches) can accommodate the application of starch-based polymer hydrogels that provide a slow release of water to the subsoil that replenishes water used by plant transpiration. Smaller diameter one inch water tubes can be used for the application

The advantage of using hydrogel is that fewer applications of water are needed to assure establishment but this must be weighed against the cost of the polymer and the greater difficulty in applying this gelatinous material.

In plantings using tall-pots, the number of water applications required depends on the ease and expense of providing water to the watering tubes, the drought tolerance of the species, the existing and expected drought conditions at the site, and the depth to ground water (in riparian situations only). Our experience with plantings during the recent multi-year drought indicates that two applications per year of hydrogel or three applications of water will probably assure high survival rates on xeric sites. On sites receiving some run-off harvest or greater precipitation, one hydrogel or two water applications will probably be needed for two to three years after planting to obtain high survival rates.

We have generally tried to apply water just as growth resumes in the spring and again in early fall to assure adequate soil moisture through the typically dry autumn period.

In some situations, an annual subsurface water application for a few years might be sufficient for acceptable survival percentages or even a single watering at planting might suffice; however, considering the expense of tall-pot plant material and the cost of installing tall-pots, adequate water application to maximize survival potential is usually justified. Successful plant establishment requires the propagation of roots into the capillary fringe for riparian plantings or the proliferation of roots capable of mining stored soil moisture for plantings on and sites.

In riparian areas with shallow ground water providing a capillary fringe at two to three foot depths, water tubes are not necessary. Other situations that may not require watering tubes would be semi-arid sites with appreciable rainfall harvest potential and porous soil allowing sufficient recharge of deep soil moisture. If precipitation levels return to the elevated averages of the recent past, only minimal subsurface water application may be required for plant establishment on many xeric sites.

Tall-pots require fabrication which is relatively expensive due to the labor involved compared with the cost of commercially available containers. The production of tall-pot plants takes considerable time so substantial lead-time is required to propagate appropriate species for each particular revegetation project. If large containerized or bare-root seedlings are available, tall-pot production will require at least one growing season for fast growing species (e.g., such as willows and cottonwoods), two to three growing seasons for many upland and riparian shrubs and trees (e.g., New Mexico olive, skunkbush sumac, shrub oaks), and as much as four years for slow growing desert species (e.g., yuccas, agaves, beargrass).

Although the production and initial maintenance of outplanted tall-pots requires a significant investment of time and money, there are many situations in arid and semi-arid regions of the Southwest where this technology will be more effective than other currently available establishment techniques.