Progress Report January 2002
Tall Pot Transplants Established With Hydrogel

A Revegetation Technique Without Intensive Irrigation For The Arid Southwest

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Introduction

Developing a successful transplanting system that has minimal follow-up maintenance, particularly irrigation was needed for landscaping highway medians and right-of-ways in the arid southwest. Container planting of shrubs, with some irrigation, is essential for successful revegetation of most dry sites. The selection of tall-pot containers coupled with the application of a superabsorbent hydrogel (sodium carboxymethyl cellulose) for irrigation is being tested at three locations in northern New Mexico that receive an average annual precipitation of 10 to 14 inches (see Appendix A). Two superabsorbents having substantially different cost per application are also being evaluated. The New Mexico State Highway and Transportation Department (NMSHTD) was the primary funding agency for this study and demonstration project. Other funding sources include the Wildland Native Seed Foundation and the New Mexico Plant Materials Center (PMC) Interagency Riparian Group.

The superior performance of containerized transplants grown in tall-pots (containers longer than 24 inches) has been well-documented (see Figure 1). After eight years of field experience testing different container size transplants, Bainbridge (1994) concludes that seedlings grown in deep containers (i.e. PVC pipe) have improved survival and growth compared to smaller transplants grown in Super Cells or plant bands. He also found that excellent seedling survival and growth can be expected even in areas with less than 3 inches of rain per year if plants are properly planted and provided with minimal water (2-3 supplemental waterings totaling about 2 quarts). The Center for Arid Lands Restoration at Joshua Tree National Monument in California has developed a tall-pot made with 32 inch tall, 6 inch diameter PVC pipe with a wire mesh base held by cross wires. Survival rates for 32-inch transplants on a south-facing slope in the low desert were more than 40 percent greater than for 16-inch transplants (Holden 1992).

Figure 1: 28-inch rootball of a shrub grown in a PVC tall-pot

Plant trials on mill tailings disposal sites have shown that it is essential to supply irrigation water during the first two growing seasons where annual precipitation is 11 to 12 inches (Ludeke, 1977).

As an alternative to traditional irrigation, a superabsorbent hydrogel can be applied. A superabsorbent hydrogel is a crosslinked polymer or acrylonitrile with cellulose that absorbs and retains water hundreds of times its own weight. There are several types of superabsorbents that have been developed (see Table 1).

Table 1: Types of Superabsorbents

Chemical Name or Ingredient	**Market Application**	**Period**
Polyethylene Oxide/sawdust	Soil amendment	1965 –1978
Polyvinyl Alcohol	Diapers	1975 –present
Acrylonitrile/starch	Tampons, napkins, soil amendment, planting seedlings	1979 – present
Potassium Propenoate/Propenamide copolymer	Soil amendment, gel seeding, plug-mix planting, root-dip,	1982 – present
Acrylic Acid	Diapers, sanitary napkins, water treatment, soil amendment	1981 – present
Acrylamide	Diapers, sanitary napkins, soil amendment	1983 – present
Acrylic Acid/Acrylamide	Diapers, soil amendment	1985 – present

Copied from Erazo (1987)

Some superabsorbents have been traditionally used in horticulture and agriculture successfully as soil additives as reported by Erazo (1987) to: 1) improve water holding capacity, 2) improve aeration and drainage of soil mix, 3) reduce irrigation frequency, and 4) increase shelf life of plants in cold storage. Also, some superabsorbents have been used as root dips for shipping and planting bare root seedlings.

DRiWATER, Inc. has developed a unique usage for a superabsorbent as an irrigation source for transplants in arid environments. When the powdered product is hydrated, each granule acts as a tiny water reservoir that becomes available to plants as microbial degradation of the cellulose releases free water that is available for movement into soil or plants through root absorption. DRiWATER, Inc. sells their product either as a powder or already hydrated in quart containers. The product in containers is opened, turned upside down, and partially buried in the root zone of a plant. Additionally, the superabsorbant sold by DRiWATER, Inc. (like some other hydrogels) is appropriate for use with plants because they are nonphytotoxic and have a neutral pH (see Attachment 1).

Methodology

Native shrub species of ecotypes with origins within a 300-mile radius of the planting (see Table 2) sites were grown in 30-inch tall, 4 inch diameter sewer pipe at the New Mexico Plant Materials Center located in Los Lunas, New Mexico.

Depending upon species, it generally takes about three years to produce a mature root ball from seed in this container (some take four years or longer, for example, mountain mahogany, winterfat and Mormon tea). These containers have two split seams that run most of the pipe length to encourage spiraling roots to grow downward and ease root ball removal. The bottoms of the containers are sealed with a porous fabric to allow drainage.

The fabric was manufactured with a Spin-Out coating (copper hydroxide) to control root penetration.

During the fall of 2000 and 2001, more than 2,200 transplants of 16 different species were planted in northern New Mexico at three locations: Milan, Santa Fe, and Eldorado Village.

Table 2: Native Plant Species and Origin of Shrubs Planted at Milan, Eldorado, and Santa Fe

Scientific Name	Common Name	Accession Number or Cultivar Name	Origin
Amelanchier uathensis	Utah Serviceberry	Commercial	Southwest CO
Cercocarpus montanus	Mountain mahogany	Commercial	North Central NM
Cercocarpus ledifolius	Curl leaf mahogany	Commercial	Southeastern Utah
Forestiera neomexicana	New Mexico privet	Jemez	North Central NM
Philadelphyus microphyllus	Littleleaf mockorange	Commercial	Southwest CO
Prunus virginiana	Chokecherry	9004629	North Central NM
Quercus gambelli	Gambel oak	Commercial	North Central NM
Quercus undulata	Wavyleaf oak	9066437	North Central NM
Rhus trilobata	Three leaf sumac (skunkbush)	Bighorn	Bighorn, WY
Ribes cereum	Wax currant	9066057	North Central AZ
Robinia neomexicana	New Mexico locust	9066428	Northeastern NM
Rosa woodsii	Wood's rose	9066421	North Central NM
Shepherdia argentea	Silver buffaloberry	9066475	Southwest CO
Chamaebatiaria millefolium	Fernbush	9062866	North Central CO
Berberis fremontii	Fremont barberry	9066439	Southwest CO
Krascheninnikovia lanata	Winterfat	9066471	Southwest CO

Planting holes were dug with 9-inch diameter, 40-inch long Beltec auger powered by a 50-horsepower farm tractor. Holes, 3-foot in depth, were hand cleaned using standard post-hole diggers. Plants were then removed from containers, placed in holes, and back-filled. Prior to backfilling, an irrigation tube was placed in each hole (see Figure 2).

Figure 2: Watering plants through irrigation tubes to hydrate the soil in the root zone (November 2000)

This tube allows the plant to be irrigated with either hydrated sodium carboxymethyl cellulose (HSCC), starched based superhydrogel or water near the bottom of the root-ball to encourage growth of a deeper root system**.** The irrigation tubes are constructed from a PVC sewer pipe 3-inches in diameter and 40-inches in length, (see Figure 3). The orifice is capped to prevent animal entry and exposure of the root systems to sunlight. The 10-inch top section of the tube can be removed from the 30-inch perforated main tube body. After the end of the irrigation period (two years), the top 10-inch section of pipe will be removed and the remainder will be back-filled with soil. Because the lower portion of the tube should contain substantial root development, it will remain in place.

Disturbed soil caused by the shrub planting and irrigation water create an ideal site for weeds to germinate. Weeds should be controlled for optimal shrub growth and visual esthetics. Pre-emergent weed control herbicides are ideal for this use.

The three plantings will be evaluated for survival in fall of 2001 through 2003.

Figure 3: Irrigation tubes used in the 3 plantings

Milan Planting

A total of 99 shrubs and trees were planted on September 12, 2000 on Highway NM 124 median in Milan, NM in front of the NMSHTD District Office. This area receives an annual average precipitation of 10- to 12-inches. The subsurface soil was damp from recent precipitation. The planting covers about 1/4 mile of highway median with the plants spaced on 10-foot centers and separated into four groups (see Figure 4 and Attachment 2). Additionally, 16 ponderosa pine and 25 piñon pine were planted December of 2001 when the root-balls of these plants were fully developed.

Figure 4: The planting on the median of NM Highway 124 in Milan (November 2000)

The HSCC was applied to the plants in early June 2001 (once spring moisture was near depletion). Five apache plume plants that were planted without irrigation tubes received about 5 gallons of surface water.

The entire planting received an application of Pendulum herbicide for weed control. An 8-foot swath was sprayed over the top of the shrubs, at the rate of 1 gallon per acre, in March 2000.

Plant survival was evaluated on October 10, 2001.

<u>Results:</u>

Plants receiving hydrostarch through the irrigation tubes displayed 98 percent survival rate (see Tables 3 and 4, and Figures 5 and 6). The five Apache plume plants that received only surface irrigation died. The 41 shrubs installed in front of the New Mexico State Highway District Office also received regular surface irrigation by the Highway Department. Subsequently, these plants were twice as large as the other plants.

Figure 5: New Mexico locust transplants at the conclusion of the first growing season (Fall 2001) on the road shoulder of NM 124, located in front of District Office building.

Figure 6: New Mexico olive transplants at the conclusion of the first growing season (Fall 2001) on the median of NM Hwy124.

**Table 3: Survival Rate of Shrubs as of November 29, 2001
Median of Highway NM 124, Milan, NM**

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Fallugia paradoxa	Apache plume	Northern Arizona	17	16	94	Good
Forestiera neomexicana	New Mexico olive	Northern New Mexico	12	12	100	Good
Rhus trilobata	Skunkbush sumac	Northern New Mexico	29	29	100	Good
Total			58	57	98	

**Table 4: Survival Rate of Shrubs as of November 29, 2001
Road Shoulder Irrigated Regularly On Highway 124, Milan, NM**

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Forestiera neomexicana	New Mexico olive	Northern New Mexico	36	36	100	Excellent
Robinia neomexicana	New Mexico locust	Northern New Mexico	15	15	100	Excellent
Total			41	41	100	

Eldorado Planting

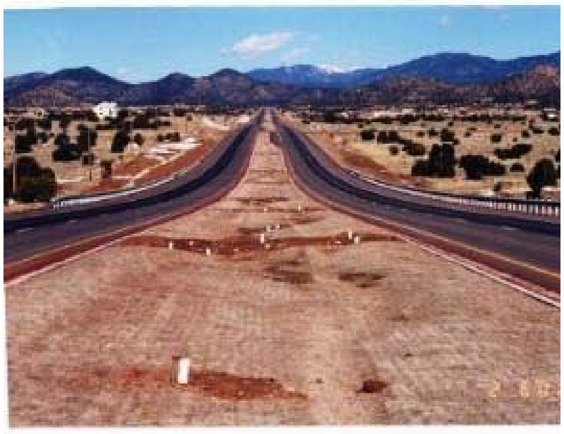

Figure 7: Plants were installed in open areas of a blanket seeding on the median of NM Highway 285 (January 2001)

From November 6 to December 8, 2000, 808 tall-pot, native shrubs were planted on the median of NM Highway 285 (beginning at the Interstate 25 junction and continuing 3 miles south). The area is known as Eldorado Village. This area receives approximately 10–12 inches of annual precipitation. The actual planting took 11 days to complete, but because of snowstorms, the planting was frequently delayed. Community volunteers assisted the PMC with the installation . Volunteers and PMC Staff installed the plants in 5- to15-unit random clusters on the median project (see Figure 7) in areas selected by the NMSHTD and by Ms. JoEllen Schilmoeller, liaison for the Eldorado Community Highway 285 project. Ms. Schilmoeller also arranged for the more than 25 community volunteers to help with planting and irrigation water that was supplied by the Eldorado Utilities Department. All plants were watered during the last week of the planting period.

In March 2001, the highway median was sprayed with a mix of Pendulum (at the rate of one gallon per acre) and Brominal (at the rate of 1 quart per acre). Many annual weeds had already emerged by this time.

In early May 2001, after plants broke winter dormancy and the soil began drying out from spring moisture, 600 plants received a 2-gallon application of HSCC (see Figure 8). 148 plants received 2 gallons of a less expensive, starch-based hydrated superabsorbent (for approximately ¼ of the cost). 30 plants received approximately 3 gallons of water. Plants will receive a second treatment in the spring of 2002. The first year application of HSCC was purchased by the Wildland Native Seed Foundation and donated to this project.

To control weeds, PMC personnel hand-hoed the highway median in July 2001. These median areas were not sprayed with Pendulum and had high densities of annual kochia, Russian thistle, and yellow sweetclover. Weeds compete for water and light potentially reducing survival of transplants. There was excellent weed control in areas that were sprayed with Pendulum (see Figures 9 and 10).

Figure 8: Applying starch-based superabsorbant to plants on the median of Highway 285 (June 2001)

We evaluated the survival rate of the shrubs on June 7, 2001. In September and October of 2001, an additional 921 native shrubs in tall-pots were planted. These plants received a 3-gallon application of water promptly after planting. Because it was an extremely dry and warm fall season, the plants received a second 3-gallon application of water in late October. The plants continued growing until mid-November.

Results:

Survival of all tall-pot shrubs averaged 97 percent (see Table 5). The lowest survival rate was displayed by Apache plume (76 percent) and Mormon tea (72 percent). Apache plume generally does not do well in poorly drained soils. The soils of this highway median were generally high in clay and contained a compacted layer about 6 inches from the surface impeding drainage and aeration. Of all species planted, the Mormon tea generally had the poorest developed root ball. When the plants were removed from their containers, often the outside soil layer, surrounding the root-ball, would crumble.

There was no difference in transplant survival of those receiving the two superabsorbent starches or water. The survival rate averaged 97 percent for both types of starches, and 100 percent for water alone.

Figure 9: New Mexico locust tall-pot transplants on the median of Highway 285 by conclusion of first growing season (November 2001)

Figure 10: Wolfberry tall-pot transplants on the median of Highway 285 by conclusion of first growing season (November 2001)

Table 5: Survival Rate of Shrubs as of June 7, 2001
Median of Highway 285, Eldorado, NM

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Amelanchier utahensis	Utah serviceberry	Northern Arizona	14	12	86	Good
Krascheninnikovia lanata	Winterfat	Northern Arizona	6	6	100	Fair
Cercocarpus montanus	Mountain mahogany	Northern New Mexico	71	69	97	Good
Cercocarpus ledifolius	Curlleaf mountain mahogany	Northern Arizona	3	3	100	Fair
Chamaebatiaria millefolium	Fernbush	Northern Arizona	37	37	100	Good
Berberis fremontii	Fremont barberry	Northern Arizona	10	8	80	Poor
Ephedra viridis	Mormon tea	Northern Arizona	18	13	72	Poor
Fallugia paradoxa	Apache plume	Northern Arizona	25	19	76	Good
Lycium torreyi	Wolfberry	Central New Mexico	36	35	97	Good
Nolina microcarpa	Beargrass	Northern Arizona	14	13	93	Poor
Celtis reticulata	Netleaf hackberry	Central New Mexico	5	5	100	Good
Prunus virginiana	Chokecherry	Northern New Mexico	8	8	100	Good

**Table 5: Survival Rate of Shrubs as of June 7, 2001
Median of Highway 285, Eldorado, NM**

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Quercus undulata	Wavyleaf oak	Northern New Mexico	78	77	99	Good
Rhus glabra	Smooth sumac	Northern New Mexico	5	5	100	Good
Rhus trilobata	Skunkbush sumac	Northern New Mexico	56	55	98	Good
Ribes cereum	Wax currant	Northern New Mexico	12	12	100	Good
Robinia neomexicana	New Mexico locust	Northern New Mexico	20	20	100	Good
Rosa woodsii	Wood's rose	Northern New Mexico	163	162	99	Good
Shepherdia argentea	Silver buffaloberry	Northern New Mexico	26	26	100	Good
Symphoricarpos oreophilus	Snowberry	Northern Arizona	6	6	100	Good
Total			790	768	97	

Santa Fe Planting

479 tall-pot native shrubs were planted on the interchange of Ridgecrest Road on Highway 599 in Santa Fe, NM (see Figure 11 and Attachment 3) from October 3–10, 2000.

Figure 11: Northwest quadrant planting just after installation on New Mexico Highway 599 at the Ridgecrest Road interchange (October 2000)

The planting consisted of 199 New Mexico olive, 161 skunkbush sumac, and 119 wavyleaf oak. This area averages about 12 to 14 inches of annual precipitation. The shrubs were planted on hillside terraces, in separate 100- to 200-foot single rows on 8-foot centers (see Figure 11 and Attachment 3). Plants received 3 gallons of water in irrigation tubes immediately after planting. Because the area had been receiving heavy precipitation during and after the planting, the starch-based superabsorbent was not applied until early June 2001. Three of the four plantings (northwest, northeast, and southeast quadrants) received HSCC. The planting in the southwest quadrant received the less expensive starch-based superabsorbent. For a treatment control, 18 plants have been irrigated only with water, receiving a 3-gallon application each time an application of hydrated supersbsorbent was applied.

In February 2001, Pendulum was applied at 1-gallon per acre to control annual weeds.

Results:

On November 17, 2001, the planting was evaluated for survival. It displayed nearly a 100 percent survival rate (see Tables 6, 7, 8, and 9, and Figure 12). Subsequently there was no measurable difference between the two different starched-based superabsorbents. Only one plant was dead, and it was a skunkbush sumac receiving the HSCC by irrigation tube.

Figure 12: Northwest quadrant near the conclusion of the first growing season on New Mexico Highway 599 at the Ridgecrest Road Interchange (November 2001)

Table 6: Survival Rate of Shrubs in the Northwest Quadrant Highway 599 Interchange at Ridgecrest Road

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Forestiera neomexicana	New Mexico Olive	Northern New Mexico	27	27	100	Good
Rhus trilobata	Skunkbush sumac	Northern New Mexico	52	52	100	Good
Total			79	79	100	

Table 7: Survival Rate of Shrubs in the Northeast Quadrant Highway 599 Interchange At Ridgecrest Road

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Forestiera neomexicana	New Mexico olive	Northern New Mexico	88	88	100	Good
Quercus undulata	Wavyleaf oak	Northern New Mexico	32	32	100	Good
Rhus trilobata	Skunkbush	Montana	27	27	100	Good

**Table 7: Survival Rate of Shrubs in the Northeast Quadrant
Highway 599 Interchange At Ridgecrest Road**

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
	sumac					
Total			147	147	100	

**Table 8: Survival Rate of Shrubs in the Southwest Quadrant
Highway 599 Interchange At Ridgecrest Road**

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Forestiera neomexicana	New Mexico olive	Northern New Mexico	31	31	100	Good
Quercus undulata	Wavyleaf oak	Northern New Mexico	50	50	100	Good
Rhus trilobata	Skunkbush sumac	Montana	25	25	100	Good
Total			106	106	100	

**Table 9: Survival Rate of Shrubs in the Southeast Quadrant
Highway 599 Interchange At Ridgecrest Road**

Plant Species	Common Name	Origin	Total Planted	Alive	Percent Survival	Vigor
Forestiera neomexicana	New Mexico olive	Northern New Mexico	53	53	100	Good
Quercus undulata	Wavyleaf oak	Northern New Mexico	27	27	100	Good
Rhus trilobata	Skunkbush sumac	Montana	58	59	100	Good
Total			138	139	99	

Conclusions:

Of the 1,386 tall-pot transplants receiving one of the two hydrogels or water by an irrigation tube, only 29 plants had died by the end of the first growing season. This equates to a 98 percent survival rate. At Milan, the five transplants without irrigation tubes and that received the two 5-gallon surface applications of water had died.

There was no measurable difference in survival of plants between the two hydrogels tested.

Based on the data for 1 year, the study results suggest that nearly a 100 percent survival rate can be achieved using tall-pots with irrigation tubes, and for transplants without hydrogel, just two applications of water are sufficient. One 3-gallon water application should be applied when the plants are first installed in the fall. A second water application should be applied in June to carry the plant through the droughty period before the monsoon period begins in July. A single application of water may be adequate to maintain survival, but this was not tested.

Acknowledgements

We would like to extend our gratitude to the New Mexico Highway and Transportation Department, Eldorado Community, Wildland Native Seeds Foundation and the Plant Materials Center Interagency Riparian Group for their valuable contributions.

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Attachment 1

Material and Safety Data Sheet

DRiWATER 1/1/93

MATERIAL SAFETY DATA SHEET

DRiWATER, Inc.	DRiWATER SOIL AMENDMENT
600 East Todd Road	
Santa Rosa, CA 95407	MSDS #2
Phone: 707 588-1444	Date: January 1, 1993

Product Identification

WARNING! SURFACE SUBJECT TO SPILLS CAN BECOME SLIPPERY!

Product: DRiWATER	HMIS RATING (1)	
CAS# (Unassigned)	Health Hazard	1 Slight
	Flammability Hazard	0 Minimal
	Reactivity Hazard	0 Minimal
INGREDIENTS:	Sodium carboxmethyl celluose (2%) CAS# 9004-32-4; aluminum sulfate (.1%) CAS# 10043-01-3; water.	
APPEARANCE AND ODER:	Colorless, odorless, tasteless gel.	

DRiWATER, Inc. has compiled the information and recommendations contained in this Material Safety Data Sheet from sources believed to be reliable and to represent the most reasonable current opinion on the subject when the MSDS was prepared. Nor warranty, guaranty or representation is made as to the correctness of sufficiency of the information. The user of this product must decide what safety measures are necessary to safely use this product, either alone or in combination with other products, and determine its environmental regulator compliance obligations under any applicable federal or state laws.

Hazardous Ingredients and Exposure Limits

This material is not expected to cause physiologic impairment at low concentration.

Typical Physical & Chemical Characteristics

SURFACES SUBJECT TO SPILLS WITH THIS PRODUCT CAN BECOME SLIPPERY!

Boiling Point:	100 C
Freezing Point:	0 C
Solubility in Water:	Not Soluable
Specific Gravity:	1.01
PH of 2% Solution:	7 +/ .5

Attachment 2

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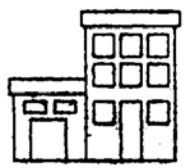
NM Highway 124



Prewitt Road

District 6 Headquarters

FAPA = Fallugia paradoxa apache plume

PIPO = Pinus ponderosa ponderosa pine

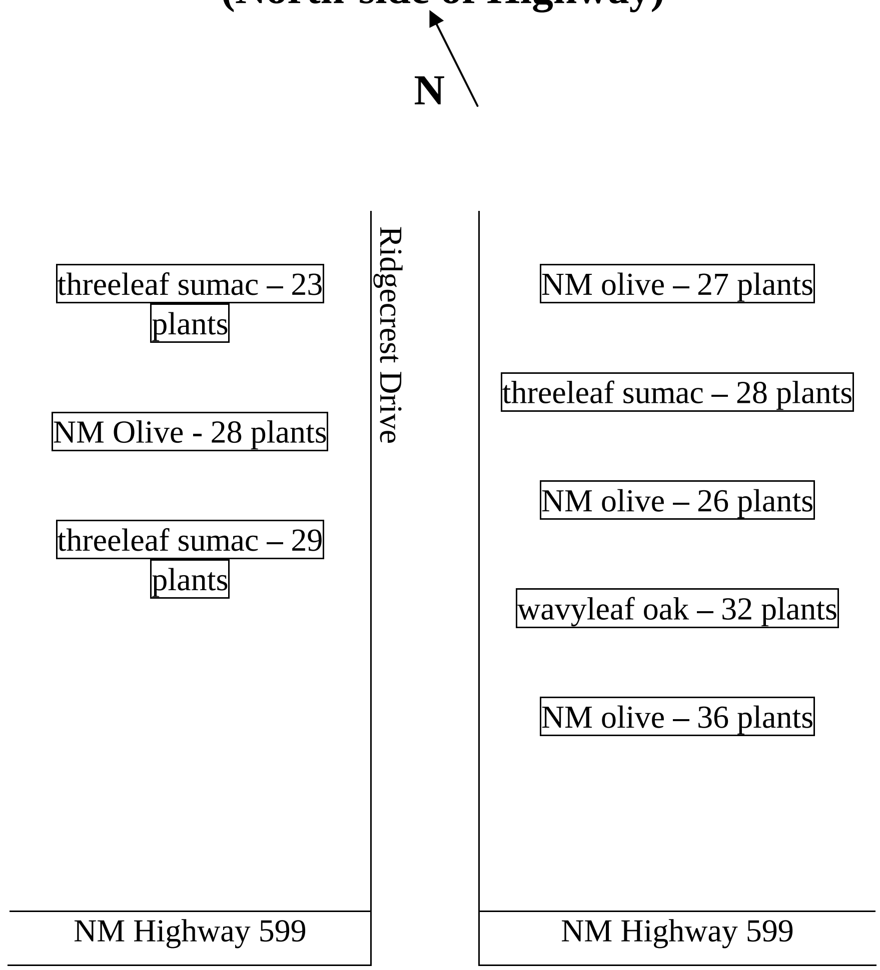
RHUS = Rhus trilobata threeleaf sumac

PIED = Pinus edulis pinyon pine

FONE = Forestiera neomexicana NM olive

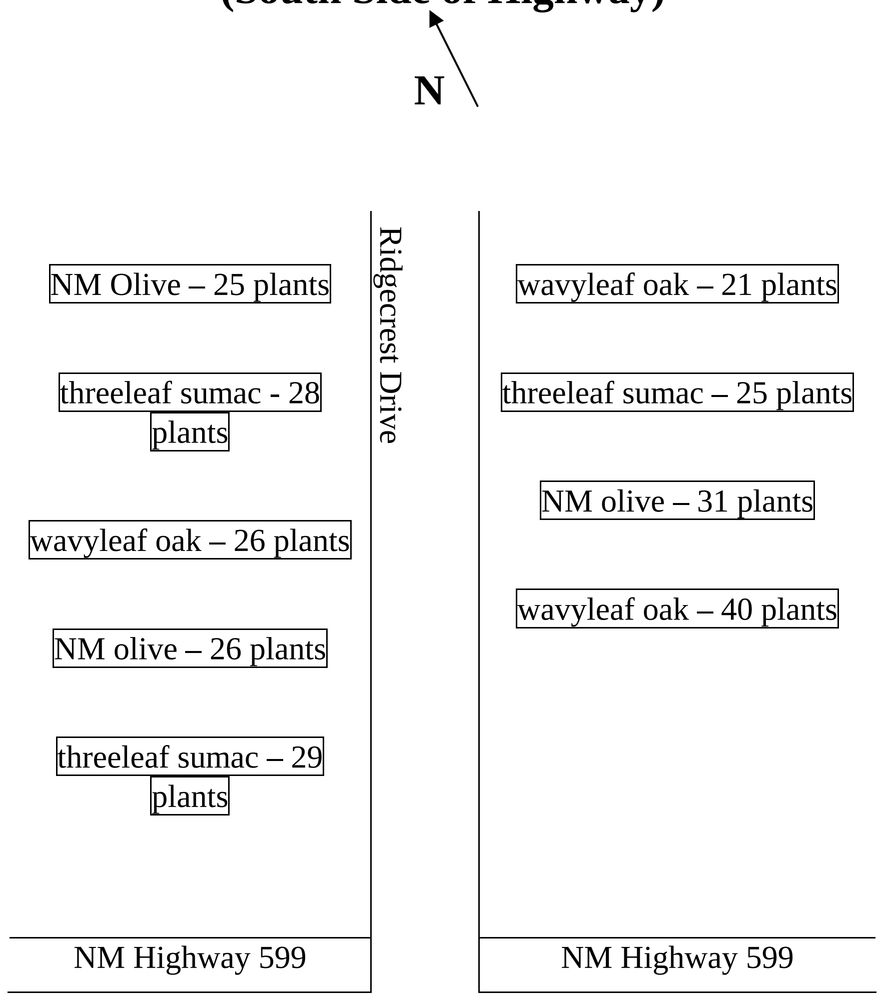
Attachment 3

Plot Plan for Thirty-Inch Transplants with Hydrogel at Santa Fe NM (2000) (North-side of Highway)



Attachment 3 (Continued)

Plot Plan for Thirty-Inch Transplants with Hydrogel at Santa Fe NM (2000) (South Side of Highway)



Attachment A - Planting Locations

Attachment B – Annual Precipitation Data

Grants, NM	1999	12.18 inches
	2000	5.35 inches
	2001	7.65 inches

Santa Fe, NM	1999	12.62 inches
	2000	12.28 inches
	2001	9.71 inches