La Semilla

The Seed

1997-1998 ANNUAL REPORT
A Product of the
TUCSON PLANT MATERIALS CENTER

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1997-1998

ANNUAL REPORT

TUCSON PLANT MATERIALS CENTER

EXECUTIVE SUMMARY

The broad objective of the Natural Resources Conservation Service (NRCS) plant materials program parallels the United States Department of Agriculture's long-term conservation objectives to protect or enhance soil, water, air, plant and animal resources.

As part of its coordinated program with America's Conservation Districts, the NRCS provides specialized activities and assistance in plant materials projects through 26 Plant Materials Centers. The Tucson PMC serves the hot desert areas of California, Nevada and Utah. It is NRCS policy to assemble, evaluate, release and distribute for commercial increase, plant materials for a broad range of resource conservation and development needs. We also develop and disseminate technical information for plant and resource management.

Conservation districts, various federal and state agencies, and private landowners cooperate in these efforts. Cooperators with the Tucson PMC include state universities, U.S. Fish and Wildlife Service, Agricultural Research Service, Forest Service, Bureau of Land Management, Bureau of Reclamation, state natural resource agencies, the Arizona Crop Improvement Association, and others. This interagency cooperation offers many opportunities for joint development and release of plant materials and for exchange of information, seed and planting stock.

The Tucson PMC began operations in 1935. The evaluation of plants as well as cultural and management practices are carried out at the federally owned 45.5 acre farm and off-center evaluation sites. The NRCS operated the PMC from 1935-1952 when the University of Arizona assumed responsibility for operations. The NRCS (formerly the SCS) resumed control of the PMC once again in 1962. This is the 37th year of operation since the NRCS took over responsibilities in 1962.

The Tucson PMC has been conducting various studies and plantings to address resource issues in the following areas: rangeland, mineland, urban lands, cropland, natural areas, and channel stabilization. Currrent Tucson PMC studies and corresponding conservation practices are displayed in Table 1.

Land Use Description: Rangeland
Sixteen rangeland related studies were conducted by Tucson PMC personnel in 1997-1998. Four of these studies focused on individual species that are in the Tucson PMC advanced evaluation stage of the selection process. These species include desert saltbush (*Atriplex polycarpa*), cane bluestem (*Bothriochloa barbinodis*), Arizona cottontop (*Digitaria californica*), and spike dropseed (*Sporobolus contractus*). All of these species are native to the southwestern United States and the intended primary use for these species is in critical area and rangeland revegetation efforts.

Four off-center studies were initiated and/or evaluated in 1997-1998; these studies included the Maggie Tank Hay Seeding - Using Grass Hay Bales, Southwestern Borderlands Savanna Grassland Ecosystem Restoration Study, Six Mile Flat Field Evaluations - Nevada Adaptation Trials, and Joshua Tree National Park Plant Adaptation Trials - Comparative Studies.

The Maggie Tank Hay Seeding using grass hay bales was designed and initiated to facilitate revegetation of deteriorated rangeland. The objective was to use livestock as a tool to incorporate grass seed through trampling in areas where grass hay bales had been scattered.

The Southwestern Borderlands Savanna, Grassland Ecosystem Restoration Study was initiated in 1996 and is a cooperative effort including the USFS Rocky Mountain Experiment Station, Coronado N.F., NRCS Douglas Field Office, NRCS Tucson Plant Materials Center, Whitewater Dray NRCD, Arizona State Land Department, Malpai Borderlands Group, USFWS, Hidalgo SWCD, and the Animas Foundation. The immediate objective of this cooperative study is to work to improve the density and composition of perennial, native grasses and reduce the influence of mesquite and other woody species.

The Six Mile Flat Field Evaluations in Nevada were initiated in 1987 in order to evaluate and select the best adapted plant materials to meet the conservation needs for MLRA 29. To date, 62 accessions encompassing 17 different species have been planted on this site.

The Joshua Tree National Park Plant Adaptation Trials - Comparative Studies was initiated to evaluate two native shrubs which are found growing in the Mohave desert: creosote bush (*Larrea tridentata*) and desert saltbush (*Atriplex polycarpa*). This study is evaluating local and non-local ecotypes for each species at two planting locations: Joshua Tree National Monument Headquarters, Twenty-nine Palms, California, and a Tucson PMC test site located at Avra Valley, Arizona. Evaluation factors include ecotypic variation and transplant size with regards to growth and survival. This information may help in determining optimum pot size in relation to plant survival after transplanting. To date this study has shown that with time there is little difference between pot sizes with regards to growth. Survival has been higher with the larger pots and this information will be analyzed before making any conclusions. Regarding ecotype variation, results to date indicate that locally collected material performs as well or better than non-local material.

The Tucson PMC is providing technical assistance to field offices and the Coronado RC&D on two watershed protection projects: Non Point Source Pollution Control in a Subwatershed of the Gila River, and Sediment Reduction in the San Pedro River.

The purpose of the project along the Gila River is to improve water quality by reducing sediment, a non-point source pollutant off of grazing land in Whitlock Valley, a subwatershed located between Safford and Duncan, Arizona. A series of small sediment retention structures were constructed in the watershed in 1998. The objective of the structures is to retain sediment, reduce surface runoff rate allowing more vegetation to establish, increase duration of channel flow, improve groundwater recharge, enhance wildlife habitat, and provide discharge to the San Simon-Gila River system that has a significantly lower amount of turbidity. 319h funds will be used for some of the installation costs, project management and a portion of the information dissemination necessary to increase the use of this type of practice on other grazing land in the Gila River Watershed and other watersheds in Arizona.

The purpose of the San Pedro River project is to improve surface water quality by reducing sediment, a non-point source pollutant of 5,976 acres of grazing land with boundaries within one-half mile of

the main river course between St. David and Tombstone. The project area is on the Running N Bar Ranch located in the San Pedro basin between St. David and Tombstone. The project site is located within two pastures that had been over utilized over the past 100 years. Over time, the area became severely eroded by sheet, rill and gully erosion that deposits sediment into the San Pedro River two miles from the pasture boundary. Vegetation on the site now consists of mesquite, yucca and burroweed-dominated communities. Grass does not exist in sufficient quantity to provide a seed source for the rangeland to recover without additional practice application.

Field planting evaluations included the 47 Ranch Field Planting, the George Morin Ranch Field Planting and the Riggs Flat Field Planting. The 47 Ranch Field Planting was installed in May 1995 and seeded five acres of P.I. 216101 cane bluestem at a rate of 2.5 lbs/acre and was compared against Lehmanns lovegrass (standard). Site preparation included rootplowing western honey mesquite on the contour and broadcast seeding afterwards. Evaluations included percent stand and a visual estimate of percent utilization. Evaluations conducted with the rancher indicate there was some successful establishment. Larger scale plantings are needed to evaluate cane beardgrass ability to establish. The George Morin Ranch Field Planting was installed during the summer of 1996. This planting compared the Tucson PMC's accession of Arizona cottontop (9003705) with a commercial wild collection. Both collections were seeded at a rate of 3 PLS pounds per acre. Evaluation factors included percent stand and precipitation amounts. Successful establishment was considered fair for Arizona cottontop. The Riggs Flat Field Planting was installed to promote the use of improved conservation plant materials for range seeding and to evaluate the adaptation of experimental plant lines for use in northern Arizona. This site was first planted in 1986 and again in 1994. The second planting utilized 17 grass and 4 shrub species. Two species, ' Hycrest II' crested wheatgrass and 'Vavilov" Siberian wheatgrass, were the superior performers with regards to stand and productivity. Based on the results of this trial it was decided to install a larger planting with these two species to evaluate how well they perform with regards to competition with winter annuals.

The Phenotypic Plasticity in Arizona Cottontop and Sideoats Grama Defoliation Tolerance are studies being conducted by Dr. Steven Smith, University of Arizona.

The TerraCottem Soil Amendment Trial was a cooperative effort with the Bureau of Land Management and Dr. Van Cotthem. The purpose of this trial was to evaluate this amendment's ability to enhance growth and survival of various species. This was a three-fold trial involving greenhouse trials, irrigated land, and transplants in a rangeland setting. The Sells Demonstration Garden is a cooperative effort between the PMC, NRCS Field Office and the Tohono O'odham Nation. Eighteen species were planted to provide local ranchers, school groups and others the opportunity to view several native species in one location. Included in this garden are two species, beargrass and yucca, which are used in making baskets.

Land Use Description: Mineland

The Cyprus Tohono Mine Revegetation Project was initiated in 1994. The objectives of this project are to conduct trials and evaluate methods of revegetating overburden and mine processed material using native plant materials. The information acquired from these trials will provide Cyprus Tohono Corporation with a prescription for large-scale revegetation, in accordance with agreements made

with the Tohono O'Odham Nation. Information gained from this project may also aid in improving conservation practices elsewhere. The primary goal for revegetating the overburden and mine processed material is to stabilize the slopes to prevent erosion and to blend the overburden piles with the surrounding vegetated mountain sides.

The use of native plant materials will eventually promote the utilization of the overburden slopes as territorial and forage locations for native wildlife species. Animals thought to directly benefit from revegetation include mule deer, javalina, Gambel's quail, desert cottontail, and various reptiles and arthropods.

The objectives of this project are also designed to meet the concerns of North Komelik Village and the Sif Oidak Grazing District, in relation to improving the aesthetic appearance of the mine as viewed from North Komelik Village and Highway 15. Revegetation of slopes facing North Komelik Village is the desired goal for Cyprus-Tohono Corporation.

BHP Biosolids Trial is a cooperative effort between BHP Mining Company, University of Arizona, and the Tucson PMC. This trial is evaluating the use of greenwaste and biosolids in reclaiming processed mined materials.

Land Use Description: Cropland

The Tucson PMC has initiated studies and activities to determine cover crops, cropping systems, and residue management practices to optimize soil and water protection, food and fiber production, and economic returns. The objective of these studies is to identify and develop legumes having minimal water requirements for use as cover crops during summer fallow periods in MLRA 30 and during winter fallow periods in MLRA 40 and 41. The Tucson PMC will work to document and promote the benefits of using cover crops and green manure crops in cropping rotations. The Cover Crop and Green Manure practice when implemented will: protect air quality by reducing wind erosion, improve soil tilth, improve soil moisture holding capacity, and reduce soil nutrient loss.

The Cool and Warm Season Cover Crop Trials are a joint study with Kai Umeda, Vegetable Crop Specialist with the Maricopa County Extension Service. The warm-season trials are specifically evaluating a legume that can be planted, turned under prior to winter vegetables. Factors being evaluated include biomass production and amount of nitrogen added to the soil. The cool season trial is a Tucson PMC study where various legumes for biomass production and adaptability to southern Arizona are being screened. The warm-season trial included 'Tropic Sun' sunn hemp (*Crotalaria juncea*), Iron & Clay cowpeas (*Vigna unguiculata*), sesbania (*Sesbaina exaltata*), sudangrass (*Sorghum sudanense*) and kenaf (*Hibiscus cannabinus*). The cool-season trial included purple vetch (*Vicia atropurpurea*),'Lana' woolypod vetch (*Vicia villosa* ssp. *varia*), 'Biomaster' pea (*Pisum sativum*) and Papago pea (*Pisum sativum*).

The Winter Forage Cover Crop Trail was a cooperative effort with the Cooperative Extension Service and local farmers to evaluate several legumes for use as a winter cover following cotton.

The 'Pete' Eastern Gamagrass Field Planting was installed in June 1997 north of Elfrida, Arizona in cooperation with the Douglas Field Office. This field planting was initiated to evaluate the

adaptability of 'Pete' eastern gamagrass as a pasture and/or silage plant in southern Arizona. Evaluation factors to be recorded are irrigation requirements, percent stand, dormancy or frost date, yield and cooperator's comments with regard to management and suitability.

The 'Seco' Barley Field Planting was installed in January 1997 north of Elfrida, Arizona in cooperation with the Douglas Field Office. This field planting was installed to compare the performance of the 'Seco' and 'Solumn' barley cultivars. The objective of this field planting was to determine which cultivar is best adapted to the Elfrida area with regard to biomass production, use as a feed silage and/or grazing preference.

The 'Donegal' Soybean Trial was a cultural evaluation involving local farmer, Douglas Field Office, and Dr. Thomas E. Devine(ARS). Dr. Devine provided the seed for the 'Donegal' which is a higher biomass producing forage strain of soybeans. The trial was initiated to determine if this variety of soybeans could be used in southern Arizona as a potential hay crop.

The Woolypod Vetch Strain Trial is a cooperative effort with Walt Graves, UC Davis Agronomist, and other cooperators in California. Eight strains of woolypod vetch were included in this trial and evaluated for stand and production.

The Heaton Farms Field Planting was initiated in 1994 in cooperation with the Fredonia Field Office. This field planting was designed to evaluate two pasture and hayland grass alternatives to tall wheatgrass on saline-sodic soils. 'Newhy' hybrid wheatgrass (*Elytrigia repens* x *Pseudoroegneria spicata*) and 'RS-Hoffman' quackgrass (*Elytrigia repens*) were planted in three borders of a small irrigated field. Two alfalfa varieties, 'Spredor 3' and 'Cimarron VR', are also part of this trial.

Evaluation of a Rapid Method for Evaluating Broad-Sense Heritability is a study conducted be Dr. Steven Smith, University of Arizona. This study is to determine if data taken from a spaced planting of wheat could provide BSH estimates comparable to those from the Difference Method.

Table 1.

Tucson PMC Studies and Related Conservation Practices

STUDY NAME	CODE	CONSERVATION PRACTICE
Atriplex polycarpa: Desert saltbush for Rangeland and Abandoned Farmland Revegetation	550	Range Seeding
	645	Wildlife Upland Habitat Management
	342	Critical Area Planting
Bothriochloa barbinodis: Cane bluestem Plant Development for Rangeland Revegetation	550	Range Seeding
	645	Wildlife Upland Habitat Management
	342	Critical Area Planting
Digitaria californica: Arizona cottontop for Rangeland Revegetation	550	Range Seeding
	645	Wildlife Upland Habitat Management
	342	Critical Area Planting
Sporobolus contractus: 1989 Spike Dropseed Population Development	550	Range Seeding
	645	Wildlife Upland Habitat Management
	342	Critical Area Planting
Maggie Tank Hay Seeding - Using Grass Hay Bales	550	Range Seeding
	645	Wildlife Upland Habitat Management
	342	Critical Area Planting
Southwestern Borderlands Savanna Grassland Ecosystem Restoration Study	550	Range Seeding
	645	Wildlife Upland Habitat Management
Six Mile Flat Field Evaluations - Nevada Adaptation Trials, Caliente, Nevada	550	Range Seeding
	645	Wildlife Upland Habitat Management
Joshua Tree National Park Plant Adaptation Trials	342	Critical Area Planting
	561	Heavy Use Area
	645	Wildlife Upland Habitat Management
Sediment Reduction in the San Pedro River	638	Water and Sediment Control Basin
	550	Range Seeding
	645	Wildlife Upland Habitat Management
Non Point Source Pollution Control in a Subwatershed of the Gila River	587	Structure for Water Control
	570	Runoff Management System
	550	Range Seeding
47 Ranch Field Planting	550	Range Seeding
George Morin Ranch Field Planting	550	Range Seeding
Phenotypic Plasticity in Populations of Arizona Cottontop	550	Range Seeding
Maintenance of Sideoats Grama Plants for Use in Research Related to Defoliation Tolerance	550	Range Seeding
Riggs Flat Field Planting	550	Range Seeding
	645	Wildlife Upland Habitat Management
Riggs Flat Field Planting #2	550	Range Seeding
	645	Wildlife Upland Habitat Management
Terracottem Soil Amendment Trial	550	Range Seeding
	342	Critical Area Planting
Sells Demonstration Garden	550	Range Seeding
Cyprus-Tohono Mine Revegetation Trials	544	Land Reconstruction, Currently Mined Land
	342	Critical Area Planting
	550	Range Seeding
BHP Bio-Solids Trial	544	Land Reconstruction, Currently Mined Land
	342	Critical Area Planting
	550	Range Seeding

Table 1 (continued).

Tucson PMC Studies and Related Conservation Practices
(continued)

STUDY NAME	CODE	CONSERVATION PRACTICE
Cool and Warm Season Cover Crop Trials	340	Cover and Green Manure Crop
	328	Conservation Crop Rotation
	327	Conservation Cover
Winter Forage Cover Crop Trials	340	Cover and Green Manure Crop
	328	Conservation Crop Rotation
	327	Conservation Cover
'Pete' Eastern Gamagrass Field Planting	512	Pasture and Hayland Planting
	327	Conservation Cover
'Seco' Barley Field Planting	340	Cover and Green Manure Crop
	327	Conservation Cover
'Donegal' Soybean Cultural Planting	340	Cover and Green Manure Crop
	327	Conservation Cover
Woolypod Vetch Strain Trail	340	Cover and Green Manure Crop
	328	Conservation Crop Rotation
	327	Conservation Cover
Heaton Farms Field Planting	512	Pasture and Hayland Planting
Evaluation of a Rapid Method for Evaluating Broad-Sense Heritability (BSH)	340	Cover and Green Manure Crop
	328	Conservation Crop Rotation
	327	Conservation Cover

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

PROJECT: RN1.7

PROJECT TITLE: **Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.**

PROBLEM STATEMENT:
Current technological information as well as current plant materials information is needed to effectively implement NRCS Range Seeding practices. Up-to-date information regarding a large number of native plant species needs to be collected and made available to NRCS Field Offices.

LAND RESOURCE REGIONS: I Southwestern Plateaus and Plains Range and Cotton Region
J Southwestern Prairies Cotton and Forage Region

MLRA: 29, 30, 31, 40, 41

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

TERTIARY: 342 CRITICAL AREA PLANTING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants condition, productivity.
SECONDARY:	Soil	Soil erosion from sheet and rill.

SCOPE/DESCRIPTION:
Plant Materials Opportunities: Develop native plants and technology to effectively implement the NRCS Range Seeding practice in areas of MLRA's 29, 30, 31, and 40 where annual precipitation is 7 inches or less. Develop native plants for reseeding burns or reseeding into killed stands of Lehmann lovegrass in MLRA 41 and the higher precipitation zones in MLRA 40. When applied, the Range Seeding practice will: (1) Protect air quality by reduction of wind induced soil erosion, (2) Protect adjacent surface water resources by reduced water induced soil erosion, (3) Provide food and cover for wildlife, and (4) Provide food for domestic grazing animals.

OBJECTIVES:
Identified needs include: (1) Improved and enhanced basic biological information on plants having rangeland applications, and (2) Development of improved plant materials for special rangeland applications. Proposed actions include: (a) Utilize Convergent-Divergent Improvement or Recurrent Restricted Phenotypic Selection methods to develop native plant populations for use in range reseeding projects, (b) Develop and release *Bothriochloa barbinodis* for use in MLRA40 and 41, (c) Develop and release *Digitaria californica* for use in MLRA 40 and 41.

STATUS OF KNOWLEDGE:
Since 1934 the primary focus of plant development at the Tucson PMC has been on the development and release of native and introduced plant materials for range reseeding in the arid Southwestern U.S. Refer to past Tucson PMC annual technical reports or additional information.

PLANNED COORDINATION:
University of Arizona Agricultural Experiment Station, Conservation Districts, various Federal and State agencies, NRCS Field Offices, Malpai Borderlands Group.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

COOPERATORS: Conservation Districts, Field Offices, Various Government Agencies, Local Municipalities.

PROJECT LEADER: Tucson Plant Materials Center

APPROVED BY PMC STATE CONSERVATIONIST ADVISORY COMMITTEE:
AZPMC High Active

STUDIES:
TUCSON, ARIZONA PLANT MATERIALS CENTER
04C017L START: 1988 END:1997
ICST - Avra Valley Retired Farmland Revegetation Trials.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04A010H START: 1987 END: 2000
Six Mile Flat Field Evaluations - Nevada Adaptation Trials, Caliente, Nevada.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04A8212L START: 1982 END: 2000
Desert Saltbush for Rangeland and Abandoned Farmland Revegetation.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04A8291L START: 1982 END: 2000
Arizona Cottontop for Rangeland Revegetation.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04A9301L START: 1993 END: 1998
Joshua Tree National Park Plant Adaptation Trials - Comparative Studies.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04A9302L START: 1993 END: 1997
Yuma Proving Grounds AE/Cultural Trials.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04S002U START: 1985 END: 1999
Cane Bluestem Plant Development for Rangeland Revegetation.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04I023L START: 1989 END: 2000
1989 *Sporobolus contractus* Population Development.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04A9501L START: 1995 END: 1999
Maggie Tank Native Hay Seeding - Using Native Grass Hay Bales.

TUCSON, ARIZONA PLANT MATERIALS CENTER
04A9701L START: 1997 END: 2000
Southwestern Borderlands Savanna Grassland Ecosystem Restoration Study.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04A8212L

Desert Saltbush for Rangeland and Abandoned Farmland Revegetation.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:

PRIMARY: 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

TERTIARY: 342 CRITICAL AREA PLANTING

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Plants	Plants management; establishment, growth, and harvest.
SECONDARY:	Animals	Animals habitat, cover or shelter.

DESCRIPTION:
Species: *Atriplex polycarpa* (Torrey)S.Wats. - Desert saltbush, cattle spinach, all-scale.

Plant Symbol: ATPO

Accession Number(s): P.I. 399195, A-18348.

This accession was collected by Wendall Hassell near Blythe, California in November 1973.

This accession was evaluated in two Initial Evaluation Plantings (IEP): 1974 Desert Species IEP and the 1977 Tree, Shrub and Annual Forb IEP. In the 1974 IEP, P.I. 399195 was the most uniform and best-looking accession. It was also noted as the best seed producer in 1974. In the 1974 IEP, P.I. 399195 was evaluated against six native accessions over a four year period. In the 1977 IEP, P.I. 399195 was consistently rated higher for vigor and cover. In this IEP, P.I. 399195 was evaluated against eleven accessions over a five year period. Uses for P.I. 399195 desert saltbush includes revegetation of eroded rangelands, retired farmlands and critical areas. Seed is harvested best by hand. This may limit production by commercial growers by not being cost-efficient. Range of adaptation is primarily MLRA's 30,31 and 40. This includes the Sonoran and Mohave deserts with elevations between 300 and 3,000 feet (91-914 meters) and annual precipitation from 3 to 10 inches (75-250 mm). Potential soils include sandy loam, loam and clay loam. Also, moderately saline soils.

DURATION OF STUDY: 1982 through 2000

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: Tucson Plant Materials Center.

METHODS AND MATERIALS:
Objectives: (1) Establish a large-scale seed production block on the Tucson PMC farm for future ICST's and Field Plantings; (2) Conduct evaluations on performance and site adaptability in ICST plantings and Field Plantings. Potential off-center sites include: Avra Valley, Joshua Tree National Park; (3) Summarize data for eventual documentation and potential release of an 'Selected' or 'Tested' class of desert saltbush.

STATUS OF KNOWLEDGE:
This information is taken from Mohave Revegetation Notes, U.C. Davis, Agronomy and Range Science, Publication Number 18, November 1977 by K.L. Burgess, C.R. Brown, and W.L. Graves. This publication reports on work supported by the BLM - Contract # 53400-CT4-2(N), Document Obligation No. 6809.

Desert saltbush (*Atriplex polycarpa*) is a perennial, low, rounded, erect intricately branched shrub 1-2 m tall, with gray or yellowish-brown branches, the bark shed in long strips. The leaves are alternate, crowded on young twigs, oblong to spatula-shaped, 3-20 mm long, coated with small scales on both sides of the leaf. One-veined from the base. Male and female flowers are borne on separate plants; the male in leaf axiles or on terminal spike; the female crowded along the numerous divergent branches in diffuse flower clusters. Flowers are tan to greenish in color. The seed is pale brown, 1-1.5 mm long.

Desert saltbush is found on alkaline plains and occasionally rocky or gravelly slopes in desert or grassland and is limited to between 120 - 900 meters (400-3,000 feet) elevation in alkali sinks in communities with creosote bush scrub, shadscale scrub, and sagebrush scrub. It is found in scattered localities in the San Joaquin Valley and Mohave and Colorado Deserts in California, southern Nevada, southwestern Utah and Arizona, Baja California, and northwestern California (Munz 1974; Benson and Darrow 1954). It is less extensive than *Atriplex canescens* in geographic distribution (Hastings et al. 1972), and less cold tolerant and more drought hardy (Nord 1977). It is reported to flower from May to August, with fruit ripening from October to December and seed dispersal occurring from November to May (Foiles, 1974).

Atriplex polycarpa has long been noted for its excellent forage qualities (Bidwell and Wooten 1925). It is rated "good for deer; good to fair for cattle, sheep and goats; and fair for horses" (Sampson and Jesperson 1963). It is known to grow well on rangelands with soil pH varying for 6-8 (Nord 1977). It is often found in association with highly unpalatable species and may be the only shrub in areas that are too arid or saline for other species to grow (Chatterton et al. 1971b). Its greatest forage value is in the fall, when grassland species make a minimal nutritional contribution to the range. Its nutritional value in crude protein, total digestible nutrients, and fats is comparable to that of alfalfa, and late in the year it is a good source of calcium, phosphorous, and carotenoids (Chatterton 1970). Goodin and McKell (1970) have estimated maximum forage yields under cultivation to be 12,822 kg/ha and suggest that cultivation as a forage crop has considerable potential in marginal lands subject to prolonged drought in excessive salinity.

Phosphorous content in the soil is significantly correlated with yield of aerial plant parts (Lailhacar-Kind 1976). Although extremely tolerant of salt in the environment, its germination has been found to be reduced with higher salt concentrations (Chatterton and McKell 1969). Large quantities of salt are accumulated in the shoots. Salinity tolerance may be due to an accumulation of salt in the trichomes on the leaf surface from adjacent mesophyll cells, reducing salinity stress of photosynthetically active tissue (Chatterton 1970). Adult plants have been tested and found to withstand shoot water potential deficits of -69 bars (Sankary and Barbour 1972).

It does not accumulate nitrate even in high-nitrate environments (Chatterton et al. 1971a). *Atriplex polycarpa* flourishes on soils unsuitable for most other species, and is usually absent from less saline soils due to competition from more aggressive species (Lailhacar-Kind 1976).

Desert saltbush has been proposed as the best species to establish in pure stands as quail habitat (Glading et al. 1945). MacMillan (1960) found that a planting rate of 45 kg/ha was adequate to establish a thick stand of saltbush. It establishes easily if adequate moisture is present in the soil, and further care involves only protection from sheep and cattle. A satisfactory management system would allow only limited use during the summer and fall months. The species has been virtually eradicated by overgrazing in many of its original localities (Sampson and Jesperson 1963). Graves et al. (1976) found transplants to be more successful than spot seeding under western Mohave Desert conditions. A saponin content of 1.2% of dry weight has been found in the foliage of *Atriplex polycarpa*. Extracts from increasing quantities of foliage

have been found to be increasingly inhibitory to germination of its own seed and that of several other species but will enhance germination of seed of California ephedra (Askham and Cornelius 1971). It is unlikely that the bracteoles of the utriculate fruiting body contain saponin (Sankary and Barbour 1972). Even so, the leaching of seeds has been found to increase germination (Cornelius and Hylton 1969). Active carbon was the best treatment for speeding initiation of germination. It also resulted in a significantly higher 7-day and 14-day germination. Stratification in moist sand at 2 °C for 30 days, heating at 60 °C for four hours, and exposure to 100 ppm ethylene for 24 hours increased 7-day germination but were not significantly different from the control at 14 days. In addition, scarification, soaking in 6% sodium hypochlorite solution for 24 hours, and soaking in 6% hydrogen peroxide solution for 10 minutes significantly decreased germination at 14 days. Nord et al. (1971) reported best emergence in late spring from a planting depth of 1.25 cm versus 2.5 cm. Williams et al. (1974) obtained no germination of *Atriplex polycarpa* in washed plaster sand at either 1 or 2 cm. Burgess et al. (1977) obtained 13% germination in the same type of medium from a 1 cm depth, using a different seed source. Covering the seed with as little soil as possible (2-3 mm) would probably improve emergence. Chatterton and McKell (1969b) reported higher seed quality and germination from a November collection than from one made in December in 1966. They suggested percentage of seed fill was highest and germination most rapid in seed that matured early. Seeds left to ripen on the plants often germinate while still on the plant. Utricle size has been found to be significantly related to germination. Size categories greater than 1.7 mm (1/15 inch) gave significantly better 14-day germination than unsorted control utricles. Size categories less than 1.7 mm gave lower germination than the control. Separating utricles on the basis of size before seeding may improve seeding success.

Evaluations with this species will be discontinued in 1999.

LITERATURE CITED:

Askham, L.R. and D.R. Cornelius. 1971. Influence of desert saltbush saponin on germination. J. Range Manage. 24:439-442.

Benson, L. and R.A. Darrow. 1954. The trees and shrubs of the southwestern deserts. University of Arizona Press, Tucson. 437 pp.

Burgess, L.K., C.R. Brown, and W.L. Graves. 1977. Mojave Revegetation Notes - Desert saltbush. No. 18. U.C. Davis, Agronomy and Range Science. 7 pp.

Chatterton, N.J. 1970. Physiological ecology of *Atriplex polycarpa*: growth, salt tolerance, ion accumulation, and soil-plant water relations. Ph.D. dissertation, U.C. Riverside. 120 pp.

Chatterton, N.J., J.R. Goodin, and R.C. Duncan. 1971a. Nitrogen metabolism in *Atriplex polycarpa* as affected by substrate nitrogen and NaCl salinity. Agron. J. 63:271-274.

Chatterton, N.J., J.R. Goodin, C.M. McKell, R.V. Parker and J.M. Rible. 1971b. Months variation in the chemical composition of desert saltbush, *Atriplex polycarpa*. J. Range Manage. 24:37-40.

Chatterton, N.J. and C.M. McKell. 1969a. *Atriplex polycarpa*. I. Germination and growth as affected by sodium chloride in water culture. Agronomy J. 61:448-449.

Chatterton, N.J. and C.M. McKell. 1969b. Time of collection and storage in relation to germination of desert saltbush seed. J. Range Manage. 22:355-356.

Cornelius, D.R. and L.O. Hylton. 1969. Influence of temperature and leachate on germination of *Atriplex polycarpa*. Agron. J. 61:209-211.

Foils, M.W. 1974. *Atriplex* L. Saltbush. p. 240-243. In: Seeds of woody plants in the United States. U.S.D.A. Agriculture Handbook No. 450, 883 pp.

Glading, B., R.W. Enderlin and H.A. Hjersman. 1945. the Kettleman Hills quail project. Calif. Fish and Game 31:139-156.

Goodin, J.R. and C.M. McKell. 1970. *Atriplex* spp. as a potential forage crop in marginal agricultural areas. Proc. of XI International Grassland Congress. 158-161.

Graves, W.L., B.L. Kay, and W.A. Williams. 1975. Seed treatment of Mojave Desert shrubs. Agron. J. 67:773-777.

Hastings, J.R., R.A. Turner, and D.K. Warren. 1972. An atlas of some plant distributions in the Sonoran Desert. University of Arizona Institute of Atmospheric Physics Technical Report No. 21. 225 pp.

Kay, B.L. 1974. Tests of seeds of Mojave Desert shrubs. Progress Report. BLM Contract No. 53500-CT4-2(N).

Kay, B.L. 1975. Test of seeds of Mojave Desert shrubs. Progress Report. BLM Contract No. 53500-CT4-2(N). 24 pp.

Lailhacar-Kind, E.S. 1976. Effect of soil parameters on the components of biomass production in *Atriplex polycarpa* (Torr.), Wats., and *Atriplex repanda*, Phil. Ph.D. dissertation, U.C. Davis. 57 pp.

MacMillan, I.I. 1960. Propagation of quail brush (saltbush). Calif. Fish and Game 46:507-509. McMinn, H.E. 1951. An illustrated manual of California shrubs. University of California Press, Berkeley. 663 pp.

Munz, P.A. 1974. A flora of southern California. University of California Press, Berkeley. 1086 pp.

Nord, E.C. 1977. Shrubs for revegetation. pp. 284-301. In: J.L. Thames (ed.) Reclamation and use of disturbed land in the southwest. University of Arizona Press, Tucson. 362 pp.

Nord, E.C., P.F. Hartless, and W.D. Nettleton. 1971. Effects of several factors on saltbush establishment in California. J. Range Manage. 24:217-223.

Sampson, A.W. and B.S. Jespersen. 1963. California range brushlands and browse plants. Univ. of Calif. Div. of Agric. Sci. Manual No. 33. 162 pp.

Sankary, M.N. and M.G. Barbour. 1972. Autecology of *Atriplex polycarpa* from California. Ecology 53:1155-1162.

Williams, W.A., O.D. Cook, and B.L. Kay. 1974. Germination of native desert shrubs. Calif. Agric. Aug. p. 13.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Include this species in the Range Planting Specification (Code 550).

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04S002U

Cane Bluestem Plant Development for Rangeland Revegetation.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

TERTIARY: 342 CRITICAL AREA PLANTING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants suitability, other.
SECONDARY:	Plants	Plants management, other.

DESCRIPTION:
This accession of *Bothriochloa barbinodis* (cane bluestem), P.I.216101, was selected for advanced evaluation because of its superior vigor, herbage production, and tolerance to drought and cold. It was included in two initial evaluation plantings out of which the 1981 *Andropogon barbinodis* Strain Trial was established (1981 Tucson PMC Annual Tech. Report, pp.93-96). Cane bluestem, P.I.216101, maintained its superior performance throughout all three evaluation trials. The potential use for this accession is primarily as an erosion control plant on mismanaged rangelands and critical areas such as abandoned cropland and road cuts. Potential adapted soil textural classes include: sandy loam, loam, fine sandy loam, loamy fine sand, and gravelly and rocky soils.

DURATION OF STUDY: 1985 through 1999

STUDY LEADER: Mark Pater

LOCATION: Arizona PMC

COOPERATORS: Tucson Plant Materials Center

METHODS AND MATERIALS:
Objectives: (1) Establish a large-scale seed production block on the Tucson PMC farm for future ICST's and Field Plantings; (2) Conduct evaluations on performance and site adaptability in ICST plantings and Field Plantings. Potential off-center sites include: Avra Valley, Six-Mile Flat, Gray Ranch, Bowie; (3) Summarize data for eventual documentation and potential release of an adapted cultivar of cane bluestem.

STATUS OF KNOWLEDGE:
Bothriochloa barbinodis (Lag.) Herter is described by Gould (1975) as a cespitose perennial, the culms often in large clumps. CULMS erect or geniculate at the base, tending to become decumbent and much-branched below in age, mostly 60-120 cm tall; CULM NODES bearded with hairs mostly 1-3 mm long (occasionally longer), these typically erect and not widely spreading; LEAVES essentially glabrous except for few to numerous long hairs on upper sheath margins and in vicinity of ligule; LIGULE 1-2 mm long, becoming erose and lacerate; BLADES firm, linear, 2-7 mm broad, often 25-30

cm or more long but the upper culm blades greatly reduced; PANICLES mostly 7-13 cm long, often partially included in upper sheath, with a straight main axis and numerous primary branches mostly 4-9 cm long, these erect or loosely spreading at tips, the basal ones moderately rebranched; INTERNODES OF PANICLE BRANCHES AND PEDICELS more or less densely villous on the thickened margins, with a broad, membranous central region; SESSILE SPIKELET 4.5-7.3 mm long excluding awn; FIRST GLUME usually sparsely hairy below the middle; LEMMA AWN 20-30 mm or more long, geniculate and twisted. Chromosome number 2*n*=180.

Gould (1956) states that *Bothriochloa barbinodis*, with the high chromosome number of 2*n*=180, frequently has irregular meiosis but appears to produce sufficient good pollen for normal fertilization. This grass is highly cleistogamous, especially under conditions of aridity and heat when the inflorescence usually remains partially enclosed in the subtending sheath or "boot".

This species is important in the Southwest since it grows in relatively dry habitats. If supplemented by occasional flooding from heavy summer showers, this species can grow where annual precipitation ranges from 130-180 mm (Judd 1962). Although the role of *Bothriochloa barbinodis* in the original grassland associations of the Southwest may have been minor in the past, it has flourished on disturbed soils of road and railroad rights of way. From eastern Texas to southern Arizona and in northern Mexico it is consistently represented in roadside floras (Gould 1953).

Bothriochloa barbinodis is considered fair to good forage while young (Judd 1962). Humphrey (1960) classified this species as fair forage because it is coarse and nutrients tend to leach from forage when plants are dry. Although Tucson PMC personnel consider this to be a poor forage species in MLRA 41, Gay and Dwyer (1965) considered it fair to good forage for cattle and sheep. Fudge and Fraps (1945) found that *Bothriochloa barbinodis* contained more crude protein and phosphoric acid than did silver bluestem. Judd (1962) states that usually it is found as scattered plants or in small groups; seldom in dense, pure stands. It is a good indicator of proper grazing, since it tends to disappear when a range is excessively utilized. Koshi et al. (1977) compared *Bothriochloa barbinodis* under irrigated and non-irrigated conditions in Big Plains, Texas. They found that cane bluestem grown under natural rainfall made a higher proportion of their seasonal growth and made more total growth late in the season (irrigated: 1.0 tons/ha; non-irrigated: 1.5 tons/ha). They concluded that when water was adequate, *Bothriochloa barbinodis* grew most between mid-June and late August. If water was not available at that time but was available later, they grew more later in the season. This flexibility in growth patterns should be considered in the management of this species and in evaluation of its potential. They also found that *Bothriochloa barbinodis* is as well or better adapted than switchgrass (*Panicum virgatum* L.) to drought conditions.

Reardon and Merrill (1974) evaluated nonstructural carbohydrates in grazed and ungrazed *Bothriochloa barbinodis*. The trend of carbohydrate reserves, major storage carbohydrates, and primary storage locations were determined in grazed and ungrazed cane bluestem plants. Sucrose was usually the major reserve carbohydrate, and the largest concentration of reserve carbohydrates was in the crown portion of the plant. The total nonstructural carbohydrate (TNC) levels were higher in grazed than in ungrazed plants. The ungrazed plants matured earlier, as indicated by an earlier TNC peak and had lower winter TNC levels. Their results indicate that maximum plant vigor can be maintained with a periodic June to November grazing deferment followed by moderate foliage removal. This deferment would allow the plant to synthesize and accumulate plant foods and go into dormancy with a relatively high reserve TNC level. Moderate grazing after the October peak should not be harmful.

This accession is scheduled to be released in 1999.

LITERATURE CITED:

Fudge, J.F. and G.S. Fraps. 1945. The Chemical Composition of Grasses of Northwest Texas as Related to Soils and to Requirements for Range Cattle. Texas Agr. Exp. Sta. Bull. 669. 56p.

Gay, C.W., Jr. and D.D. Dwyer. 1965. New Mexico Range Plants. New Mexico Agr. Ext. Ser. Circ. 374. 85p.

Gould, F.W. 1956. A Cytotaxonomic Study in the Genus *Andropogon*. Amer. Jour. Bot. 40:297-306.

Gould, F.W. 1956. Chromosome Counts and Cytotaxonomic Notes on Grasses of the Tribe *Andropogoneae*. Amer. Jour. Bot. 43:395-404.

Gould, F.W. 1975. The Grasses of Texas. Texas A&M University Press, College Station, Texas. P.600.

Humphrey, R.R. 1960. Arizona Range Grasses, Their Description, Forage Values, and Management. Ariz. Agr. Exp. Sta. Bull. 298. 104p.

Judd, B.I. 1962. Principal Forage Plants of Southwestern Ranges. Rocky Mtn. For. and Range Exp. Sta., Colo. State Univ., Fort Collins, CO. P.16.

Koshi, P.T., A.V. Eck, J. Stubbendieck, and W.G. McCully. 1977. Cane Bluestem: Forage Yield, Forage Quality, and Water Use Efficiency. Jour. Range Mgmt. 30(3):190-193.

USDA. 1960. Plant Material Introduced January 1 to December 31, 1954 (Nos. 212043 to 222845). Plant Industry Publication, Washington, D.C. p.158.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Amendment to Range Seeding Specifications, Technical Note.

OTHER ACTIONS: Plant Guide Publication, Plant Release Publication.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04A8291L

Arizona Cottontop for Rangeland Revegetation.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

TERTIARY: 342 CRITICAL AREA PLANTING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants suitability, other.
SECONDARY:	Plants	Plants management, other.

DESCRIPTION:
Two accessions of *Digitaria californica* (9003694 AND 9003705) were selected from the 1976 Arid Land Grass IEP at the Tucson PMC. The final report on the 1976 planting was published in the 1980 Tucson PMC Annual Technical Report. The abstract in this report states that 9003694 was the superior accession. The plant performance data shows that 9003705 had the best vigor rating and the highest forage production. In addition, the remarks column shows 9003705 as the best performing accession (Tucson PMC Annual Technical Report, 1989). The potential use for this species is as an erosion control plant on degraded rangelands and critical areas such as abandoned farmland and roadway construction sites.

DURATION OF STUDY: 1982 through 2000

STUDY LEADER: Mark Pater

LOCATION: Arizona PMC

COOPERATORS: Tucson Plant Materials Center.

METHODS AND MATERIALS:
Objectives: (1) Establish a large-scale seed production block for accession 9003705 on the Tucson PMC farm for future ICST's and Field Plantings; (2) Conduct evaluations on performance and site adaptability using ICST's and Field Plantings. Potential off-center sites include: Avra Valley, Six-Mile Flat, Gray Ranch, Bowie; (3) Summarize data for eventual documentation and potential release of an adapted cultivar of Arizona cottontop.

STATUS OF KNOWLEDGE:
Digitaria californica (Benth.) Henr. (Arizona cottontop) is a leafy perennial bunchgrass that contributes considerable range forage in the Southwest, from southern Colorado to Texas, Arizona, and northern Mexico. This grass makes rapid growth following winter rains and furnishes earlier forage than most associated grass species (Gould 1983).

Gould (1977) describes this species as: CULMS firm, erect from a hard base, mostly 40-100 cm tall but occasionally much less; BLADES flat or somewhat folded, usually glaucous, bluish-green, and glabrous or nearly so, 2-5 mm broad; LIGULE membranous, 2mm or more long; PANICLE contracted, 5-15, occasionally 20 cm long, with relatively few branches, these erect, usually appressed; SPIKELETS 3-4 mm long excluding the hairs; SECOND GLUME narrow, densely villous with soft, silvery or purple-tinged hairs 2-4 mm or more long; STERILE LEMMA broad, three-nerved, villous on the margins but glabrous on the internerves; GRAIN ovate-lanceolate, abruptly narrowing to a short awn-tip, mostly 2.5-3.2 mm long.

Arizona cottontop is found on open, well-drained soils, often on steep, rocky slopes, at elevations of 1,000 to 6,000 feet; reported from all counties in Arizona except Apache but much more abundant in the southern portion of the state than in the northern counties, flowering mostly August to November.

Cable (1979) states that Arizona cottontop is considered as a climax dominant species in the semidesert grassland type. This species does have several morphological and physiological characteristics that allow it to tolerate severe climatic conditions or use:

1. Individual culms and roots are long-lived
2. Culms exhibit low-level apical dominance.
3. Removing the growing point at the beginning of the summer growing season stimulates the sprouting and growth of axillary shoots.
4. Cottontop plants utilize both winter and summer precipitation.
5. Shoots are produced throughout the growing season.
6. Inflorescences mature throughout the summer growing season and continue as long as soil moisture is available.
7. Cottontop is highly palatable to cattle.
8. Cottontop tolerates relatively heavy grazing use over long periods.
9. Cottontop extracts soil water rapidly when it is available. It is also able to endure prolonged periods in soil with essentially no available water.
10. An established stand of Arizona cottontop competes strongly with velvet mesquite seedlings.
11. Cottontop can be successfully reseeded on upland areas receiving at least 11 inches (28 cm) of annual precipitation.
12. Cottontop is only moderately affected by fires.
13. Cottontop is highly flexible in its adaptability to management strategies provided grazing intensity is held below 60%. Light summer use 2 years out of 3 is recommended to maintain optimum vigor while at the same time stimulating axillary sprouting to increase productivity.

Arizona cottontop is reported to be a comparatively long-lived grass. Records from the Santa Rita Experimental Range show that some plants live up to 11 years of age (Canfield 1957). Arizona cottontop and sprucetop grama (*Bouteloua chondrosioides*) rated highest among 11 perennial grasses in survival during the first four years of life; from 17 to 21% of cottontop plants lived to four years of age. Other longevity studies show Arizona cottontop living past 15 years (Cable 1979).

Arizona cottontop is both self-pollinated and cross-pollinated. More than half of the florets of an Arizona cottontop plant are self-pollinated. The self-pollinated ovaries can mature to viable seed despite a lack of soil moisture preventing the panicle from emerging from the sheath (Cable, 1979).

Seed longevity was evaluated by Tiedemann and Pond (1967) using germination trials on seven batches of cottontop seed kept under uncontrolled storage conditions at the Santa Rita Experimental Range headquarters for periods varying from 3 to 30 years. These tests showed that seed maintained a relatively high germination (>80%) for about 3 years. Germination was noted to decline about 6% per year for the next 12-14 years, to less than 10%.

Studies by McGinnies and Arnold (1939) have shown Arizona cottontop to have a moderate water requirement with a tendency for high production in late spring and during the summer months with moderate temperatures and moderate to low humidity. Arizona cottontop exhibited poor growth during periods of excessively hot, dry weather and only moderate growth under hot, humid conditions (Cable 1979).

Studies by Glendening and Paulsen (1955) revealed that of 100 velvet mesquite seeds planted per treatment, only seven seedlings became established in a stand of cottontop as compared with 56 established mesquite seedlings on an adjacent bare area. One year after planting, mesquite seedling survival averaged 18% on the cottontop plot and 80% on the bare area. Large increases in cottontop production have been observed when existing stands of mesquite were controlled (Cable 1979).

Arizona cottontop was first comparatively evaluated with an assembly of 22 accessions of *Digitaria* (*Trichachne*) *californica* in the 1976 Arid Land Grass Initial Evaluation Planting (IEP) conducted at the Tucson Plant Materials Center. This IEP trial was initiated to evaluate various grasses for stand establishment, vigor, seed production, forage production, and ability to spread. Accession 9003705 was determined to be the best performing Arizona cottontop accession and moved into the Advanced Evaluation process (Briggs, 1980).

This accession was also evaluated in a 1993 planting at the Avra Valley Planting Site. This planting was installed to evaluate species in advanced testing for their ability to become established on retired cropland from various planting depths. Accession 9003705 performed very well at planting depths of 0.25 and 0.5 inches (Pater, 1996).

LITERATURE CITED:

Briggs, J.A. 1980. 1976 Arid Land Grass IEP. Final Summary. In: Tucson Plant Materials Center 1980 Annual Technical Report. U.S.D.A. Soil Conservation Service, Tucson, AZ pp.9-29.

Cable, D.R. 1979. Ecology of Arizona cottontop. Res. Pap. RM-209, 21p. U.S.D.A. For. Ser. Rocky Mtn. For. And Range Exp. Stn., Fort Collins, CO.

Canfield, R.H. 1957. Reproduction and life span of some perennial grasses of southern Arizona. J. Range Manage. 10:199-203.

Gould, F.W. 1977. Grasses of Southwestern United States. Univ. of Ariz. Press, Tucson, AZ. P.296.

Gould, F.W. and R.B. Shaw. 1983. Grass Systematics, 2nd edition. Texas A&M University Press, College Station, TX. P.213.

McGinnies, W.G. and J.F. Arnold. 1939. Relative water requirements of Arizona range plants. Univ. Ariz. Agric. Exp. Stn. Tech. Bull. 80, pp.167-246.

Pater, M. 1996. Avra Valley Retired Farmland Revegetation Trials. Final Report. In: Tucson Plant Materials Center 1996 Annual Technical Report. U.S.D.A. Natural Resources Conservation Service, Tucson, AZ pp.49-59.

Tiedemann, A.R. and F.W. Pond. 1967. Viability of grass seed after long periods of uncontrolled storage. J. Range Manage. 20(4):261-262.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Amendment to Range Seeding Specifications, Technical Note.

OTHER ACTIONS: Plant Guide Publication, Plant Release Publication.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04I023L

1989 Sporobolus Contractus Population Development

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Initial Evaluation

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:

PRIMARY:	550	RANGE SEEDING
SECONDARY:	645	WILDLIFE UPLAND HABITAT MANAGEMENT
TERTIARY:	342	CRITICAL AREA PLANTING

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Plants	Plants condition, productivity.
SECONDARY:	Soil	Soil erosion, other.

DESCRIPTION:
The 1989 *Sporobolus contractus* IEP consists of 44 accessions, the bulk of which were collected from various locations in southeastern Arizona. The remaining accessions were collected from other various locations in Arizona, southern Utah, and Nevada. Progressive systems to evaluate and improve plant materials are currently being applied at the Tucson PMC. One of two plant development systems will be employed for *Sporobolus contractus* (spike dropseed), depending on the method of reproduction for this species: (a) Convergent-Divergent selection method will be utilized if the species is cross-pollinated, or (b) Modified Mass Selection will be used if the species is self-pollinated. Either way, the desired end-result should be the development of a population of spike dropseed with a broad genetic base that is adapted to a wider area within its natural range than would a source-identified ecotype. Objectives of this study include: (a) Develop a genetically broad-based population for use as an alternative choice for some of the introduced lovegrass species. The primary use for this population will be for range revegetation projects. (b) Determine the method of reproduction and utilize an appropriate breeding/selection system for population development. (c) Evaluate seed production, germination and seedling establishment characteristics as well as harvesting and seed processing techniques. (d) Summarize data for eventual documentation and release of a genetically broad-based population of spike dropseed.

DURATION OF STUDY: 1989 through 2000

STUDY LEADER: Mark J. Pater

LOCATION: Arizona PMC

COOPERATORS: University of Arizona Agricultural Experiment Station, Agricultural Research Service.

EXPERIMENTAL DESIGN:

METHODS AND MATERIALS:
All of the collection sites for the accessions assembled for this evaluation will be plotted on a map in order to determine the range of collection within the species' natural range of adaptation. The map will also aid in the development of a genetically broad-based population. The planting block was designed to allow for 3 individuals from each of the 44

accessions to be randomly placed into an 11x12 completely randomized block design. This resulted in a total of 132 plants being planted into a modified mass selection block. Seed harvested from this block is to be bulked in equal quantities to form a new population. Seed from this population is to be used to establish a small-scale seed production block at the Tucson PMC. Seed produced in this block will be used to propagate individual plants which will be used for off-center plantings at various locations from within the species natural range of adaptation. Seed will be harvested from surviving plants at these various off-center plantings and bulked together in equal amounts to form a new population. This population may then be used as breeders seed or another round of off-center plantings and seed harvesting may be conducted.

STATUS OF KNOWLEDGE:
Sporobolus contractus, spike dropseed, is a native cespitose, perennial, warm-season bunchgrass; CULMS 40-120 cm tall and 2-4 mm in diameter at the base, in small clusters to moderately large clumps; SHEATHS rounded and glabrous on the back, usually with tufts of long hairs on either side of the collar and often ciliate pilose on the margins; LIGULE a dense fringe of short or rather long hairs; BLADES mostly 10-30 cm long, flat or involute, tapering to a slender tip, glabrous; PANICLE dense, contracted, spikelike or moderately lobed, typically 1 cm or less thick and 15-20 cm long, at least the basal portion and sometimes the entire panicle remaining enclosed in the sheaths; SPIKELETS light brownish or lead colored, 2-2.8, rarely 3 mm long; GLUMES thin, membranous, unequal, the first usually about half as long as the second, the second equaling the lemma or slightly shorter; CARYOPSIS mostly about 1 mm in length, broad and flattened (Gould 1977). This species occurs naturally on dry, open, sandy or rocky slopes and washes, frequently along roadsides, mostly at elevations from 760-1,981 meters. It flowers mostly from August to October, occasionally as early as June. Spike dropseed is found growing from Colorado to southeastern California to Texas, and Sonora, Mexico (Gould 1977).

According to Sabo et al. (1979), spike dropseed germination was highest within two ranges of alternating temperatures: 15.5 to 19 ºC (8 hr) and 26.5 to 29.5 ºC (16 hr), and at 26 to 32.5 ºC (8 hr) and 15.5 to 19 ºC (16 hr). The mean times for germination at the first set of temperatures range from 3.3 to 4.9 days with the highest germination percentage (78%) occurring with a mean of 4.8 days. Mean times in the second set of temperatures were slightly longer, ranging from 4.3 days to 7.3 days.

Sabo et al. (1979) also reported that all moisture stress levels below 0 bars were found to decrease germination of spike dropseed. They also stated that germination of spike dropseed seed was determined not to be affected by either the presence or absence of light. Toole (1941) states that germination is best with light. However, Sabo et al. (1979) stated that the light response phenomenon may depend on ecotype since source and light was not required by the seed source used in their temperature and moisture stress studies.

LITERATURE CITED:
Gould, F.W. 1977. Grasses of Southwestern United States. Univ. of Ariz. Press, Tucson, AZ p.225.

Pater, M.J. 1991. 1989 *Sporobolus contractus* IEP. 1991 Report. USDA-SCS, Tucson Plant Materials Center Ann. Tech. Report. P.4-7.

Sabo, D.G., G.V. Johnson, W.C. Martin and E.F. Aldon. 1979. Germination Requirements of 19 Species of Arid Land Plants. Research Paper RM-210. U.S.D.A. Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. P.14.

Toole, V.K. 1941. Factors Affecting the Germination of Various Dropseed Grasses (*Sporobolus* spp.). Journal of Agricultural Research. 62:691-715.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Amendment to Range Seeding Specifications, Technical Note.

OTHER ACTIONS: Plant Guide Publication, Plant Release Publication.

1998 RESULTS

With assistance from Don Decker (Range Management Specialist, Willcox F.O.), three Convergent-Divergent Improvement (CDI) sites were located at the Dusty A7 ranch near Pomerene, Arizona, the 4Y ranch near Texas Canyon, and inside a BLM exclosure near Bowie, Arizona. Within MLRA 41, these three sites were selected to provide wet, dry and intermediate climatic conditions and elevations for this resource area.

The "wet" and "higher" location is represented by the site at Texas Canyon (MLRA 41-1) , the "intermediate" location is represented by the site near Pomerene, Dusty A7 ranch (MLRA 41-3), and the "dry", "lower elevation" location is represented by the site north of Bowie, Arizona in the BLM exclosure (MLRA 41-2).

On August 14, 17, and 18, 1998, 196 spike dropseed plants were installed into 14x14 planting grids on each site (Dusty A7 ranch - August 14, 4Y ranch - August 17, and Bowie - August 18, 1998). Holes were dug using a gasoline-powered auger. Each hole was filled with approximately 2 quarts of water prior to each plant being transplanted. This was done to allow each plant a fair chance to overcome transplant shock and become established on the sites. No additional water was provided except for naturally occurring precipitation. Each planting site will be monitored during 1999 for survival. In August-September 1999 individual plants from each site will be selected using a 3x3 grid and transported back to the Tucson PMC for transplanting into the field. These plants will then provide breeders seed for field increase and foundation seed production.

Rainfall following planting installation was recorded at the 4Y ranch by the owners Alvin and Barbara Owens:

August 17, 1998	0.08”
August 19, 1998	0.36”
August 24, 1998	0.20”
August 28, 1998	0.26”
September 3, 1998	0.70”
September 10, 1998	0.65”
September 16, 1998	0.22”
Total	2.47”

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04A9501L

Maggie Tank Hay Seeding - Using Grass Hay Bales.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

TERTIARY: 342 CRITICAL AREA PLANTING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants management; establishment, growth, and harvest.
SECONDARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
The Maggie Tank Hay Seeding project is located on private land within the Sheep Canyon grazing allotment. The allotment is approximately 12 miles south of Bowie, Arizona in Cochise County. The following people are involved in the project: Larry Humphrey and Ted McRae - BLM; Kim McReynolds - University of Arizona Cooperative Extension; Mark Pater - NRCS Tucson Plant Materials Center; Hugh Peterson - Ranch Manager. This project was designed to facilitate revegetation of deteriorated rangeland. Some natural revegetation had been occurring on the allotment over the past 10 years. However, there were areas that were not showing any significant response to improved grazing management. The idea was to use the cattle as a tool to plant grass seed by trampling around the area where hay was thrown out.

DURATION OF STUDY: 1995 through 1999

STUDY LEADER: Kim McReynolds, Mark Pater

LOCATION: Arizona PMC

COOPERATORS:
Cooperative Extension Office - Willcox, Arizona (Kim McReynolds; BLM - Safford, AZ (Larry Humphrey, Ted McRae); Willcox Field Office (Don Decker); Hugh Peterson - Ranch Manager.

EXPERIMENTAL DESIGN:

METHODS AND MATERIALS:
In 1995, the Tucson Plant Materials Center supplied approximately 50 bales of plains bristlegrass and yellow bluestem hay for the project. On March 8, 1995 half of the hay (both species) was thrown out in a trap along a pre-set line that had been previously sampled for grass plants. Approximately 90 head of cattle (including calves) were kept in the trap for several days. The cattle had never been fed hay, so instead of picking through it to eat, they used it for bedding. The second seeding trial was conducted on September 3, 1995. Transects were established for baseline data and hay was thrown in a line similar to the first seeding. Data is being collected using the pace frequency method.

STATUS OF KNOWLEDGE:
Native grass hay is very similar to straw and can be applied at the same rates as straw mulch. If properly cut and dried, native grass hay stems are longer and stronger than grain straw (Munshower 1994). Native grass hay also contains seed of native species rather than cereal grains. Use of this form of material in revegetation efforts can aid in the establishment of a diverse native plant community.

Since native grass hay mulch contains many leaves, flowers, and seed heads, it often contains a small amount of nitrogen very little to fertilizer amendment may need to be applied. Native grass hay can be applied with a hay spreader or by hand. If the hay material is applied using a dry blower or hydromulcher, most of its desirable properties may be lost (Munshower 1994). The hay bales may also used to construct temporary water spreading structures or dams and allowed to slowly degrade over time.

If the native grass hay bale material is spread by hand, livestock may be used to incorporate the material into the soil. Studies by Winkel and Roundy (1991) suggest that seedbed disturbance by cattle may enhance revegetation success in the Southwest in years of moderate precipitation but not so during wet years or dry years. The practice of livestock trampling to incorporate seed into the soil and enhance seedling emergence is a recommended technique in rangeland revegetation (Plummer et al. 1955, Hormay 1970, Pearson and Ison 1987, Vallentine 1989).

LITERATURE CITED:

Hormay, A.L. 1970. Principles of rest-rotation grazing and multiple-use land management. USDI-BLM.

Munshower, F.F. 1994. Practical handbook of disturbed land revegetation. CRC Press, Inc., Boca Raton, FL. Pp.91-92.

Pearson, C.J. and R.L. Ison. 1987. Agronomy of grassland systems. Cambridge Univ. Press. Cambridge.

Plummer, P.A., A.C. Hull, Jr., G. Stewart, and J.H. Robertson. 1955. Seeding rangelands in Utah, Nevada, Southern Idaho, and Western Wyoming. USDA Forest Service, Agr. Handb. 71.

Vallentine, J.F. 1989. Range development and improvements, 3rd ed. Academic Press. San Diego, CA.

Winkel, V.K. and B.A. Roundy. 1991. Effects of cattle trampling and mechanical seedbed preparation on grass seedling emergence. J. Range Manage. 44(2):176-180.

TECHNOLOGY TRANSFER PRODUCTS: Range Seeding Alternative Publication
FOTG ACTIONS: Technical Note, Amendment to Range Seeding Specifications

RESULTS
1995
The March 8, 1995 planting site was evaluated in October 1995 to determine if seeds did germinate and seedlings had become established. Transects were not run but 86 seedlings were counted along the line.

1996
Following a break in a severe drought, a transect for the March 8, 1995 planting was run in the fall of 1996. Significant differences in percent frequency of plains bristlegrass, yellow bluestem and burroweed were found. Plains bristlegrass showed a 42% frequency, burroweed a 20% frequency and yellow bluestem exhibited a 4% frequency (see Table 1 and Chart 1).

The September 3, 1995 trial was evaluated on October 23, 1996. Significant differences in percent frequency were found in fluffgrass, yellow bluestem, plains bristlegrass, burroweed, snakeweed and mesquite (see Table 2 and Chart 2). Observations revealed that the March 8, 1995 planting has significantly more grass than before but the plants appeared less healthy. This may be due to two factors. First, the hay may have been spread too thin which allowed the hay to break

down faster and the seedlings did not have added protection and moisture. The second and obvious one is that they were greatly stressed during the drought period. It was surprising that any plants survived. The September 3, 1995 planting did not spread the hay out as thin as the first planting. At first this was thought to have been a mistake because no germination was observed. However, by the time the drought ended, the hay had decomposed enough that much better germination and survival was observed in comparison with the March 8, 1995 planting.

In addition, one buffelgrass and one pink pappusgrass plant were noted. The buffelgrass is not expected to survive the cold winters at this site. Also, with the heavier hay application, an abundance of threeawn plants had become established on the edges of the hay line where they could take advantage of the more hospitable microclimate.

1997 RESULTS

1997 pace frequency evaluations on the first trial (Plot Plan #9501) revealed significant increases in burroweed and significant decreases in plains bristlegrass and yellow bluestem. Slight increases were also noted for mesquite and tobosa. Below average summer precipitation may have been the major element in the decrease of the herbaceous species.

1997 pace frequency evaluations on the second trial (Plot Plan #9502) revealed a significant increase in fluffgrass, hog potato, burroweed and mesquite. Significant decreases were noted for threeawn and yellow bluestem. These changes may be due to below average precipitation and use by herbivores such as rabbits and various rodents.

1998 RESULTS

1998 pace frequency evaluations on the first trial (Plot Plan #9501) revealed a significant decrease in plains bristlegrass. Slight decreases in burroweed, snakeweed and mesquite were also noted. Extremely low amounts of summer precipitation is the major factor in these vegetation changes. Herbivores such as rabbits and various rodents have also impacted the grass species significantly.

1998 pace frequency evaluations on the second trial (Plot Plan #9502) revealed a significant increase in burroweed. Significant decreases were noted for fluffgrass, yellow bluestem and hog potato. Extremely low amounts of measurable precipitation was the major factor for these vegetative changes.

MAGGIE TANK HAY SEEDING
Pace Frequency Summary
First Trial - First Line of 100

Table 1

SPECIES	% FREQUENCY 1995	% FREQUENCY 1996	% FREQUENCY 1997	% FREQUENCY 1998
fluffgrass (TRPU)	2	7	6	10
black grama (BOER)	1	0	0	0
tobosa grass (HIMU)	1	0	4	1
threeawn (ARIST)	1	0	0	1
plains bristlegrass (SEMA)	0	42*	13*	1*
yellow bluestem (BOIS)	0	4*	0	0
Arizona cottontop (DICA)	0	0	0	1
ambrosia (AMBRO)	0	3	2	1
hog potato (HODE)	0	1	2	1
burroweed (b) (HATE)	28	18*	22	16
burroweed (c) (HATE)	20	2*	15*	22
snakeweed (b) (GUSA)	1	3	3	2
snakeweed (c) (GUSA)	0	2	1	4
mesquite (b) (PROSO)	2	0	0	1
mesquite (c) (PROSO)	8	7	11	8

* Significant difference at p=0.95

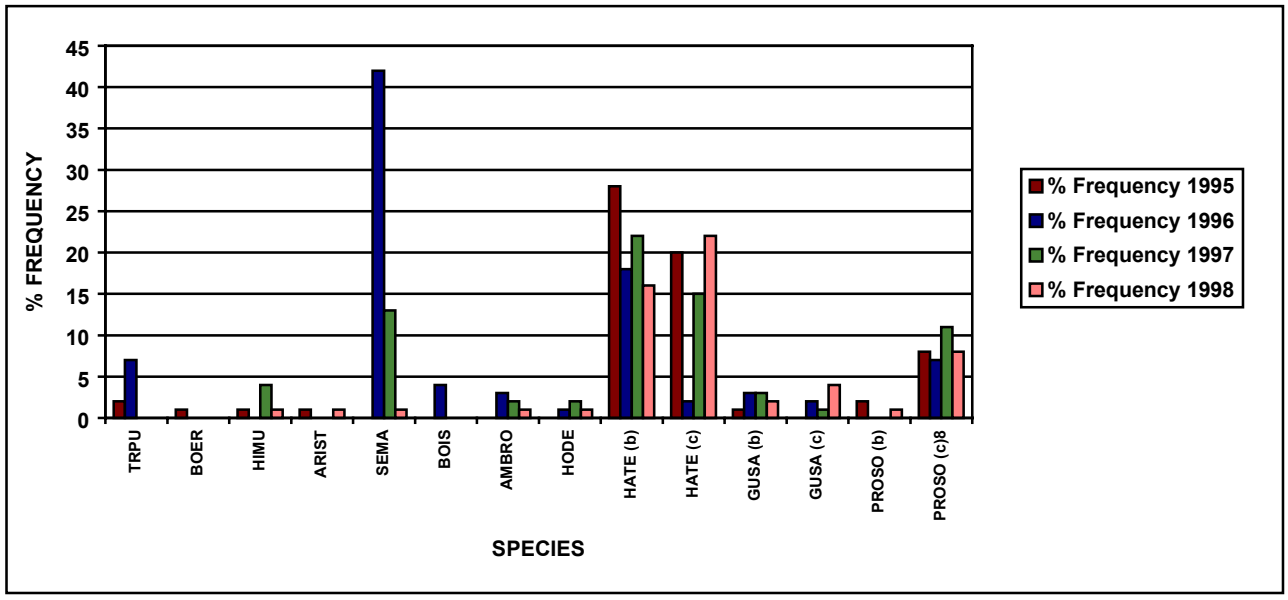


Chart 1. Comparison of percent frequency summary for all species found along the first trial transect evaluated in the fall of 1996.

MAGGIE TANK HAY SEEDING
Pace Frequency Summary
Second Trial - First Line of 100

Table 2

SPECIES	% FREQUENCY 1995	% FREQUENCY 1996	% FREQUENCY 1997	% FREQUENCY 1998
fluffgrass	20	2*	12*	4*
threeawn	4	10	2*	1
plains bristlegrass	2	41*	38	30
yellow bluestem	0	46*	28*	12*
bush muhly	2	0	1	0
sand dropseed	2	0	0	0
buffelgrass	0	1	3	1
Lehmann lovegrass	0	1	0	0
Az Cottontop	0	0	3	0
Hall's panic	0	0	3	0
hog potato	10	1*	30*	9*
composite spp.	4	0	0	0
Bahia	0	0	1	0
Perezia	0	0	1	0
soaptree yucca (b)	0	0	0	0
soaptree yucca (c)	2	0	1	0
creosote (b)	0	1 (seedling)	0	0
creosote (c)	0	0	1	0
burroweed (b)	33	6*	13*	23*
burroweed (c)	15	2*	15*	11
snakeweed (b)	11	0	1	3
snakeweed (c)	8	1*	4	3
mesquite (b)	3	3 (seedlings)	4	3
mesquite (c)	6	0*	5*	4
agave (c)	0	0	0	1

* Significant difference at p=0.95

MAGGIE TANK HAY SEEDING
Pace Frequency Summary
Second Trial - First Line of 100

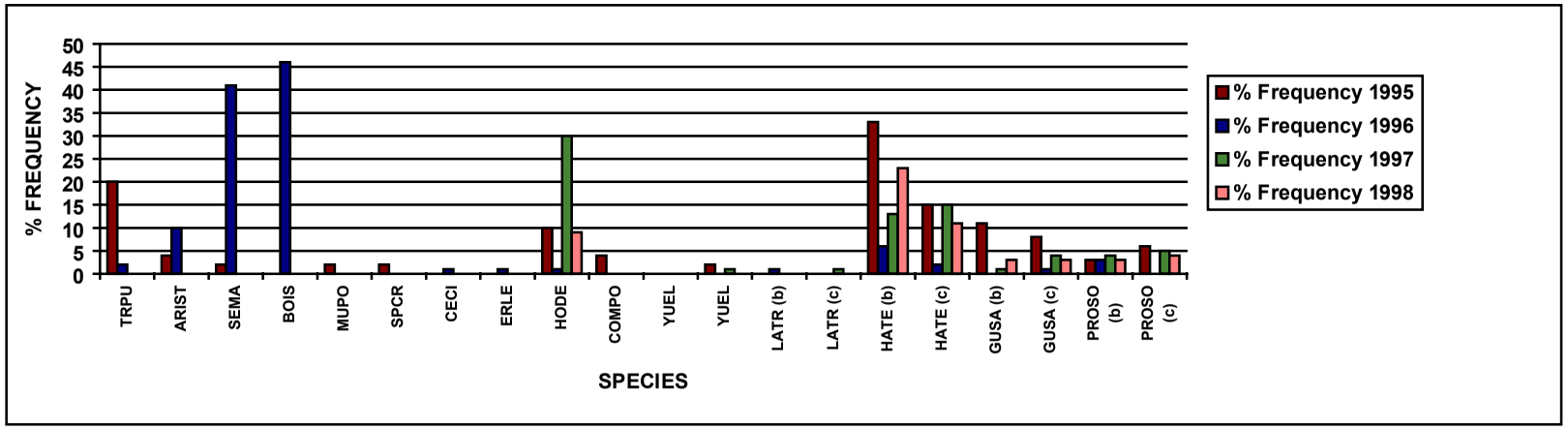


Chart 2. Comparison of percent frequency summary for all species found along the second trial transect evaluated on October 23, 1996.

Key:						
	TRPU	fluffgrass	ERLE	Lehmanns lovegrass	PROSO	mesquite
	ARIST	threeawn species	HODE	hog potato		
	SEMA	plains bristlegrass	COMPO	composite species		
	BOIS	yellow bluestem	YUEL	soaptree yucca		
	MUPO	bush muhly	LATR	creosote bush		
	SPCR	sand dropseed	HATE	burroweed		
	CECI	buffelgrass	GUSA	snakeweed		

MAGGIE TANK HAY SEEDING
Species List (1995-1996)

Table 3

COMMON NAME	SCIENTIFIC NAME
black grama	*Bouteloua eriopoda*
buffelgrass	*Cenchrus ciliaris*
bush muhly	*Muhlenbergia porteri*
fluffgrass	*Tridens pulchellus*
Lehmann lovegrass	*Eragrostis lehmanniana*
plains bristlegrass	*Setaria macrostachya*
sand dropseed	*Sporobolus cryptandrus*
threeawn	*Aristida spp.*
tobosa	*Hilaria mutica*
yellow bluestem	*Bothriochloa ischaemum*
pink pappusgrass	*Pappophorum bicolor*
ambrosia	*Ambrosia spp.*
composite	*Composite family*
hog potato	*Hoffmanseggia densiflora*
burroweed	*Haplopappus tenuisectus*
creosote	*Larrea tridentata*
mesquite	*Prosopis juliflora*
snakeweed	*Gutierrezia sarothrae*
soaptree yucca	*Yucca elata*

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04A9701L

Southwestern Borderlands Savanna Grassland Ecosystem Restoration Study

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: RANGE SEEDING

SECONDARY: WILDLIFE UPLAND HABITAT MANAGEMENT

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants management; establishment, growth, and harvest.
SECONDARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
The Borderlands Ecosystem Project area covers nearly 1 million acres in southeastern Arizona and southwestern New Mexico and includes the San Bernardino, southern San Simon and Animas Valleys. Much of the region supports semi-desert grass-shrub ranges and woodlands that are vital for livestock growers and local economies. This vegetation type occupies a strip of 50 to 100 miles along the United States-Mexico border in Arizona, New Mexico, and west Texas (Martin 1975). Elevations generally are from 3,000 to 6,000 feet. Precipitation, depending on geographic location along a northwest to southeast axis, ranges from 8 to 20 inches annually. In order to better understand and quantify the effects of different management practices on encroachment of woody species in grasslands and savannas, a multiple year research study is being implemented that considers the effect of several management strategies on ecosystem processes, function and composition. Other partners, in addition to the Rocky Mountain Experiment Station and Coronado National Forest included the Natural Resources Conservation Service (NRCS), the Whitewater Draw Natural Resource Conservation District, Arizona State Land Department, Malpai Borderlands Group, Hidalgo Soil and Water Conservation District, Animas Foundation, and U.S. Fish and Wildlife Service at the San Bernardino National Wildlife Refuge. The objective of the research study is to evaluate the impacts of a number of management treatments on components of the rangeland ecosystem: soils, vegetation, wildlife, and livestock. In Arizona, study locations include the San Bernardino National Wildlife Refuge (NWR), the Malpai Ranch, and the Sycamore Ranch. Locations on both the Malpai Ranch and the Sycamore Ranch include land leased from the State of Arizona. In New Mexico, the locations include the George Wright pasture of the Gray Ranch and a location north of Rodeo on the Roos Ranch. Study areas are easily accessible for logistical reasons and enhanced value for demonstration and learning. The focus of this study is not eradication of woody species, but rather a reduction of woody species density to improve range and watershed condition and promote development of a viable and productive perennial grass component. A successful treatment would be expected to produce a savanna condition with more widely scattered woody species and improved herbaceous cover, condition and productivity. Past efforts to mechanically control mesquite in the area have focused on either lifting of individual plants and root systems or root plowing and shearing. These treatments result in significant soil disturbance. An alternative mechanical treatment using a Marden duplex drum brush cutter (roller chopper) is being proposed for much of this study. While the brush cutter will not kill plants, it should be effective in breaking down crowns and breaking up the soil surface while incorporating some of the crown organic material into the upper soil layer and minimizing further soil disturbance. The treatment also reduces the transpiring leaf surface area of the mesquite plants. Mechanical treatment will be combined with and without native species seeding appropriate to each site. Sprouting of woody species is expected, however, establishment of an herbaceous layer should allow effective use of prescribed fire to control sprouts in the near future. Herbicides will not be used as part of this study.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

DURATION OF STUDY: 1997 through 2000

STUDY LEADER: C. Edminster, R. Bemis, M. Pater

LOCATION: Arizona PMC

COOPERATORS: Rocky Mountain. Experiment Station, Coronado N.F., Douglas F.O., Whitewater Draw NRCD, AZ State Land Dept., Malpai Borderlands Group, USFWS, Hidalgo SWCD, Animas Foundation.

METHODS AND MATERIALS:
Treatments planned for the locations at the San Bernardino NWR, the Malpai Ranch, the George Wright pasture at Gray Ranch, and the Roos Ranch include (1) Control (no treatment), (2) Congregating livestock into small area for a few days and feeding hay, and (3) Hand cutting mesquite to reduce transpiration while increasing coarse organic material on the soil, congregating livestock and feeding hay. Native species hay for this portion of the study is being provided by the NRCS Tucson Plant Materials Center. The Borderlands research project currently has two years (1997 and 1998) remaining on its original charter. Plans are to implement the treatments in the spring of 1997 and monitor results for a minimum of two growing seasons. Hopefully the project charter will be extended to allow for continued monitoring and implementation of future prescribed burning treatments.

STATUS OF KNOWLEDGE:
One of the persistent concerns in many ecosystems in the Southwest is the increase in density of shrubs and trees during the past century years (Martin 1975; Dahl et al. 1978; Branson 1985; Ruyle et al. 1988; Brown and Archer 1989; Grover and Musick 1990; Bahre 1991). Of particular interest in the Borderlands Project area are increases of velvet mesquite in Arizona and honey mesquite in New Mexico (Little 1980). At higher elevations in the region, concern focuses on one-seed juniper and alligator juniper. Traditional explanations for this increase have focused on changes in climate, livestock grazing, and fire regimes. Recently an alternative hypothesis that encroachment of woody plants into grass dominated communities is driven by increases in atmospheric CO_2 has been proposed (Mayeux et al. 1991; Polley et al. 1994; Idso 1992; Johnson et al. 1993). While atmospheric CO_2 increases and possible climate change may have facilitated shifts to woody plant domination, numerous case studies have established a strong link between effects of changes in fire regimes and livestock grazing management on encroachment of woody plants into grasslands and savannas (Archer et al. in press). The goal of public land managers and ranchers in the Borderlands area is to manage the semi-desert grasslands and savannas according to the concepts of ecosystem management with emphasis on sustaining, and where needed, restoring ecological function and production and health of the entire ecosystem, from soils to humans. Goals in the region are to improve and rehabilitate rangelands to the benefit of a majority of components. This is anticipated to support rural livelihoods and, in turn, protect to open space nature and biodiversity of the landscape. An objective of the proposed study is to determine if and how the shrub and tree components can be managed for the ecological and economic benefit of the system. Improved composition and density of perennial grasses, preferably native species, and reduced influence of mesquite and other woody species are immediate objectives. The eventual return of fire, a natural component of the ecosystem and management tool, is of particular interest.

LITERATURE CITED:

Archer, S., Schimel, D.S., Holland, E.A.. In press. Mechanisms of shrubland expansion: land use, climate change, or CO_2?. Climate Change.

Bahre, C.J. 1991. A legacy of change: historic human impact on vegetation of the Arizona borderlands. University of Arizona Press, Tucson, AZ 231 p.

Branson, F.A. 1985. Vegetation changes on western rangelands. Range Monograph No. 2. Society for Range Management. Denver, CO.

Brown, J.R. and Archer, S. 1989. Woody plant invasion of grasslands: establishment of honey mesquite (*Prosopis glandulosa* var. *glandulosa*) on sites differing in herbaceous biomass and grazing history. Oecologia. 80:19-26.

Dahl, B.E., Sosebee, R.E., Goen, J.P., Brumley, C.S. 1978. Will mesquite control with 2,4,5-T enhance grass production? Journal of Range Management. 31:129-131.

Grover, H.D. and Musick, H.B. 1990. Shrub land encroachment in southern New Mexico, USA: an analysis of desertification processes in the American Southwest. Climate Change. 17:305-330.

Idso, S.B. 1992. Shrubland expansion in the American Southwest. Climate Change. 22:85-86.

Johnson, H.B., Polley, H.W., Mayeux, H.S. 1993. Increasing CO_2 and plant-plant interactions: effects on natural vegetation. Vegetation. 104-105:157-170.

Little, E.L. 1980. The Audubon Society field guide to North American trees: western region. Albert A. Knopf. New York. 639p.

Martin, S.C. 1975. Ecology and management of southwestern semidesert grass-shrub ranges: the status of our knowledge. Research Paper RM-156. Fort Collins, CO: U.S. Dept. of Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station. 39p.

Mayeux, H.S., Johnson, H.B., Polley, H.W. 1991. Global change and vegetation dynamics. In James, L.F., Evans, J.O., Ralphs, M.H., Sigler, B.J., (eds.). Noxious Range Weeds. Westview Press. Boulder, CO 62-74.

Polley, H.W., Johnson, H.B., Mayeux, H.S. 1994. Increasing CO_2: comparative responses of the C_4 grass *Schizachyrium* and grassland invader *Prosopis*. Ecology. 75:976-988.

Ruyle, G.B., Roundy, B.A., Cox, J.R. 1988. Effects of burning on germinability of Lehmann lovegrass. Journal of Range Management. 41:404-406.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Technical Note

OTHER ACTIONS: Publication on using native grass hay for range reseeding.

1998 RESULTS

The McDonald Research Plot has been established to evaluate the establishment of herbaceous cover on a significant archeological site without any unpermitted ground-disturbing activities (grazing is a permitted use).

Two treatments were applied to introduce seed to this plot:

1. On November 11-13, 1997, native grass hay was fed to 279 head of cows to produce 777 days of cow impact on the site. That is a stocking rate of approximately 11 cows per acre on the 25 acre plot. The hay consisted of approximately 250 bales of cane beardgrass, 60 bales of plains bristlegrass, and 40 bales of Arizona cottontop. Heavy rains occurred while the cattle were being fed, this resulted in the hay becoming well incorporated into the soil with some being washed off the site.

2. On February 3-4, 1998, the following amounts of seed were broadcast onto the site:

SPECIES	AMOUNT APPLIED	LBS/ACRE	SEEDS/FT^2
giant sacaton	20 lbs on 21 acres	0.95 lbs acre^{-1}	44 seeds ft^{-2}
alkali sacaton	20 lbs on 21 acres	0.95 lbs acre^{-1}	30 seeds ft^{-2}
fourwing saltbush	20 lbs on 21 acres (de-winged)	0.95 lbs acre^{-1}	1 seed ft^{-2}
sideoats grama	150 lbs on 21 acres	7.1 lbs acre^{-1}	23 seeds ft^{-2}
blue grama	31 lbs on 21 acres	1.48 lbs acre^{-1}	24 seeds ft^{-2}

The scattered native grass hay bales produced the best stands of grass. The cane beardgrass appeared to germinate best, followed closely by the plains bristlegrass. A major difference here is that approximately 76% more bales of cane beardgrass were applied to the site. Where the Arizona cottontop bales were scattered, a reasonably good number of seedlings were identified. Feeding cattle the native grass hay has resulted in the very successful germination of native species. It is expected that very good results will be observed on this site next summer (1999) if the seedlings survive the winter of 1998-1999.

The five species that were hand broadcast lived up to the traditional expectations. After an extensive review of the research plot only two blue grama seedlings were identified, a few giant and alkali sacaton seedlings were found, no fourwing saltbush seedlings were found, and a visual estimate of sideoats grama seedlings revealed 50-75 individual seedlings. Frost damage during the winter of 1998-1999 is a concern.

The 1998 summer rains were very light until mid-October when a storm produced over one inch of precipitation. This storm was followed in November by a storm that produced over two inches of precipitation. The plants have responded very favorably to this precipitation. A late summer inspection revealed little to no germination of any of the grass species planted through the use of hay bales. Therefore it is assumed that all new grass seedlings are the results of the late season storms described above. This is consistent with many other seeding projects previously conducted in this area. Late rains appear to produce better germination rates than the earlier summer rains.

On November 11, 1998, Ron Bemis and Jerry Gottfried (USFS Rocky Mtn. Research Station) visited the site. They reported that the scattered mulch was still evident on the soil surface with 10 to 50% of the soil surface being exposed and a good stand of new Arizona cottontop and cane bluestem seedlings were observed (pictures 1 & 2). In areas where the mulch was very heavy and still completely covered the soil surface, little to no germination was observed. In the areas where the mulch was incorporated by livestock trampling, little to no germination was observed.

Recommendations:

A. Any further livestock grazing on this site would be damaging to the continued establishment of the new seedlings until they have become either healthy, mature plants or they have died as a result of frost damage, drought damage, or herbivory by rodents and insects.
B. The native grass hay currently stacked on this site should be used to (a) build a few small check dams to see if runoff water could be effectively spread over a larger area to improve germination of seedlings; (b) use the remaining bales to be spread over bare areas to provide mulch and a seed source. Mulching should be applied to achieve 60-75% cover.
C. The electric fence should be maintained and kept "hot" whenever any grazing livestock are in the pasture where this research plot is located.

Picture 1. Arizona cottontop (*Digitaria californica*) seedlings from scattered haybales on the McDonald Research Plot.

Picture 2. Cane bluestem (*Bothriochloa barbinodis*) seedlings from scattered haybales on the McDonald Research Plot.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04A010H

Six Mile Flat Field Evaluations - Nevada Adaptation Trials, Caliente, Nevada. Final Report

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants management; establishment, growth, and harvest.
SECONDARY:	Animals	Animals habitat, food.

DESCRIPTION:
The Six Mile Flat planting site is located 31 miles west of Caliente, Nevada on Highway. To date, Tucson PMC personnel have conducted 6 plantings on this site.

The planting design on the site is a completely randomized block design using four replications for each accession being evaluated. A cultural treatment planting was also installed on this site in 1989 to evaluate plant/stand establishment using furrows and pitting.

To date, 62 accessions encompassing 17 different species have been planted on the Six Mile Flat site. The planting site is located in MLRA 29. The soils are classified as Toyken series with a coarse sandy loam texture. Average annual precipitation for this area is 178 mm and the elevation is 1,495 meters.

Indigenous species found on this site include: budsage (*Artemesia spinescens*), spiny hopsage (*Grayia spinosa*), spiny horsebrush (*Tetradymia axillaris*), snakeweed (*Gutierrezia sarothrae*), Mormon tea (*Ephedra* spp.), squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), big galleta (*Hilaria jamesii*), and fluffgrass (*Tridens pulchellus*).

Cooperating agencies and groups include: BLM, Lincoln County Conservation District, Nevada State Land Department - Division of Forestry, NRCS - Caliente Field Office and the Tucson Plant Materials Center. The purpose of this planting is to evaluate and select the best adapted plant materials to meet the conservation needs for MLRA 29.

The ten acre site is primarily used for replicated testing of selected plant materials (released cultivars as well as materials in Advanced Evaluation) received from various plant materials centers located in the western United States. The site is also used to evaluate cultural treatments which may aid in plant establishment. Another objective is to use this site as a demonstration site to show cooperators and interested groups which plant materials are most successful in establishing vegetative cover in MLRA 29.

DURATION OF STUDY: 1987 through 2000

STUDY LEADER: Bruce Munda

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

LOCATION: Arizona PMC

COOPERATORS: Caliente NRCD, BLM, Tucson Plant Materials Center.

METHODS AND MATERIALS:
The replicated plantings were installed using a randomized complete blocks design with each accession being replicated four times. Each planting block for each replication measured 1.83 x 15.24 m (6 x 50 feet) and was cleared of all existing vegetation using a rear-mounted undercutter knife on a Case 275 tractor (see Project Plan Map). Since 1987, the seed has been planted using either a Planet Junior (hand-operated or tractor-mounted), hand broadcasting, a rangeland drill, and a Kincaid No-Till Plot Drill. Seed was planted directly into the cleared evaluation blocks. Seeding depth and rate varied but followed NRCS recommendations for species and seed size.

The first planting was conducted in November, 1987. This planting included the following list of plant species:

SPECIES	CULTIVAR/ACCESSION
fourwing saltbush - *Atriplex canescens*	478837
	9003134
	478838
	9003136
	9003126
	'Rincon'
	'Santa Rita'
	'Marana'
	'Wytana'
Indian ricegrass - *Oryzopsis hymenoides*	478833
	9035287
	'Nezpar'
	'Paloma'
basin wildrye - *Leymus cinereus*	478831
	'Magnar'
	'Prairieland'
lovegrass species - *Eragrostis* spp.	'A-67'
	'Cochise'
Mediterranean ricegrass - *Oryzopsis coerulescens*	253339
smilograss - *Piptatherum miliaceum*	198091

The second planting was conducted in November, 1988. This planting was installed using the following species:

SPECIES	CULTIVAR/ACCESSION
alkali sacaton - *Sporobolus airoides*	421071
	421069
	'Saltalk'
	'Salado'
penstemon - *Penstemon* spp.	9004621
	9007036
	'Cedar'
	'Bandera'
Russian wildrye - *Psathyrostachys juncea*	'Bozoisky-select'
	'Vinall'
bush muhly - *Muhlenbergia porteri*	9003824
	'El Vado'
Streambank wheatgrass - *Elymus lanceolatus ssp. lanceolatus*	9021076
	'Critana'
slender wheatgrass - *Elymus trachycaulus ssp. trachycaulus*	'Primar'
	'Pryor'
	'San Luis'
mammoth wildrye - *Leymus racemosus*	'ND-691'
	'Volga'
western wheatgrass - *Pascopyrum smithii*	'Rodan'
crested wheatgrass - *Agropyron cristatum*	'Nordan'
	Standard Syn. 1
	'Fairway'
	'Hycrest'
	'Ephraim'
	'P-27'

The third planting was conducted on July 25, 1989. The following is a list of the species that were planted:

SPECIES	CULTIVAR/ACCESSION
black grama - *Bouteloua eriopoda*	'Nogal'
	'Sonora'
blue grama - *Bouteloua gracilis*	'Hachita'
	'Lovington'
sideoats grama - *Bouteloua curtipendula*	'Haskell'
	'El Reno'
	'Vaughn'
	'Niner'
buffelgrass - *Cenchrus ciliaris*	9003686
	T-4464
yellow bluestem - *Bothriochloa ischaemum*	P.I. 237110
	'Ganada'
lovegrass species - *Eragrostis spp.*	'A-67'
	'Catalina'
	'Cochise'
western wheatgrass - *Pascopyrum smithii*	'Arriba'

July 25, 1989 Planting, continued.

	'Barton'
	'Rosana'
	'Rodan'
Mediterranean ricegrass - *Oryzopsis coerulescens*	253339
smilograss - *Piptatherum miliaceum*	198091

The 1989 cultural treatment planting objective was to evaluate the use of pits and furrows and their ability to assist in the establishment of perennial vegetation. This particular planting site borders the east side of the replicated planting area. The total area for the cultural treatment planting encompasses 2.5 acres. The area was divided into 3 blocks of equal size: the pitted area located in the south 1/3, the control area located in the center, and the furrowed area was located in the north 1/3 of the site. Furrowing shovels, mounted on a tool bar, spaced four feet apart, were used to create the furrows and pits. The pits are approximately 12-16 feet long, 6 inches deep, and 20 inches wide. The pits follow the natural contour of the ground and were spaced alternately on each pass with the tractor. The furrows are 6 inches deep and 20 inches wide, continuous, and following the contour of the slope. Both the pitted and furrowed areas were seeded after the treatments were installed. The control area was seeded prior to the treatment installation using the tractor tire tread as a simulated imprinter. Each treatment was seeded to 1.33 bulk pounds of 'Cochise' lovegrass.

The fourth planting was installed on July 31 - August 1, 1990. Most of the warm-season species were replanted at this time. The following is a list of the species that were planted:

SPECIES	**CULTIVAR/ACCESSION**
alkali sacaton - *Sporobolus airoides*	421071
	421069
	'Salado'
lovegrass species - *Eragrostis spp*.	'Catalina'
	'Cochise'
Mediterranean ricegrass - *Oryzopsis coerulescens*	253339
smilograss - *Piptatherum miliaceum*	198091
yellow bluestem - *Bothriochloa ischaemum*	P.I. 237110
	'Ganada'
black grama - *Bouteloua eriopoda*	'Nogal'
	'Sonora'
blue grama - *Bouteloua gracilis*	'Hachita'
	'Lovington'
sideoats grama - *Bouteloua curtipendula*	'Haskell'
	'El Reno'
	'Niner'
	'Vaughn'
big galleta - *Pleuraphis rigida*	'Viva'

The cultural treatment area was replanted with 'Viva' galleta grass seed using the rangeland drill and disk weights in order to plant the seed as deep as possible. The seed was planted at a depth of 0.5 to 1.0 inches. Three raptor perch poles were installed to help with natural rodent control.

The fifth planting was installed in November 1990. Due to the apparent failures of the previous replicated plot plantings, it was decided to try to establish a cover crop using annual grain species: 'Seco' barley and 'Aroostock' rye. The objective was to see if a dead litter cover would facilitate the establishment of perennial vegetation on this planting site. Each grain species was replicated one time for each perennial species being tested. On November 6, 1990 Tucson PMC personnel planted 29.8 bulk pounds of 'Seco' barley and 20 bulk pounds of 'Aroostock' rye. Four rows were planted into each selected planting block at an average depth of 1 inch. The total area planted for each grain species was 0.33 acres at a seeding rate of 29.8 pounds per 0.33 acres for 'Seco' (90 lbs/acre) and 20 pounds per 0.33 acres for 'Aroostock' rye (60

lbs/acre). to help reduce rodent predation, Tucson PMC personnel broadcast wheat seed over the tops of the drill-seeded plots.

The sixth planting was installed on March 24-25, 1992. Most of the cool-season species were planted back into their original plots using the Kincaid No-Till Plot Drill. All species were seeded at a depth of 1.5 inches. After planting, bales of oat straw mulch was applied to the first three replications for all species except the Russian wildrye and western wheatgrass plots. In those plots, the first replication was not mulched. The actual mulch application rate was 2,100 lbs of straw per 0.62 acres (total area mulched). The straw was anchored into the soil using a mulch tucker (crimper). The site had received over 8 inches of precipitation since October of 1991 and the Tucson PMC personnel observed excellent soil moisture during the planting.

The seventh planting was installed on November 30, 1993. This planting effort involved replanting the three best species, based on results from previous trials, at three different depths (0.5, 1.0, and 2.5 inches). Species used were Indian ricegrass (Nezpar & Palm), Crested wheatgrass (Nordan & Hycrest), and Western wheatgrass (Rosana & Arriba). Planting design was a completely randomized design with three replications and treatments of two seeding rates (25 and 50 pls/foot) at the three planting depths. Oat straw was applied over the plots at a rate of 1.5 to 2 bales per plot. Each plot was approximately 300 ft^2.

The eighth and final planting was installed on April 29, 1997. This planting involved the comparison of local and non-local ecotypes. We used transplants due to our numerous unsuccessful attempts with direct seeding. Five species and 439 transplants were utilized in this trail. See following table for species list, plot location, number planted, and origin of seed. Half of the P-27, Vavilov, Nezpar, and Paloma transplants had 'Terracottem' soil amendment added to the potting mixture during the initial propagation stage. It was considered desirable to test this material to see if it would enhance plant survival.

SPECIES	ACCESSION	ORIGIN	# PLANTED
Menodora[1]	9064062	Tonopah, NV	25
Menodora	"		25
Menodora[1]	9064056	Lincoln Co., NV MLRA 30	25
Menodora	"		25
Siberian wheatgrass[1]	Vavilov	----	40
Siberian wheatgrass	"	----	40
Siberian wheatgrass[1]	P-27	----	40
Siberian wheatgrass	"	----	40
Desert stipa	9058811	Lincoln Co., NV MLRA 30	4
"	9064009	Mohave Co., AZ	6
"	9064034	Gila Co., AZ MLRA 39-4	8

[1] Plants had Terracottem in the potting mix.

Desert stipa	9058802	Lincoln Co., NV MLRA 29	1
"	9064006	Kane Co., UT MLRA 35-3	4
"	9063995	Clark Co., NV MLRA 30	4
"	9064004	Mohave Co., AZ	3
"	9064005	Flagstaff, AZ Coconino Co.	5
"	9064008	Lincoln Co., NV MLRA 29	3
Indian ricegrass[1]	Nezpar		20
Indian ricegrass	"		19
Indian ricegrass[1]	Paloma		15
Indian ricegrass	"		17
Ephedra	9058833	Tucson PMC / IEP increase	5
Ephedra	9058814	Lincoln Co., NV	15

[1] Plants had Terracottem in the potting mix.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Technical Note, Possible amendment to NRCS range seeding specifications

RESULTS:

1988
The 1987 planting (1) was first evaluated in June of 1988. Overall, the results were judged as poor to fair. This planting was evaluated again in November, 1988 and it was observed that the status of the fourwing saltbush seedlings was holding steady but the Indian ricegrass, western wheatgrass and basin wildrye plants had all desiccated and died. This was primarily due to the lack of summer moisture and low amount of winter moisture.

1989
The November 1988 (2) and July 1989 (3) plantings were evaluated during the course of the year. It was noted that no seedling emergence was observed in either plantings including the cultural treatment plots. It was noted that the site had received little to no summer moisture and very low winter precipitation. Considerable rodent activity was observed in the newly seeded plots. The rodents tended to first retrieve the seed in all of the 'Barton' western wheatgrass plots. They would then systematically retrieve the seed from each freshly seeded plot in order of preference. There were also no visible signs of seed germination or seedling establishment of the 'Cochise' lovegrass that was seeded in the cultural treatment plots. The 1987 planting (1) of fourwing saltbush was inspected on July 24, 89and we found a few individuals surviving for the following accessions: 9003134, 9003136, 9003126, and 'Santa Rita'. Rick Orr stated that the November, 88 seeding (2) had germinated but drought out by the summer of 1989.

1990
The November 88, July 89, and cultural treatments were evaluated by field office personnel on September 12, 1990. No emergence of germination were observed. However, substantial rodent activity in all of the previous plantings was observed. The 88 and 89 plantings were again evaluated on July 30, 1990. Again, no seedlings of any species were found in any of the previous plantings, except the fourwing plots. The 4th planting was installed July 30, 1990. The 4th planting was reviewed in November of 1990 when we installed the 5th planting on November 6, 1990. There were no visible signs of seed germination or seedling establishment of the 'Viva' galleta grass which was planted in the cultural treatment area with the 5th planting. We did find 3-4 individual plants of 'Nordan' crested wheatgrass in replication plot #3 from the November 88 planting (#2). We also found evidence of fair to good emergence of 'Catalina' and 'Cochise'

lovegrass in each of the replicated plots from the July 89 planting (#3). Plant emergence was most evident in shallow depressions where there was a light gravel mulch. These grass seedlings were very small and showing signs of stress. Due to their small size, we were very doubtful that they would survive the 1990-91 winter.

1992

The 6th planting was installed March 24, 1992. This planting involved replanting the cool season species used in planting #5 and planting all species to depth of 1.5 inches. It also included the use of oat straw mulch applied at a rate of about 3400 lbs/ac. The 6th planting was first evaluated on April 14, 1992. It was reported that seedling emergence was evident in the unmulched plots. The seedlings were reported to be 1-1.5 inches in height and good soil moisture was evident below 2 inches. No seedlings were visibly evident in the mulched plots. A few seedlings of Indian ricegrass seedlings were found for 478833, 9035287, and Nezpar in the cereal rye mulch. A few Magnar wildrye plants were found in the tucked straw mulch. A few Arriba, Barton, and Rosana western wheatgrass plants were found with a strong number of Rodan plants found in the tucked straw mulch replication. The best emergence was from Bozoisky and Vinall Russian wildrye using the tucked straw mulch. Other species which did well are: Volga Mammoth wildrye with tucked straw mulch, Cedar penstemon, and 9007036 penstemon both in the Seco mulch. The site was evaluated again on June 25, 1992. It was noted that the seedlings in the unmulched plots had appeared to have gone dormant and some additional new seedlings were also evident. It was also noted that a significant number of seedlings were lost due to desiccation. The mulched plots were still difficult to evaluate. Precipitation on the site to date since planting was 1.47 inches.

1993

The seventh planting was installed on November 30, 1993 - see Materials and Methods for species and planting information. Results from the March 24-25, 1992 planting were very poor. Some of the germinated species were covered by wire mesh cages to protect them from herbivory. Upon later evaluation those that were covered had become established. It was postulated that the wire mesh provided protection from herbivory but also provided needed shade--modifying the surface soil temperatures and reducing evaporation. All of the raptor poles have signs of being well used. This planting site was evaluated on August 1994 with the results presented in the following table. Plots not included in the tables below were blank or had less than 15 plants per plot. Most of the germination was seen where the mulch was the thickest. Germination was spotty and not uniform over the plots for all the species and treatments.

WESTERN WHEATGRASS

SPECIES	PLOT LOCATION	SEEDING RATE (pls/ft)	SEEDING DEPTH (in)	OBSERVATIONS
Arriba	1A	25	1.0	few (15-45 plts/plot)
Arriba	1B	50	2.5	med. (45-90 plts/plot)
Arriba	1C	50	0.5	few (15-45 plts/plot)
Arriba	1D	50	0.5	few (15-45 plts/plot)
Arriba	2A	50	2.5	med (45-90 plts/plot)
Rosana	2C	50	2.5	few
Arriba	2d	25	2.5	few
Arriba	2E	50	2.5	several (>90 plts/plot)
Rosana	3A	50	1.0	few
Rosana	3b	50	0.5	few
Rosana	3C	50	0.5	few
Arriba	3D	50	1.0	med
Rosana	3E	50	2.5	few
Arriba	3F	50	1.0	few
Arriba	4A	25	1.0	med
Rosana	4B	25	0.5	several

WESTERN WHEATGRASS
(continued)

Rosana	4C	50	1.0	med
Arriba	4F	25	2.5	several
Arriba	5A	50	1.0	few
Arriba	5B	50	0.5	few

Rosana	5d	50	1.0	med
Rosana	5E	25	1.0	few
Rosana	6B	25	1.0	med
Arriba	6E	25	2.5	few
Arriba	6F	25	1.0	few

INDIAN RICEGRASS

SPECIES	PLOT LOCATION	SEEDING RATE (pls/ft)	SEEDING DEPTH (in)	OBSERVATIONS
Nezpar	7A	50	1.0	med.
Paloma	7B	25	1.0	med. (45-90 plts/plot)
Nezpar	8A	25	2.5	few (15-45 plts/plot)
Paloma	8C	50	2.5	several
Paloma	8D	25	2.5	med
Nezpar	8E	25	1.0	several
Paloma	8F	25	2.5	med
Paloma	9A	50	2.5	several (>90 plts/plot)
Paloma	9B	50	1.0	med
Nezpar	9D	50	2.5	med
Paloma	9E	25	1.0	few
Nezpar	10A	25	1.0	few
Paloma	10B	25	1.0	med
Paloma	10E	50	1.0	few
Nezpar	11D	50	2.5	few
Nezpar	11E	25	1.0	med
Paloma	11F	50	1.0	med
Nezpar	12A	25	1.0	few
Nezpar	12B	25	2.5	few
Paloma	12C	50	2.5	several
Nezpar	12D	50	2.5	several
Paloma	12E	25	2.5	few

CRESTED WHEATGRASS

SPECIES	PLOT LOCATION	SEEDING RATE (pls/ft)	SEEDING DEPTH (in)	OBSERVATIONS
Nordan	13A	50	0.5	few (15-45 plts/plot)
Hycrest	13B	25	2.5	med. (45-90 plts/plot)
Hycrest	13D	50	2.5	few (15-45 plts/plot)
Nordan	13F	50	1.0	few (15-45 plts/plot)
Hycrest	14B	25	0.5	few
Nordan	14D	50	1.0	few
Nordan	14F	50	0.5	few
Hycrest	15C	50	0.5	few

CRESTED WHEATGRASS
(continued)

Nordan	15F	50	2.5	few
Nordan	16A	25	1.0	few
Hycrest	16B	25	0.5	few
Hycrest	16D	25	1.0	few
Hycrest	16F	25	1.0	few

Hycrest	17B	50	1.0	few
Hycrest	17C	50	0.5	few
Nordan	17D	50	1.0	few
Hycrest	17F	50	1.0	few
Nordan	18F	25	0.5	few

1997

The 7th planting was inspected in the fall of 1997 when it was observed that most of the plants showed good vigor and growth. However, the site had a very dry fall and winter until the 'El Nino' event in February, 1998. The planting was evaluated in May 27, 1998 with results show below. Indian ricegrass performed the best with regards to survival. Also, it is apparent that the terracottem did not make a difference with regards to plant survival. In fact most plants did better or as well without Terracottem. 'Paloma' Indian ricegrass appears to have survived better than 'Nezpar'. Collection sites, or local ecotypes, appears to have had little effect on survival. Locally collected ecotypes of spiny menodora and desert needlegrass performed as poorly as those ecotypes collected in northern Arizona. All of the surviving plants showed signs of herbivory with 'Vavilov' and the spiny menodora accessions showing severe signs of defoliation. All of the plants were showing signs of stress due to drought.

Numerous species, seeding depths and seeding methodologies have been tried at this site with some favorable results with regards to germination. However, due to herbivory and drought we have had dismal results with regards to plant establishment and survival. Rick Orr and I will work on summarizing the results of this planting in a technical note. This concludes a long and diligent effort to try to find a method for successful plant establishment and survival at Six-Mile Flat.

SPECIES	ACCESSION	LOCATION	# PLANTED	# SURVIVED
Menodora[1]	9064062	Tonopah, NV	25	0
Menodora	"		25	1
Menodora[1]	9064056	Lincoln Co., NV MLRA 30	25	4
Menodora	"		25	1
Siberian wheatgrass[1]	Vavilov	----	40	1
Siberian wheatgrass	"	----	40	8
Siberian wheatgrass[1]	P-27	----	40	2
Siberian wheatgrass	"	----	40	6
Desert stipa	9058811	Lincoln Co., NV MLRA 30	4	1
"	9064009	Mohave Co., AZ	6	5
"	9064034	Gila Co., AZ MLRA 39-4	8	1

SPECIES	ACCESSION	LOCATION	# PLANTED	# SURVIVED
Desert stipa	9058802	Lincoln Co., NV MLRA 29	1	0
"	9064006	Kane Co., UT MLRA 35-3	4	1
"	9063995	Clark Co., NV	4	2

		MLRA 30		
"	9064004	Mohave Co., AZ	3	1
"	9064005	Flagstaff, AZ Coconino Co.	5	3
"	9064008	Lincoln Co., NV MLRA 29	3	0
Indian ricegrass[1]	Nezpar		20	7
Indian ricegrass	"		19	11
Indian ricegrass[1]	Paloma		15	13
Indian ricegrass	"		17	14
Ephedra	9058833	Tucson PMC / IEP increase	5	2
Ephedra	9058814	Lincoln Co., NV	15	3

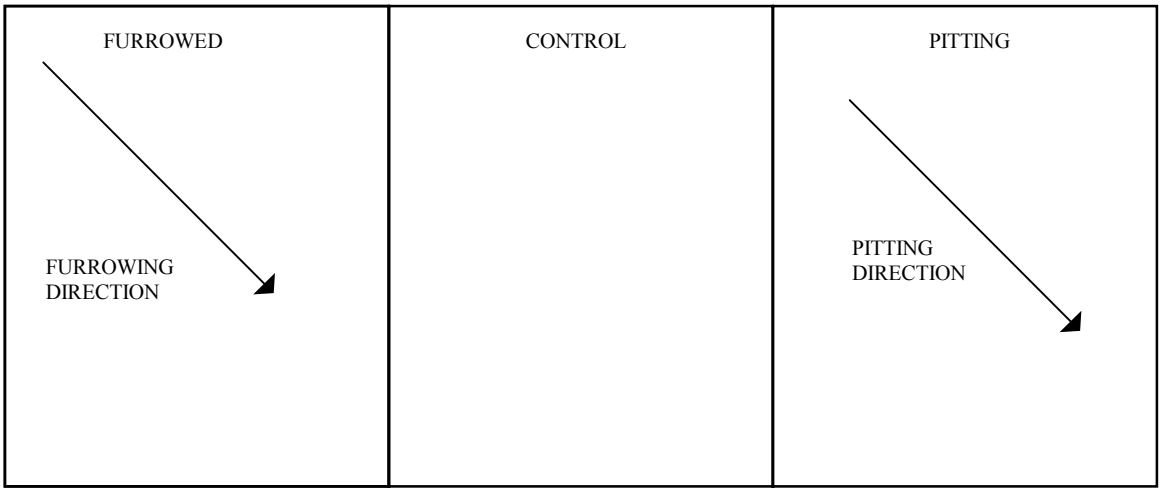
[1] Plants had Terracottem in the potting mix.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

SIX-MILE FLAT, NEVADA EVALUATION SITE
PROJECT PLAN MAP
(Not to Scale)

NORTH ➨

	A	B	C	D	E	F	G	H	I
1	478837	9003134	Rincon	Santa Rita	9003126	Wytana	478838	Marana	9003136
2	Santa Rita	9003136	Marana	9003134	Wytana	478838	478837	9003126	Rincon
3	478837	Marana	9003126	9003136	9003134	Rincon	478838	Santa Rita	Wytana
4	9003126	Santa Rita	Rincon	Marana	478838	9003134	9003136	Wytana	438837
5	Paloma	Nezpar	9035287	478833	Magnar	478831	271893	253339	198091
6	Nezpar	9035287	Paloma	478833	478831	Magnar	271893	198091	253339
7	478833	Paloma	Nezpar	9035287	271893	478831	Magnar	253339	198091
8	Paloma	478833	9035287	Nezpar	271893	Magnar	478831	198091	253339
9	Cochise	A-67	Catalina	Arriba	Barton	Rosana	Rodan	Bozoisky	Vinall
10	Catalina	Cochise	A-67	Barton	Rosana	Arriba	Rodan	Bozoisky	Vinall
11	Cochise	A-67	Catalina	Rosana	Arriba	Barton	Rodan	Vinall	Bozoisky
12	Catalina	Cochise	A-67	Arriba	Rodan	Barton	Rosana	Vinall	Bozoisky
13	Ephraim	Fairway	Standard	P-27	Hycrest	Nordan	San Luis	Primar	Pryor
14	Hycrest	Nordan	Standard	P-27	Fairway	Ephraim	Primar	Pryor	San Luis
15	Nordan	Standard	Ephraim	P-27	Fairway	Hycrest	San Luis	Pryor	Primar
16	Hycrest	Standard	Ephraim	Nordan	P-27	Fairway	Primar	San Luis	Pryor
17	El Vado	9003824	Saltalk	421071	421069	Salado	ND-691	Volga	
18	9003824	El Vado	421071	Salado	Saltalk	421069	Volga	ND-691	
19	9003824	El Vado	421069	Salado	Saltalk	421071	Volga	ND-691	
20	El Vado	9003824	Saltalk	421069	Salado	421071	ND-691	Volga	
21	9004621	9007036	Bandera	Cedar	Haskell	Vaughn	Niner	El Reno	
22	Cedar	9004621	9007036	Bandera	Vaughn	Niner	Haskell	El Reno	
23	Bandera	9004621	9007036	Cedar	Niner	Vaughn	Haskell	El Reno	
24	Bandera	9004621	Cedar	9007036	Vaughn	Niner	Haskell	El Reno	
25	Critana	9021076	Hachita	Lovington	Nogal	Sonora			
26	Critana	9021076	Hachita	Lovington	Sonora	Nogal			
27	Critana	9021076	Lovington	Hachita	Sonora	Nogal			
28	9021076	Critana	Hachita	Lovington	Sonora	Nogal			
29	237110	Ganada	Ganada	237110	Ganada	237110	237110	Ganada	
30	9003686	T-4464	T-4464	9003686	T-4464	9003686	9003686	T-4464	



2.5 ACRE CULTURAL TREATMENT AREA
07/26/89 - Seeded to 'Cochise' lovegrass (hand-broadcast seeded)
07/30/90 - Seeded to 'Viva' galleta grass using the "baby" rangeland drill (#2 setting with all disk weights)

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04A9301L

Joshua Tree National Park Plant Adaptation Trials - Comparative Studies.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Natural area, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 342 CRITICAL AREA PLANTING

SECONDARY: 561 HEAVY USE AREA

TERTIARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Plants	Plants suitability, other.
SECONDARY:	Soil	Soil erosion, other.

DESCRIPTION:
This study was initiated to evaluate two native shrubs which are found growing in the Mohave desert: creosote bush (*Larrea tridentata*) and desert saltbush (*Atriplex polycarpa*). This study will evaluate local and non-local ecotypes for each species at two planting locations: Joshua Tree National Monument Headquarters, Twenty-nine Palms, California, and a Tucson PMC test site located at Avra Valley, Arizona. Evaluation factors include ecotype variation and transplant size with regards to growth and survival. This information may help in determining optimum pot size in relation to plant survival after transplanting.

DURATION OF STUDY: 1993 through 1999

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: National Park Service - Joshua Tree National Park, RC&D

EXPERIMENTAL DESIGN:

METHODS AND MATERIALS:
Seed was collected by Joshua Tree National Monument personnel near the monument headquarters. Avra Valley seed collections were conducted by Tucson PMC personnel near the Tucson PMC's Avra Valley Advanced Evaluation site. Populations were collected from a minimum of 50+ plants within a 5 acre area. Seed harvested from each individual plant was kept separate so that equal amounts of seed could be blended to form the bulk population.

The transplant evaluation will be conducted using Joshua Tree and Avra Valley ecotypes and three pot sizes: a) two-gallon round pots, b) Citrus pots (171 in^3), c) Joshua Tree "Tall Pots" (848 in^3, 30" deep).

Seed sowing dates should be staggered to allow well developed transplants to be planted to the field at the same time. Tall pots require 2 years for proper root development. Therefore, the citrus and one-gallon pots should be sown 12-14 months after the tall pots.

The ecotype evaluation will compare the Avra Valley and Joshua Tree collections using only the citrus pot size. A split-split plot design with three replications will be used at the two locations. Treatments will be the three pot sizes and two ecotypes. Five plants per replication will be used. To maintain a workable number of plants, the Avra Valley ecotypes will be grown in one pot size (citrus pots).

The number of plants to be propagated: Joshua Tree ecotypes = 2 species x 3 replications x 2 sites x 5 plants/replication x 3 pot sizes = 180. This breaks down to 60 Tall Pots, 60 Citrus Pots, and 60 2-gallon pots. Avra Valley ecotypes = 2 species x 3 replications x 2 sites x 5 plants/replication x 1 pot size = 60 citrus pots.

A split-split design will be used for both the Joshua Tree planting site and the Avra Valley materials. The first analysis will compare variation due to pot size, at both locations, for only Joshua Tree plants. The second analysis will compare ecotype variation between Avra Valley plants and Joshua Tree plants for citrus pots only and at both locations.

TECHNOLOGY TRANSFER PRODUCTS: Paper, Technical Note

FOTG ACTIONS:

OTHER ACTIONS:
Develop information relative to the collection and processing of seed, propagation, and transplanting techniques for native species in the southwestern United States.

RESULTS:
1996
Desert saltbush height data was collected at both evaluation sites in 1996 to track growth rates for both ecotypes and the different container sizes (Fig's. 1 and 2). The Citrus Pot containers show a positive growth rate at both sites for both ecotypes. The Tall Pot and 2-gallon containers with the Joshua Tree National Park (JTNP) ecotype show a positive growth rate at the JTNP site but a negative growth rate at the Avra Valley evaluation site. This may be due to an adaptability or a transplant shock problem.

1998
Planting will be evaluated once a year for the Desert saltbush plantings. These evaluations were performed on June 4, 1997, and July 27, 1998 at the Avra Valley, AZ site. At Joshua Tree National Park evaluations were conducted in April, June, July, August of 1996 and then in June, 1997 and August, 1998. Creosote bush transplants were installed July, 1998 at Avra Valley and May, 1997 at Joshua Tree. Analysis of data was conducted, using SAS, for both species with data presented in tables one through ten. Differences between pot sizes were evident during the first year. However, with well established plants, excluding creosotebush at Avra Valley, there were no significant differences with regards to height after the first year. Indicating that citrus pots will perform as well as larger pots. With regards to ecotype, significant differences varied over time with the 1998 evaluations showing no differences in relation to height at either of the planting sites. Indicating that local ecotypes perform as well as none local ecotypes. Plant survival is presented in tables 11 and 12. Creosotebush survival data at Avra Valley was not included due to only one set of observations. Survival data will be analyzed and presented in the next technical report.

JOSHUA TREE NATIONAL PARK SITE

Table 1: Desert Saltbush / Height[1] (cm) Comparisons by Pot Size

Date	Citrus Pot (1)	2 Gallon Pot (2)	Tall Pot (3)
4/96	21.3a	23.7ab	27b
6/96	27.6a	28.4a	34.4b
7/96	25.1a	29.0a	35.5b
8/96	25.8a	28.1a	36.4b
6/97	29.0a	30.3a	39.4b
8/98	49.1a	52.4a	55.8a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 2: Desert Saltbush / Canopy[1] (cm) Comparisons by Pot Size

Date	Citrus Pot (1)	2 Gallon Pot (2)	Tall Pot (3)
4/96	17.6a	24.5b	24.0b
6/96	27.3a	31.9ab	35.4b
7/96	27.3a	31.9ab	35.4b
8/96	25.7a	31.6ab	34.0b
6/97	32.1a	33.6ab	40.2b
8/98	63.5a	73.8a	69.0a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 3: Desert Saltbush / Height[1] (cm) Comparisons by Ecotype

Date	Avra Ecotype	Joshua Tree Ecotype
4/96	29.2a	24.0b
6/96	34.1a	30.1a
7/96	36.6a	29.8a
8/96	38.2a	30.1b
6/97	34.6a	29.3b
8/98	53.0a	49.0a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 4: Creosotebush / Height[1] (cm) Comparisons by Pot Size

Date	Citrus Pot (1)	2 Gallon Pot (2)	Tall Pot (3)
6/97	16.2a	12.2a	43.1b
8/98	41.0a	36.6a	46.2a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 5: Creosotebush / Canopy[1] (cm) Comparisons by Pot Size

Date	Citrus Pot (1)	2 Gallon Pot (2)	Tall Pot (3)
6/97	18.6a	13.4a	31.9b
8/98	47.7a	30.0a	41.4a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 5: Creosotebush / Height[1] (cm) Comparisons by Ecotype

Date	Avra Ecotype	Joshua Tree Ecotype
6/97	14.4a	16.2a
8/98	31.6a	40.9a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 6: Creosotebush / Canopy [1] (cm) Comparisons by Ecotype

Date	Avra Ecotype	Joshua Tree Ecotype
6/97	17.6a	18.6a
8/98	31.5a	47.8b

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

AVRA VALLEY SITE

Table 7: Desert Saltbush / Height[1] (cm) Comparisons by Pot Size

Date	Citrus Pot (1)	2 Gallon Pot (2)	Tall Pot (3)
6/96	22.2a	23.2a	34.5b
11/96	27.2a	25.1a	37.9b
6/97	29.4a	24.6a	38.0b
7/98	39.0a	37.0a	43.8a
3/99	49.9a	43.2a	53.3a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 8: Desert Saltbush / Height [1] (cm) Comparisons by Ecotype

Date	Avra Ecotype	Joshua Tree Ecotype
6/96	25.0a	26.9a
11/96	30.2a	30.0a
6/97	34.0a	29.9a
7/98	46.4a	38.5a
3/99	56.8a	41.8b

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 9: Creosotebush / Height [1] (cm) Comparisons by Ecotype

Date	Avra Ecotype	Joshua Tree Ecotype
3/99	42.2a	40.6a

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 10: Creosotebush / Height[1] (cm) Comparisons by Pot Size

Date	Citrus Pot (1)	2 Gallon Pot (2)	Tall Pot (3)
3/99	41.2a	54.2b	72.4c

1 = within a row, means followed by the same letter are not significantly different at P≤0.05

Table 11: Desert Saltbush Survival at Joshua Tree National Park Site

Date	Citrus Pot (1)Avra Ecotype	Citrus Pot (1)Joshua Tree Ecotype	2 Gallon Pot (2)	Tall Pot (3)
4/96[1]	15	15	12	15
7/96[2]	15	15	12	15
8/98	13	14	9	15

1= number planted
2= number considered established
3= number considered surviving

Table 12: Desert Saltbush Survival at Avra Valley Site

Date	Citrus Pot (1)Avra Ecotype	Citrus Pot (1)Joshua Tree Ecotype	2 Gallon Pot (2)	Tall Pot (3)
4/96[1]	15	15	11	15
11/96[2]	15	14	11	15
3/99	15	12	10	15

1= number planted
2= number considered established
3= number considered surviving

Table 13: Creosotebush Survival at Joshua Tree National Park Site

Date	Citrus Pot (1)Avra Ecotype	Citrus Pot (1)Joshua Tree Ecotype	2 Gallon Pot (2)	Tall Pot (3)
6/97[1]	15	15	15	15
6/97[2]	15	15	14	15
8/98	10	13	8	14

1= number planted
2= number considered established
3= number considered surviving

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04C9801E

Sediment Reduction in the San Pedro River Through Installation of Erosion Control Practices on Grazing Land in the Watershed.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Cooperative work with field offices, other agencies, and private groups.

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:

PRIMARY: 638 WATER AND SEDIMENT CONTROL BASIN

SECONDARY: 550 RANGE SEEDING

TERTIARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Soil	Soil erosion from sheet and rill.
SECONDARY:	Plants	Plants management, other.

DESCRIPTION:
The purpose of this project is to improve surface water quality in the San Pedro River of southeastern Arizona by reducing sediment, a non-point source pollutant of 5,976 acres of grazing land with boundaries within one-half mile of the main river course between St. David and Tombstone. The project area is on the Running N Bar Ranch located in the San Pedro basin between St. David and Tombstone. The climate is arid, warm and temperate. The mean annual precipitation averages from 7 to 12 inches. The climate makes the area generally attractive as a tourist area and as a location for retirement communities. It is part of the fastest growing areas in the United States from a population standpoint. The project site is 5,976 acres within two pastures that had been over utilized over the past 100 years. The central portion of this pasture is a sandy loam upland range site on Dona Ana-Mojave complex soil type with production potential of 550 pounds of grass per acre. This soil type is surrounded by Monzingo-Ugyp complex soils that are limy, with moderate to severe potential for water erosion and support largely unpalatable brush species. Historically, the Dona Ana-Mojave soils producing grass were grazed until forage was completely depleted before animals moved into the brushland. Over time, the area became severely eroded by sheet, rill and gully erosion that deposits sediment into the San Pedro River two miles from the pasture boundary. Vegetation on the site now consists of mesquite, yucca and burroweed-dominated communities. Grass does not exist in sufficient quantity to provide a seed source for the rangeland to recover without additional practice application.

DURATION OF STUDY: 1998 through 2000

STUDY LEADER: Donna Vettleson, Mark Pater, Don Decker

LOCATION: Tombstone, Arizona

COOPERATORS: Donna Vettleson, USDA/NRCS; George Monzingo, San Pedro NRCD; Tucson Plant Materials Center; Leonard Lane, ARS;

METHODS AND MATERIALS:
This project will use a combination of three practices to restore this area of the watershed to healthy conditions and stop the area from contributing sediment to the San Pedro River. The Running N Bar Ranch will defer the entire pasture from grazing for two years and then will graze it as part of a management plan designed and monitored by NRCS. Nineteen earthen structures will be installed in eroded gullies at critical areas as determined by NRCS staff and installed by a contractor with compacted earth from materials available on the site. Spillways of each structure will be armored with rock that will have to be purchased and hauled in and placed by hand. In addition to structures, measures will be installed to address the problem of sheet and rill erosion and the lack of a grass seed source. Grass will be seeded in three contour bands across the sandy loam range site. The band closest to the river will be 500 feet wide and 7,500 feet long; the central band will be 1,000 feet wide and 5,000 feet long; the upper band will be 1,000 feet wide and 2,500 feet long. Each contour will be ripped to a depth of 18 inches and followed immediately with a broadcast seeding of native grasses on the disturbed ground. The roughness of the contour bands will stop sediment and allow infiltration of water to establish the grass stand. the established grass will have the same effect and will provide a seed source to revegetate the entire range site to grasses. All practices as well as the range condition and effectiveness of sediment control will be monitored by the rancher and assisting state and federal land management agencies. Monitoring methods will be range transects, photo and visual monitoring and direct sediment measurement and correlation with rainfall and other land management and technical agencies of the effectiveness of this type of grazing land restoration in highly impacted watersheds.

STATUS OF KNOWLEDGE:
The San Pedro River Basin of Southeastern Arizona has been identified by the Southeastern Arizona Governments Organization (SEAGO) Water Quality Management Plan as a river and contributing to sediment loading at Ashurst-Hayden Dam. These sediments have been found to contain boron, chlorides, sulfates, residual sodium carbonates and sodium absorption ratios (SAR) that present some local problems where it empties into the Gila River. The San Pedro watershed area adjoins the interstate Gila Watershed Project. In the context of the sediment that it carries to the Gila, the San Pedro has international and interstate impacts.

TECHNOLOGY TRANSFER PRODUCTS:
FOTG ACTIONS: Fact Sheet, Update Technical Guide, Plant Guide.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04C9802H

Non Point Source Pollution Control on Grazing Land Through the Use of Natural Materials Structures in a Subwatershed of the Gila River.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Cooperative work with field offices, other agencies, and private groups.

LAND USES: Rangeland, Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 587 STRUCTURE FOR WATER CONTROL

SECONDARY: 570 RUNOFF MANAGEMENT SYSTEM

TERTIARY: 550 RANGE SEEDING

RESOURCE	**CONSIDERATION/PROBLEM**	
PRIMARY:	Soil	Soil erosion from sheet and rill.
SECONDARY:	Water	Water quality, surface water contaminants suspended sediment

DESCRIPTION:
The purpose of this project is to improve water quality in the Gila River by reducing sediment, a non-point source pollutant off of grazing land in Whitlock Valley, a subwatershed located between Safford and Duncan, Arizona. The project site is on the Hackberry Ranch located between Duncan and Safford. The project partners are: the local Non-Point Source Advisory Group, Gila Valley Natural Resource Conservation District, Coronado Resource Conservation and Development Area, Natural Resources Conservation Service, Arizona State Land Department, Bureau of Land Management, and Hackberry Ranch. These partners with assistance from volunteer labor will put in a series of small sediment retention structures in the watershed. The objective of the structures is to retain sediment, reduce surface runoff rate allowing more vegetation to establish, increase duration of channel flow, improve groundwater recharge, enhance wildlife habitat, and provide discharge to the San Simon-Gila River system that has a significantly lower amount of turbidity. 319h funds will be used for some of the installation costs, project management and a portion of the information dissemination necessary to increase the use of this type of practice on other grazing land in the Gila River Watershed and other watersheds in Arizona.

DURATION OF STUDY: 1998 through 2005

STUDY LEADER: D. Vettleson, D. Fisher, M. Pater

LOCATION: Safford, Arizona

COOPERATORS: USDA-NRCS, Safford Field Office, Coronado RC&D, Tucson PMC; Norman "Pete" Brawley.

METHODS AND MATERIALS:
This project will install sediment retention structures on grazing land in the Whitlock Valley watershed, a tributary to the Gila River. These structures will illustrate the benefits to grazing land by increased vegetation resulting from slowing runoff. Sediment will be trapped behind structures reducing sediment load into the San Simon-Gila River system. This project will install sediment retention structures on grazing land in the Whitlock Valley watershed, a tributary to the Gila River. These structures will illustrate the benefits to grazing land by increased vegetation resulting from slowing runoff.

Sediment will be trapped behind structures reducing sediment load into the San Simon-Gila River System. Technical assistance to locate structures within washes, development of structure design and monitoring of rangeland condition will be provided by a Natural Resources Conservation Service Rangeland Management Specialist. Structures will be installed on two different range sites, one a limy upland with predominantly creosote cover, and the other is located in basalt hills with grass on Malpai. The type of structure installed will be based on available material, size and scope of site. Structures will be rock, rock and brush, or layered filters. Data collected will be a comparison of the effectiveness of each type of structure. Monitoring will include measurement of sediment trapped by the structures themselves and increase in ground cover as a result of slowing runoff. Structure installation in these two washes is expected to improve condition on approximately 300 acres of grazing land in southwestern New Mexico and southeastern Arizona drained by the Gila River and its tributaries above Coolidge Dam. The main land uses of the Gila River watershed in Arizona have been grazing, farming, recreation, and mining. The area has wide and comparatively flat valleys between narrow, rugged mountain ranges that tend generally northwest - southeast. The rivers have cut narrow canyons through the mountain ranges. The valleys below 7,000 feet are arid with average annual precipitation of 9.5 inches. Vegetation is primarily a desert scrub or desert grassland type. Most of the rain is received from thunderstorms in the summer, resulting in heavy runoff. Winter rains are generally gentle but can result in heavy runoff after the soil is saturated. Sampling by the Arizona Department of Environmental Quality (ADEQ) and others have shown water quality exceedences particularly in turbidity. In response to water quality concerns, the San Carlos/Safford/Duncan Management Zone was established in 1993. Their goal is to develop and implement non-point source management strategies in the upper Gila River drainage area. This group has developed a ten year plan that has identified runoff control on grazing lands as one of their priorities. Information and education will be a major component. A major priority is to teach people the benefits of this type of conservation work and supply them with the information necessary to implement these projects on their land. This aspect of the project will be implemented through the local Non-point Source Group and Conservation District as outlined in the Education Component. Monitoring will include measurement of sediment trapped by the structures themselves and increase in ground cover as a result of slowing runoff. Structure installation in these two washes is expected to improve condition on approximately 300 acres of grazing land and reduce erosion due to water by 95% on these acres and in the gullies. This project will work with State and Federal land management agencies as well as local citizens, units of government and volunteer groups. It will serve as a demonstration and has the potential to be duplicated in all watersheds across the state.

RESULTS

1998

Two pace frequency transects were established on the study site, within the treated drainage, to evaluate the effectiveness of the rock filters. This effectiveness can be defined by sediment accumulation behind the rock filters, vegetation becoming established within the drainage channel and the reduction of bare ground within the drainage channel. Information derived from this form of monitoring will provide a quantitative expression of the presence or absence of individuals of a species in a population. It is defined as the percentage of occurrence of a species in a series of samples of uniform size. Vegetative attributes that can be monitored with this method include frequency, basal cover and general cover categories including litter, and reproduction of key species.

Frequency data was collected using a 40 cm^2 frame, at a frequency of 50 frames per transect. Transect #1 is located near the top of the drainage, beginning just below a large concrete filter. Transect #2 is located further down the drainage, at the first rock filter south of the main trail that crosses the drainage. Data was collected from both transects in March and October of 1998. Data collected in March will be considered to be the baseline information. Data collected over time can be compared with the baseline information in order to try to define the effectiveness of the rock filters (Tables 1 & 2). To determine if a change between sampling periods is significant, a Chi Square contingency table analysis should be utilized. Frequency will be analyzed separately for each species. Chi Square analysis of variance may also be used to detect changes in cover classes between sampling periods.

Table 1. Frequency data collected in March and October 1998 - Transect #1

PLANT SPECIES	FREQUENCY (%) MARCH 1998	FREQUENCY (%) OCTOBER 1998
sideoats grama (BOCU)	14	22
slim tridens (TRMU)	2	14*
bush muhly (MUPO2)	2	
black grama (BOER4)		2
spider grass (ARTE3)		2
Rothrock grama (BORO2)		2
spice bush (AMFR)	6	12
short leaf baccharis (BABR)	2	2
snakeweed (GUSA2)	4	2
globemallow (SPAM2)		2
ragweed (AMBRO)		2
Bare Ground	2	8*
Gravel (0.25-3")	24	14*
Rock (3")	50	30*
Litter	8	18*
Live Vegetation (Basal)	2	2
Rock Filter	5	28

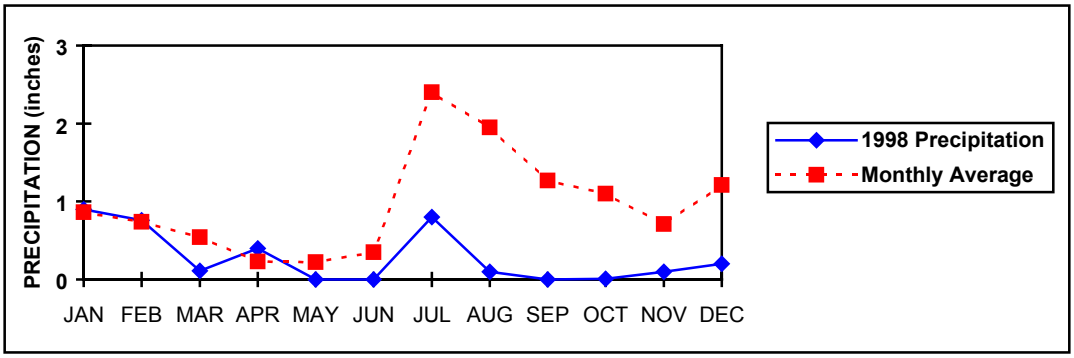
Table 2. Frequency data collected in March and October 1998 - Transect #2

PLANT SPECIES	FREQUENCY (%) MARCH 1998	FREQUENCY (%) OCTOBER 1998
sideoats grama (BOCU)	18	24
threeawn (ARIST)	16	20
slim tridens (TRMU)		12*
cane beardgrass (BOBA)	4	6
black grama (BOER4)		4
bush muhly (MUPO2)		2
pappusgrass (PAPPO)		2
annual panicgrass		2
snakeweed (GUSA2)	8	12
catclaw acacia (ACGR)	8	4
mesquite (PRGL2)		2
ragweed (AMBRO)		20*
chinchweed (POGR5)		4
Bare Ground	24	20
Gravel (0.25-3")	16	4*
Rock (3")	30	36
Litter	14	18
Live Vegetation (Basal)	2	3
Rock Filter	14	8

* Significantly different at the 0.05 level of significance.

During 1998 an increase in vegetation within the drainage area was observed. Significant increases were observed for slim tridens along both transects and for ragweed along Transect #2. Significant increases along Transect #1 were also noted for litter, significant decreases along this transect were noted for bare ground, gravel, and rock. Gravel frequencies along Transect #2 were also significantly lower. Rainfall on the Hackberry ranch is monitored on a monthly basis. This information will be used in conjunction with data collected from the frequency transects (Figure 1).

Figure 1. 1998 rainfall data - Hackberry Ranch



UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04F9601H

47 Ranch Field Planting / Final Report

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland

VEGETATIVE PRACTICES:	**PRIMARY:**	550	RANGE SEEDING

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
Approximately four sections of private rangeland below 47 Ranch headquarters on the south side of Davis Road were heavily overgrazed in the early 1900's. The area has been heavily invaded by western honey mesquite and there is little to no perennial grass cover. Approximately 500 acres were rootplowed on the contour and then broadcast seeded to Lehmanns lovegrass as the standard of comparison and approximately 5 acres were seeded to P.I. 216101 cane beardgrass, an accession in advanced testing at the Tucson PMC.

DURATION OF STUDY: 1995 through 1998

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: Douglas Field Office, Whitewater Draw NRCD, Howard Harshbarger-Ranch owner

METHODS AND MATERIALS:
This planting was installed in May 1995. The location is T21S, R24E, Sec 21 just south of Davis Road and approximately 1 mile east of the 47 Ranch headquarters. P.I. 216101 cane beardgrass was seeded on 5 acres at a rate of 2.5 lbs per acre and was compared against Lehmanns lovegrass (standard). Site preparation included rootplowing western honey mesquite on the contour and broadcast seeding afterwards. Evaluations will include percent stand and a visual estimate of percent grazing.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Update FOTG range seeding practice.

OTHER ACTIONS: Evaluations will provide documentation for release of P.I .216101 for commercial production.

RESULTS
1997
Planting was evaluated on November 26, 1997 by Ron Bemis and Bruce Munda. Cane beardgrass plants were not found in the designated seeding area. However, native stands of cane beardgrass were found in natural swales within the treatment area. The Lehmanns seeding is considered a success but the cane beardgrass was a failure. This species will continue to be available for reseeding practices.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04F9501H

George Morin Ranch / Final Report

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the U.S.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland

VEGETATIVE PRACTICES:	**PRIMARY:**	550	RANGE SEEDING

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
This field planting was installed on George Morin's ranch during the summer of 1996 to evaluate Arizona cottontop. Comparing the PMC's accession 9003705 to a commercial wild collection. The planting site in located at T23S, R26E, Sec 7. The site was brushed and then broadcast seeded at a rate of 3 PLS pounds per acre for both collections.

DURATION OF STUDY: 1996 through 1998

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: Douglas Field Office, Whitewater Draw NRCD, George Morin (owner)

METHODS AND MATERIALS:
The Tucson PMC provided 60 PLS pounds of Arizona cottontop, 9003705, to be compared with a commercial wild collection of cottontop. 9003705 is in advanced testing at the PMC. Seeding rate was 3 PLS pounds per acre and seed was broadcast seeded following a brushing operation. Twenty acres was seeded to 9003705 next to a control of 2 acres which was planted to commercial wild collection of Arizona cottontop. Evaluation factors are: percent stand, rainfall amounts and timing, planting date.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Update FOTG range planting practice.

OTHER ACTIONS: Information will help provide documentation for a cultivar release.

RESULTS
1997
Planting was evaluated on November 26, 1997 by Ron Bemis, Mr. Morin and Bruce Munda. Mr. Morin had pushed approximately 100 acres of mesquite and reseeded to substantial mixture of native and introduced grasses. A large number of cottontop plants were found within the seeded area. Frequency data was not collected. But, based on the number of cottontop plants found along with plains lovegrass, sideoats grama and spike dropseed I would say Mr. Morin's seeding was successful. I would rate the cottontop stand as fair.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04C9814Z

Phenotypic Plasticity in Populations of Arizona Cottontop

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland

VEGETATIVE PRACTICES:	**PRIMARY:**	550	RANGE SEEDING

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
Evaluate phenotypic plasticity exhibited by four populations of Arizona cottontop in response to variable moisture.

DURATION OF STUDY: 1997 through 2000

STUDY LEADER: Dr. Steven Smith

LOCATION: Arizona PMC

COOPERATORS: Tucson PMC, University of Arizona

METHODS AND MATERIALS:
Vegetative propagules from six genotypes from each of the four populations were transplanted into separate irrigation basins in fall 1997. The three moisture regimes (irrigation in early spring-summer, supplemental summer irrigation and unirrigated) were not imposed on these basins in 1998 because of excess summer and spring precipitation and mortality among certain genotypes. Caryopses representing half-sib families have been harvested from individual plants and these will be used in studies to evaluate genetic variation for germination and establishment characteristics in the greenhouse in 1999. We plan to impose the irrigation treatments in the field plots in 1999 and evaluate plant performance as originally intended.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS:

OTHER ACTIONS: Information may provide documentation for release of Arizona cottontop.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04C9515Z

Maintenance of Sideoats Grama Plants for Use in Research Related to Defoliation Tolerance.

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland

VEGETATIVE PRACTICES: **PRIMARY:** 550 RANGE SEEDING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
We have on-campus research projects dealing with the response to defoliation in populations of sideoats grama from southern Arizona with different grazing histories.

DURATION OF STUDY: 1995 through 2000

STUDY LEADER: Dr. Steven Smith

LOCATION: Arizona PMC

COOPERATORS: Tucson PMC, University of Arizona

METHODS AND MATERIALS:
A nursery established at the Tucson PMC in 1995 has served as a backup source of propagules for use in this research. This nursery is no longer needed and will be abandoned in fall 1998.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS:

OTHER ACTIONS: Information may provide documentation for release of Arizona cottontop.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
STUDY PLAN

STUDY NUMBER: 04F9407H

Riggs Flat Field Planting-Final Report

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Advanced Evaluation

LAND USES: Rangeland & Wildlife

VEGETATIVE PRACTICES: **PRIMARY:** 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants management, pests (brush, weeds, insects, diseases.)
SECONDARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
The goals of this field planting are: promote the use of improved conservation plants for range seeding, evaluate the adaptation of experimental plant lines for use in northern Arizona, and obtain data to update FOTG. Riggs flat is located on the Kaibab Paiute Indian Reservation approximately 6 miles west of Fredonia, Arizona and is immediately adjacent to highway 389. Elevation is 4600 feet and is within Major Land Resource Area 35-4. Annual precipitation is 9.4 inches with 27% received during July through October and 42% received from January through May. Soil is classified as Jocity clay loam, deep and well drained, and the range site is a clay loam bottom. This site was first planted in 1986 and then replanted in 1994. The 1986 planting was a complete failure due to lack of moisture and competition from weeds, primarily cheatgrass. The site was replanted in November, 1994 using 17 grass and 4 shrub species. Evaluations will be conducted through 2000.

DURATION OF STUDY: 1994 through 2000

STUDY LEADER: Fredonia Field Office and Tucson PMC

LOCATION: ARIZONA PMC

COOPERATORS: Fredonia Field Office and the Kaibab-Paiute Tribe

EXPERIMENTAL DESIGN: Randomized Complete Block Design

METHODS AND MATERIALS:
The 1986 planting involved 16 species. These were: 'Ephraim' crested wheatgrass, 'Secar' bluebunch wheatgrass, 9002950 bluebunch wheatgrass, 478838 fourwing saltbush, 'Niner' sideoats grama, 'Hachita' blue grama, 421036 yellow bluestem, 'Ganada' yellow bluestem, 478840 winterfat, 'Paiute' orchardgrass, 478831 basin wildrye, 'Magnar' basin wildrye, 'Viva' galleta grass, 9035287 Indian ricegrass, 'Salado' alkali sacaton and 9003963 sand dropseed. The 1994 planting incorporated 21 species in a randomized complete block design with three replications. Each replication is 200 feet long by 6 feet wide with a 10 foot unseeded area separating each block. Sixteen of the twenty-one species were seeded on November 15 with the remaining species seeded by the field office on 12/3/94 and the forage Kochia seeded on 2/24/95. A Kincaid plot drill was used to seed 12 of 16 grass species. The remaining four species were hand broadcasted and then raked to incorporate the seed into the soil surface, except winterfat. Winterfat seed was broadcast

and left on top of the soil surface. All drill seeded species were planted to a depth of 0.5 inches except for Indian ricegrass which was planted to a depth of 1.5 inches. See attachment one for listing of species, planting rates and depth.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Update Range Seeding Specifications

OTHER ACTIONS: If appropriate, prepare or update plant guides

1995 RESULTS

This field trial was designed to evaluate a wide range of native and introduced grasses and shrubs for use in conservation planning. Thirteen species were planted on November 15, 1994 with the Tucson PMC plot drill. Seven others were planted on December 2, 1994 using either the Fredonia NRCD range drill or broadcasting. The final species, 'Immigrant' forage kochia, was broadcast seeded on February 2, 1995. The area received excellent precipitation, 16.22 inches, from October 1994 through September 1995. With 13.13 inches received from October 1994 through May 1995. This moisture, combined with unusually warm winter temperatures, allowed the cool-season annuals to germinate and establish earlier and heavier than normal. Cheatgrass (*Bromus tectorum*), filaree (*Erodium cicutarium*), and blue mustard (*Chorispora tenella*) have all provided heavy competition for the seeded species, as well as emergence evaluations difficult. Late spring and summer moisture germinated a lot of Russian thistle (Salsola kali) as well. The field trial was evaluated 5 times during this first growing season - March 8, March 28, April 26, May 30 and September 14. 'Hycrest 2' crested wheatgrass came up quicker than any of the other cool-season species planted. by March 8 there were fairly solid rows of young seedlings. It appeared to be very vigorous at that early stage. By March 28 the plants were in the 3-4 leaf stage and by May 30 were well established. On September 14 the rows were visible through the mat of dead annuals. This species appears to have had a very successful first year. 'Douglas broadleaf' crested wheatgrass also had many seedlings by March 8 and appears to be doing quite well based on subsequent evaluations. It has not established as uniformly as 'Hycrest 2' but must be considered quite successful to date. 'Hycrest' crested wheatgrass, 'Ephraim' crested wheatgrass and 'Vavilov' Siberian wheatgrass have followed a similar pattern. 'Mankota' and 'Bozoisky' Russian wildrye have had a patchy first year establishment. Established plants are healthy and vigorous but there are lots of bare ground in the seeded area. Both varieties were visible by March 8. There were a few 'P-27' Siberian wheatgrass seedlings found in March, but by May 30 they were difficult to find. The few seedlings found were small and exhibited poor vigor. By September 14 no seedlings could be found. On March 8 the '9052861 and 478833 Indian ricegrass were just beginning to emerge, while the '9035287' and 'Paloma' could not be found. On March 28 all four varieties had a few plants up. By April 26 the seedlings were in the 2-3 leaf stage, and did not look healthy. At the end of May there were only a few seedlings found of each variety, and all looked poor. In September no seedlings could be found. A few seedlings could be found of both 'Pamirian' and common winterfat on March 28, but none have been found since. Several 'Immigrant' forage kochia plants were observed in each replication during the September evaluation. They are 2-3 inches tall and appear to be healthy. There have been no observations of any galleta, blue grama, fourwing saltbush, or alkali sacaton. There is quite a lot of pocket gopher and ant activity within the plot. Most of the cool-season grasses have been grazed, some severely. This grazing does not appear to be by rabbits as there are no pellets within the area. September rains have started some of the cool-season annuals, and many of the cool-season species show new late-summer growth.

1996 RESULTS

There is no sign of the warm-season grasses like blue grama and galleta. Indian ricegrass had some germination in 1995 but never looked healthy. None can be found this spring. The few winterfat seedlings observed last year have not survived. No fourwing saltbush plants have been seen yet. Several cool-season grasses, including 'Ephraim' and 'Hycrest' crested wheatgrasses and two varieties of Russian wildrye, can be found. There are only a few plants and they are small, dry and hard to find. 'Vavilov' Siberian wheatgrass has done very well so far. The plants are numerous enough that the drill rows can be seen through the cover of dead annuals. So far this species looks very promising for this type of tough site. 'Hycrest 2' crested wheatgrass has also done very well for this tough site. This is not actually a new variety, but a pure type of the original 'Hycrest' variety which was released in 1985. Crested wheatgrass cross-fertilizes quite readily if grown too closely together, and over the years the characteristics for which 'Hycrest' was originally selected for - seedling vigor, quick establishment, greater productivity- have been watered down in the seed which is commercially available.

1998 RESULTS

The Riggs Flat planting received excellent spring moisture with several species exhibiting outstanding growth. Twenty-one species, replicated three times, where planted in November of 1994. There were five clear winners in this trial; 'Hycrest 2' crested wheatgrass, 'Vavilov' Siberian wheatgrass, Standard crested wheatgrass, 'Ephraim' crested wheatgrass and 'Hycrest' crested wheatgrass. A few scattered plants of 'Mankota' and Bozoisky-Select Russian wildrye were found but considered insignificant with regards to clipping or taking plant counts. Clipping measurements where made on the Hycrest 2 and Vavilov wheatgrasses and plant densities were conducted on five species as shown below.

SPECIES	Plants/9.6ft^2	Plants/Ac.	Fresh Wgt. (lbs/ac)	Dry Wgt. (lbs/ac)
Hycrest 2	2.65	12,024	1388	622
Vavilov	1.6	7,260	567	278
Crested (Std.)	0.8	3,630	not measured	not measured
Ephraim	0.67	3,040	" "	" "
Hycrest	0.1	454	" "	" "

Winter annual competition, cheatgrass, has been considerable throughout the life of this planting. Making the results of this planting all the more impressive and useful.

The following is a general summary on the germination and establishment of the various species at Riggs Flat. This information was compiled by Art Meen from November, 1994 through September, 1997.

No Germination Observed:
'Hachita' blue grama, 'Willis' blue grama, 'Alma' blue grama, alkali sacaton, 'Viva' galleta, and fourwing saltbush.

Germination But No Establishment:
'P-27' Siberian wheatgrass, 9052861 Indian ricegrass, 478833 Indian ricegrass, 9035287 Indian Ricegrass, 'Paloma' Indian ricegrass, Pamirian winterfat, common winterfat, forage kochia.

Excellent Establishment:
'Vavilov' Siberian wheatgrass, 'Hycrest 2' crested wheatgrass.

Moderate Establishment:
'Ephraim' crested wheatgrass, 'Hycrest' wheatgrass, Standard crested wheatgrass.

Marginal Establishment:
'Mankota' Russian wildrye, Bozoisky-Select Russian Wildrye.

A large scale planting will be installed at Riggs Flat this November using Vavilov and Hycrest 2.

1994 RIGGS FLAT FIELD PLANTING
ATTACHMENT ONE
STUDY/FIELD PLANTING No. 04F9407H

No.	COMMON NAME	SCIENTIFIC NAME	METHOD SEEDED	DEPTH	DATE
1	Hycrest 2 crested wheatgrass	Agropyron cristatum X desertorum	plot drill	0.5”	11/14/1994
2	Douglas Broadleaf crested wheatgrass	Agropyron cristatum	plot drill	0.5”	“
3	Vavilov Siberian wheatgrass	Agropyron fragile ssp. sibiricum	plot drill	0.5”	“
4	Hachita blue grama	Bouteloua gracilis	plot drill	0.5”	“
5	Willis blue grama	Bouteloua gracilis	plot drill	0.5”	“
6	Alma blue grama	“ “	“ “	0.5”	“
7	9052861 Indian ricegrass	Oryzopsis hymenoides	“ “	1.5”	“
8	Mankota Russian wildrye	Psathyrostachys juncea	“ “	0.5”	“
9	9035287 Indian ricegrass	Oryzopsis hymenoides	“ “	1.5”	“
10	Ephraim crested wheatgrass	Agropyron cristatum	“ “	0.5”	“
11	478833 Indian ricegrass	Oryzopsis hymenoides	“ “	1.5”	“
12	Pamirian winterfat	Ceratoides latens	hand broadcasted	surface	“
13	Bozoisky-Select Russian wildrye	Psathyrostachys juncea	plot drill	0.5”	“
14	P-27 Siberian wheatgrass	Agropyron fragile ssp. sibiricum	NRCD range drill	0.5”	12/05/1994
15	Hycrest crested wheatgrass	Agropyron cristatum X desertorum	“ “ “	0.5”	12/05/1994
16	Common winterfat	Krascheninnikovia lanata	hand broadcasted	surface	12/01/1994
17	Paloma ricegrass	Oryzopsis hymenoides	NRCD range drill	0.5”	12/05/1994
18	Alkali sacaton	Sporobolus airoides	hand broadcasted	surface	12/01/1994
19	Viva galleta	Hilaria jamesii	hand broadcasted	0.25”	12/05/1994
20	Fourwing saltbush	Atriplex canescens	NRCD range drill	0.5”	12/05/1994
21	Immigrant forage kochia	Kochia prostrata	hand broadcasted	surface	02/24/1995

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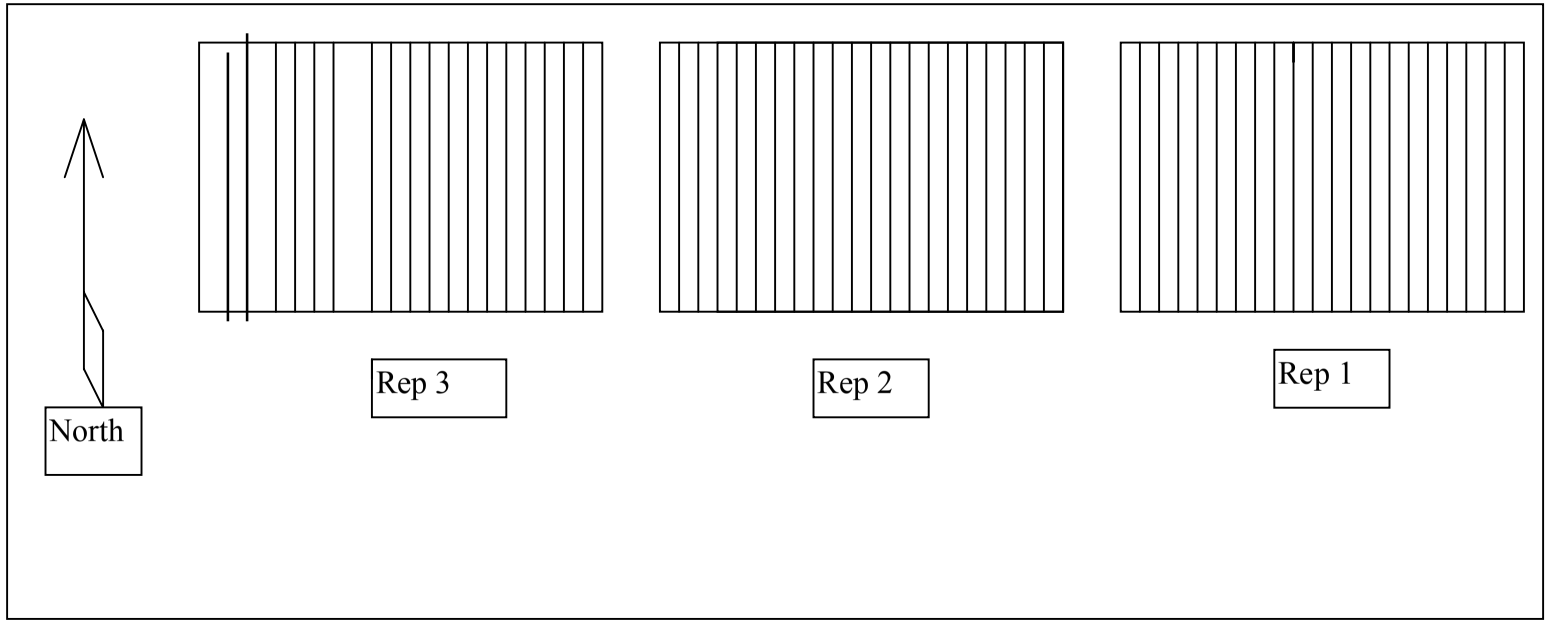
1994 Riggs Flat Field Planting
Plan Map



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STUDY NUMBER: 04F9809H

Riggs Flat Field Planting #2

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Rangeland & Wildlife

VEGETATIVE PRACTICES:
PRIMARY: 550 RANGE SEEDING

SECONDARY: 645 WILDLIFE UPLAND HABITAT MANAGEMENT

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Plants	Plants suitability, plants are not well adapted to site.
SECONDARY:	Soil	Soil erosion from sheet and rill.

DESCRIPTION:
The goals of this field planting are: promote the use of improved conservation plants for range seeding, evaluate the adaptation of experimental plant lines for use in northern Arizona, and obtain data to update FOTG. Riggs flat is located on the Kaibab Paiute Indian Reservation approximately 6 miles west of Fredonia, Arizona and is immediately adjacent to highway 389. Elevation is 4600 feet and is within Major Land Resource Area 35-4. Annual precipitation is 9.4 inches with 27% received during July through October and 42% received from January through May. Soil is classified as Jocity clay loam, deep and well drained, and the range site is a clay loam bottom. This site was first planted in 1986 and then replanted in 1994. The 1986 planting was a complete failure due to lack of moisture and competition from weeds, primarily cheatgrass. The site was replanted in November, 1994 using 17 grass and 4 shrub species. Based on the results of the 1994 planting we have installed this larger planting using HycrestII and Vavilov Siberian wheatgrass. We will be evaluating their establishment with regards to competition with winter annuals and imposing two treatments (disking & herbicides). Disking and herbicide applications will be evaluated with regards to improvement, if any, with stand establishment of the two seeded species.

DURATION OF STUDY: 1998 through 2002

STUDY LEADER: Fredonia Field Office and Tucson PMC

LOCATION: Arizona PMC

COOPERATORS: Fredonia Field Office and the Kaibab-Paiute Tribe

EXPERIMENTAL DESIGN: Split-Split plot

TREATMENT 1 TITLE:	Species
TREATMENT 1 DESCRIPTION:	HycrestII and Vavilov
TREATMENT 2 TITLE:	Disking
TREATMENT 3 TITLE:	Herbicide
TREATMENT 3 DESCRIPTION:	Roundup

METHODS AND MATERIALS:
Species were sown at a rate of 6.5 lbs/A using the PMC plot drill. Seeds were planted to a depth of 0.5 inches. Trial is a split-split design with four replications. Disking is the subplot and the herbicide treatment is the split-split plot. Disking will be conducted prior to seeding to control already growing annuals and the herbicide treatment will be applied in early spring. Trial size is 160 feet by 500 feet with main plots 40 feet by 125 feet. This trial is located in the original trial site where the first and second plantings were sown.

STATUS OF KNOWLEDGE:
Based on the success of the 1994 planting we chose HycrestII and Vavilov for a larger scale planting. To control winter annuals the disking and herbicide treatments were included to evaluate their effectiveness for winter annual control.

TECHNOLOGY TRANSFER PRODUCTS: Paper, presentation, tech not

FOTG ACTIONS: Update Range Seeding Specifications

OTHER ACTIONS: If appropriate, prepare or update plant guides.

RESULTS

1998
Actually, no work was conducted in 1998 except for developing the plan and acquiring the seed. Scheduled 1998 plantings were postponed due to weather. The planting was installed February 2, 1999. Herbicide applications were conducted mid-February, 1999. Below is the planting plan map.

STUDY NUMBER: 04C9707Z

Terracottem Soil Amendment Trial

PROJECT NUMBER: RN1.7

Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Rangeland Cropland

VEGETATIVE PRACTICES: **PRIMARY:** 550 RANGE SEEDING

SECONDARY: 342 CRITICAL AREA PLANTING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants condition, health and vigor
SEC'DARY	Soil	Soil condition; tilth, crusting, water infiltration, organic

DESCRIPTION:
This was a cooperative project with the BLM (Beau McClure) and Dr. Van Cotthem, Professor at the University of Ghent, Belgium. Dr. Van Cotthem has developed a product called terracottem, a soil amendment, which he has had success with in arid land revegetation. The product enhances water infiltration, provides basic nutrients, and stores water for future plant use--like a super-slurper. The purpose of these trails was to evaluate how it enhances plant growth and production of several vegetable species in a greenhouse setting, as a soil amendment for a critical area seeding along the San Pedro River, field demonstration planting, and as a soil amendment for potted transplants at the Six-Mile Flat AEP in Nevada. The project started in December 1996 with the greenhouse trials and plantings at San Pedro and finished in 1998 with a final evaluation of transplants at the Six-Mile Flat site.

DURATION OF STUDY: 1996 through 1998

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: BLM, Dr. Van Cotthem, Caliente FO, Tucson PMC

EXPERIMENTAL DESIGN:

METHODS AND MATERIALS:
The greenhouse experiment consisted of eight vegetable. Seeds were initially planted in "supercell" containers, with the appropriate amount of terracottem and native soil on 12/11/96. Pots were placed under a mist system which irrigated the pots for 10 seconds every 20 minutes for 8 hours a day. After germination and sufficient plant growth (one month) plants were moved to one-gallon pots, again using a mixture of native soil and approximately on handful of terracottem per pot. Plants were moved to the lathhouse on April 1, 1996. The field demonstration was installed in field 2 border 5,6 & 7. We evaluated three different application rates with the applications applied in 6 foot bands across the with of the border. Rates were 0.6, 1.4, and 3.6 kg/m^2. Terracottem was applied using a drop spreader and was incorporated into the soil with a spike tooth harrow. Seco barley was planted on 2/11/97 at a sowing rate of 89.6 kg/hectare. Irrigation was applied on 2/12/97 and 4/2/97. Each irrigation applied 11.9 cm of water for a total

application of 23.8 centimeters. Field size was approximately 0.2 hectares. Six-Mile Flat ecotype trail: three species and two ecotypes/cultivars per specie were used in the terracottem transplant trial. Half of the following species had an equivalent of 7kg of terracottem per cubic meter of soil added to the potting mix: Vavilov and P-27 Siberian wheatgrass, Nezpar and Paloma Indian ricegrass, and Menodora spinosa (9064062 & 9064056). Plants were grown in Deepots (10 inches deep with a volume of 40 cubic inches). Transplants were planted in existing plots, at Six-Mile Flat, 3 feet apart within the row and 2.5 feet apart between rows. Plants were mudded in using holes 1 foot deep. Plant ages varied from 4 months for the ricegrass and wheatgrass to 2.5 years for the spiny menodora.

STATUS OF KNOWLEDGE:

LITERATURE CITED:

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: none
OTHER ACTIONS: technical note, article

RESULTS
1998
Greenhouse demonstration: cucumbers and lettuce emerged first on 12/13 (3 days after planting) followed by tomatoes (7 dap), cantaloupe (9 dap), both peppers (14 dap), and parsley (17 dap). In general, treated pots had better stands and higher vigor with terracottem. Plant counts were conducted on 1/8/97 with cucumber at 13 w/TC and 4 wo/TC, tomatoes at 14 w/TC or wo/TC, watermelon at 10 w/TC and 5 wo/TC, cantaloupe at 12 w/TC and 8 wo/TC, parsley 6 w/TC and 11 wo/TC, pepper 9 w/TC and 7 wo/TC, lettuce 14 for both treatments, and CA-pepper 10 w/TC and 12 wo/TC. The native soil was not the best potting media for this trial due to soil cracking and allowing water to drain down the sides of the pot. The field demonstration was very disappointing with the barley showing no response to the terracottem for all three application rates. The transplant ecotype trial at Six-Mile Flat had similar results with most plants surviving better without terracottem. However, plant survival was extremely poor for all species no matter the treatment. The spiny menodora did have more plants surviving (1& 4 vs. 0 & 1) for the two ecotypes planted. The Siberian wheatgrass (Vavilov and P27) and Indian ricegrass (Nezpar & Paloma) had better survival without Terracottem, 8 vs. 1, 6 vs2, 11 vs. 7, and 14 vs. 13, respectively. In general, I believe that the terracottem has potential for potted plants (houseplants, garden setting, etc.) but it did not show any evidence of enhancing plant survival or performance in a field setting.

STUDY NUMBER: 04F9806Z

Sells Demonstration Garden

PROJECT NUMBER: RN1.7
Improving the production and soil protection of rangeland in the arid, semi-arid and deserts of the US.

STUDY TYPE: Cooperative work with field offices, other agencies, and private groups.

LAND USES: Rangeland Urban

VEGETATIVE PRACTICES: **PRIMARY:** 550 RANGE SEEDING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants management; establishment, growth, and harvest**.**
SEC'DARY:	Plants	Plants suitability, other.

DESCRIPTION:
This demonstration garden consists of 18 species (2 forbs, 9 grasses, and 7 shrubs) which are indigenous to the rangelands on the Tohono O'odham Nation. Ten to twenty plants were transplanted for each species in rows. A drip irrigation system was installed to ensure plant establishment and growth. The purpose of this planting is two-fold: first to provide an area to show students and ranchers what various plants look like and second to show local basket weavers that plants used in basket weaving could be grown locally. Many of the materials (yucca and beargrass) are hard to find and typically, sources are quite distant from the Tohono O'odham Nation. Plants were grown at the Tucson PMC with site location and installation conducted by local representatives, field office and PMC staff. Local students are developing the necessary signs for the plot and individual species.

DURATION OF STUDY: 1998 through 2002

STUDY LEADER: Bruce Munda

LOCATION: Sells Livestock Complex

COOPERATORS: Sells Field Office, Tohono O'odham Nation

EXPERIMENTAL DESIGN:

METHODS AND MATERIALS:
Eighteen species were transplanted on March 20, 1998 at the Sells Livestock Complex. Forb species include; Desert globemallow and Desert marigold. Grasses include: Cane beardgrass, Pima pappusgrass, Arizona cottontop, Curly mesquite, Rothrock grama, Spike dropseed, Purple threeawn, Tobosa, and Bush muhly. Shrubs include: False mesquite, Rough menodora, Fourwing saltbush, Jojoba, Yucca, Desert saltbush, and Beargrass. Twenty plants were planted for the forbs, grasses, and rough menodora. Ten plants were planted for the remainder of the shrubs. All materials were propagated from seed.

STATUS OF KNOWLEDGE:

LITERATURE CITED:

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: None

OTHER ACTIONS: Popular article

RESULTS
1998
Planting was installed on March 20, 1998. Plants were initially irrigated once a weed for approximately 1-2 hours. Summer rains were excellent and the plants grew very well. In July the irrigation was turned off with subsequent irrigation's applied on an as-needed basis. On July 9, 1998 the planting was evaluated for survival and plant performance. The following species had 100% survival: Desert globemallow, Cane beardgrass, Pima pappusgrass, Purple threeawn, Tobosa, False mesquite, fourwing saltbush, Jojoba, Yucca, and Desert saltbush. Desert marigold was 16 of 20 (80%), Spike dropseed was 19/20 (95%), Bush muhly was 14/20 (70%), Menodora was 18/20 (90%), and beargrass was 9/10 (90%). Signs for each species and a project sign are being developed by the Art class at the local school and should be ready for installation in 1999. The plot is large enough to accommodate additional transplants and/or a seeding area (north side). This area will be sown to a wildflower mix in November 1998.

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Sells Livestock Complex Demonstration Garden
Plan Map
Installed March 20, 1998

North

Future planting area (seeding trial)	
SHRUBS	
Row 18: Beargrass (*Nolina microcarpa*)	10 plants
Row 17: Desert saltbush (*Atriplex polycarpa*)	10 plants
Row 16: Yucca (*Yucca elata*)	10 plants
Row 15: Jojoba (*Simmondsia chinensis*)	10 plants
Row 14: Fourwing saltbush (*Atriplex canescens*)	10 plants
Row 13: Rough menodora (*Menodora scabra*)	20 plants
Row 12: False mesquite (*Calliandra eriophylla*)	10 plants
GRASSES	
Row 11: Bush muhly (*Muhlenbergia porteri*)	20 plants
Row 10: Tobosa (*Pleuraphis mutica*/*Hilaria mutica*)	20 plants
Row 9: Purple threeawn (*Aristida purpurea*)	20 plants
Row 8: Spike dropseed (*Sporobolus contractus*)	20 plants
Row 7: Rothrock grama (*Bouteloua rothrockii*)	20 plants
Row 6: Curly mesquite (*Pleuraphis belangeri*/*Hilaria belangeri*)	20 plants
Row 5: Arizona cottontop (*Digitaria Californica*)	20 plants
Row 4: Pima pappusgrass (*Pappophorum vaginatum*)	20 plants
Row 3: Cane beardgrass (*Bothriochloa barbinodis*)	20 plants
FORBS	
Row 2: Desert globemallow (*Sphaeralcea ambigua*)	20 plants
Row 1: Desert marigold (*Baileya multiradiata*)	20 plants

Valve box

Valve Box: Two valves--North valve is for future plantings (seedings in the north 1/3 of the plot). South valve is for the main planting area (transplants which are irrigated with drip emitters)

Main line is a 3/4" PVC line coming from the hose bib near the shop. There is a shut off valve at the hose bib to cut water to the garden.

PROJECT: ML1.2

PROJECT TITLE: **Improve erosion control and the quality of water leaving mined land and other disturbed sites in the western US.**

PROBLEM STATEMENT:
Current information on technology and plant materials is needed to assist customers in the rehabilitation of mined lands in the arid areas of the southwestern United States.

LAND RESOURCE REGIONS: I Southwestern Plateaus and Plains Range and Cotton Region
J Southwestern Prairies Cotton and Forage Region

MLRA: 29, 30, 40, 41

LAND USES: Mined lands, Rangeland

VEGETATIVE PRACTICES:

PRIMARY:	342	CRITICAL AREA PLANTING
SECONDARY:	550	RANGE SEEDING
TERTIARY:	645	WILDLIFE UPLAND HABITAT MANAGEMENT

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Water	Water quality, surface water contaminants suspended sediment
SECONDARY:	Soil	Soil erosion from sheet and rill.

SCOPE/DESCRIPTION:
Develop native plants and technology to effectively implement the NRCS Critical Area Planting practice in areas of MLRA 30 and 40 with less than 7 inch annual rainfall and where mine spoil is highly acidic. When applied, the Critical Area practice will: (1) Protect air quality by reduction of wind induced soil erosion, (2) Protect adjacent surface water resources by reduced water induced soil erosion, (3) Provide food and cover for wildlife, and (4) Provide plant resources for other economic uses, i.e. grazing.

OBJECTIVES:
Identified needs include: (1) Salvaging and establishment technology for Mojave desert conditions, (2) Identify acid pH tolerant plants for hot desert areas, (3) Develop management and maintenance methods for rehabilitated sites, (4) Define rehabilitation success for bond release (in Nevada), (5) Improve interagency efforts. Proposed actions include: (1) Develop funding sources to initiate on-center screening of plant material for use in acid tailing and other mined lands within arid environments, (2) Develop funding sources to evaluate and demonstrate rehabilitation requirements in arid environments, (3) Develop and maintain interagency relationships that impact mineland rehabilitation technology, i.e. ADEQ and their development of Best Management Practices for mineland rehabilitation, (4) Assist in developing a publication for use by field office customers that summarizes the current state of knowledge and recommended practices in arid areas.

STATUS OF KNOWLEDGE:
The Tucson PMC has, in the past, worked with various agencies and companies to develop information on reclamation of mined lands in the arid southwestern United States. Refer to past Tucson PMC annual technical reports for more information.

PLANNED COORDINATION:

Bureau of Reclamation, Cyprus, Phelps-Dodge, BHP, Tohono O'Odham Nation, Navajo Nation, Arizona NRCS Field Offices.

COOPERATORS: Tucson Plant Materials Center, NRCS Field Offices.

PROJECT LEADER: Tucson Plant Materials Center

APPROVED BY PMC STATE CONSERVATIONIST ADVISORY COMMITTEE:
AZPMC High active

LITERATURE CITED:
Tucson Plant Materials Center Annual Technical Reports, Tucson PMC Long Range Plan - 1994-2000.

STUDIES:
TUCSON, ARIZONA PLANT MATERIALS CENTER
04A9406D START: 1994 END: 2000
Cyprus-Tohono Mine Revegetation Trials (Reimbursable Project).

STUDY NUMBER: 04A9406D

Cyprus-Tohono Mine Revegetation Trials

PROJECT NUMBER: ML1.2

Improve erosion control and the quality of water leaving mined land and other disturbed sites in the western US.

STUDY TYPE: Advanced Evaluation

LAND USES: Mined lands, Rangeland

VEGETATIVE PRACTICES:

PRIMARY:	544	LAND RECONSTRUCTION, CURRENTLY MINED LAND
SECONDARY:	342	CRITICAL AREA PLANTING
TERTIARY:	550	RANGE SEEDING

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Soil	Soil condition, contaminants; excess chemical content.
SECONDARY:	Plants	Plants management; establishment, growth, and harvest.

DESCRIPTION:
The Cyprus-Tohono Mine is located in the Phoenix Desert Shrub, Major Land Resource Area 40-2, between 1,800-2,252 feet in elevation. The mine is located approximately 32 miles southwest of Casa Grande, Arizona on Highway 15 on the southwestern side of the Slate Mountains.

The objectives of this project are to conduct trials and evaluate methods for revegetating overburden and mine-processed material using native plant materials. The information acquired from these trials will provide Cyprus-Tohono Corporation with a prescription for large-scale revegetation, in accordance with agreements made with the Tohono O'Odham Nation. Information gained from this project may also aid in improving conservation practices elsewhere in the southwestern U.S. The primary goal for revegetating the overburden and mine processed material is to stabilize the slopes to prevent erosion and to blend the overburden piles with the surrounding, undisturbed slopes.

The use of native plant materials will eventually promote the utilization of the overburden slopes as territorial and forage locations for native wildlife species. Animals thought to directly benefit from revegetation include mule deer, javalina, Gambel's quail, desert cottontail, and various reptiles and arthropods.

The objectives of this project are also designed to meet the concerns of North Komelik Village and the Sif Oidak Grazing District, in relation to improving the aesthetic appearance of the mine as viewed from North Komelik Village and Highway 15. Revegetation of slopes facing North Komelik Village is the desired goal for Cyprus-Tohono Corporation.

The soils and bedrock were analyzed and found to be calcareous. Soils in the disturbed areas will be affected by the removal of vegetation, excavation and the storage of topsoil. The potential for erosion is high on the non-vegetated 4:1 slopes. Some evidence of rill erosion is apparent on newly created and

exposed slopes. Potential for gully formation is great once the summer rains begin. Sheet and rill erosion are also a concern during medium to heavy precipitation events. Wind and water erosion can be evaluated using RWEQ (Revised Wind Erosion Equation) and RUSLE (Revised Universal Soil Loss Equation). There is no evidence of compacted layers that will restrict water or root penetration. No evidence of crusting has been observed. No excess of natural or applied chemicals or elements such as boron, selenium, or other heavy metals have been found. The potential for surface water quality impact is low due to the ephemeral nature of surface water at the site. There are no aquatic organisms observed near the site. Groundwater quality is monitored by the mine on a recurring basis. The air quality at this site may be affected by the activities at the mine. Strong winds are common and airborne particulates can obstruct vision. The planting site does not significantly contribute to air quality problems due to its small size and low amount of fine particulate matter in the soil substrate.

Dominant plants currently surrounding the site include: littleleaf palo verde, ironwood, triangle-leaf bursage, white ratany, creosote bush, ocotillo, and saguaro and hedgehog cacti. Plant species needed to stabilize the site must be native to the Sonoran Desert ecosystem with emphasis on species occurring in the USDA NRCS Range Site Description for MLRA 40-2. Plant species may include triangle-leaf bursage, creosote bush, littleleaf palo verde, purple threeawn, brittlebush, white ratany, and fourwing saltbush.

DURATION OF STUDY: 1994 through 2000

STUDY LEADER: Mark Pater

LOCATION: Tucson PMC, Cyprus-Tohono Mine

COOPERATORS: Cyprus-Tohono Mine, Sells Field Office, Tohono O'Odham Nation, Tucson PMC.

METHODS AND MATERIALS:

1996 Planting

The March 18-29, 1996 planting was made using 1,374 containerized plants that were propagated at the Tucson PMC. The three container sizes were: tree pots (532 cubic inches), Deepots (40 cubic inches), and containers (15 cubic inches). Approximately 2 gallons of water was poured into each hole immediately before transplanting each containerized plant. Table 1 lists the species used in this planting.

Table 1. Species propagated for the 1996 planting.

Scientific Name	Common Name
Acacia constricta	whitethorn acacia
Ambrosia dumosa	white bursage
Atriplex canescens	fourwing saltbush
Baileya multiradiata	desert marigold
Cercidium microphyllum	littleleaf palo verde
Encelia farinosa	brittlebush
Larrea tridentata	creosotebush
Lupinus arizonica	lupine
Prosopis juliflora	mesquite
Sphaeralcea ambigua	desert globemallow

Plant height and canopy cover data were collected on a monthly basis beginning in April 1996 through August 1996. Survival data were collected in September 1996.

1997 Planting
The 1997 spring and summer plantings are organized as Randomized Complete Blocks design. Each treatment area has 4 randomized complete blocks (planting plots) containing each of the 5 species to be planted. Each randomized complete block was replicated 4 times: 4 randomized complete blocks x 2 treatment areas x 2 planting times = 16 total plots. Each plot contains 5 species, 10 individuals per species = 50 plants per plot; 16 total plots at 50 plants per plot = 800 plants.

The Spring planting was divided into two treatment areas, fertilized versus not fertilized, to determine if fertilizer application at the time of transplanting aids in transplant survival. The Summer planting did not involve any fertilizer treatments.

The plants for each species were propagated at the Tucson PMC. At the evaluation site, the plants in each replicated plot were transplanted by hand. Each planted row for all replicated plots is 50 feet in length and spaced 10 feet apart. Each plant within each row within all replicated plots is spaced 15 feet apart. The plants will be evaluated on a monthly basis for growth and survival.

1998 Planting
The FY 1998 planting was planned to be a large-scale planting using a more natural planting layout relative to the block designs used in the past. The proposed planting site is located on a former water tank storage site. This storage site is located on top of a small hill and is approximately 1/2 acre in size. Evaluation criteria for this planting include survival percentage and growth rate. Data will be analyzed and interpreted by Tucson PMC personnel.

The primary objective for the FY 1998 planting is visual mediation using native species. The species for the FY 1998 planting include: creosote bush, whitethorn acacia, mesquite, palo verde, ironwood, globemallow, fourwing saltbush, brittlebush, desert marigold, and purple threeawn. These species were propagated in Deepot containers at the Tucson PMC.

At the time of the planting installation, Cyprus Tohono Corporation will provide: (1) protective wire cages for each plant or fence the entire area in order to reduce damage by small animals, (2) one 500 gallon water tank with hose in order to water the transplants at the time of installation, (3) sufficient labor to properly execute the planting. Prior to planting the site will need to be contour-graded and ripped. Prior to planting, soil samples will be obtained and evaluated for pH and soil fertility. The optimum planting period would be after the onset of the summer rains (July-August). This time of year is generally characterized as having lower daytime temperatures, higher relative humidity and greater potential for precipitation as compared to the months of April through mid June. A supplemental watering system may be installed at the discretion of the Cyprus Tohono Corporation.

It is estimated that 1,500 plants will need to be propagated. The planting design will try to be laid out to give a natural appearance and blend in with the undisturbed vegetation next to the planting site. All plants will be spaced approximately five to ten feet apart, this should allow for 1,500 plants to cover a total area of 37,500 ft^2 (0.86 acres).

STATUS OF KNOWLEDGE:
Surface mining removes vegetation that protects soil against erosion. Surface mined areas that have not been reclaimed usually become a wasteland of rubble and waste dumps. Runoff erodes these areas, carrying sediment, and in some places chemical pollutants to surface and groundwater. In addition, unprotected sites are sources for blowing dust, thereby degrading air quality (USDA 1973). The visual aesthetics of the mined areas have a negative effect upon urban and recreation areas. Over 80% of surface mines in the U.S. are within 10 miles of population centers and 60% are visible from public use areas (Copeland 1973).

Seeding critical areas have historically had limited success primarily due to a lack of adequate precipitation. The Tucson PMC decided to evaluate the use of containerized plant materials to determine whether this could be an effective method of revegetation on mined lands. Containerized stock should have a higher

establishment success rate over direct seeding primarily because the period from seeding through seedling emergence and establishment is completed in a relatively low stress nursery setting. Containerized planting stock can be grown relatively quickly. The developed root system is generally well protected during the planting process and therefore survival rates of the transplanted material is generally increased. A disadvantage of containerized planting stock is that the materials can be quite heavy and difficult to handle. Proper storage areas, watering facilities, and daily care also increase the cost of producing this type of materials (Monsen et al. 1979).

The application of fertilizer on nutrient-deficient soils may improve plant establishment and growth. Consideration must be given to the nutrient requirements of the species being planted. Some plant species have lower nutrient needs than others and thus may not require fertilizers. Soil nutrient deficiencies need to be determined by field and lab soils tests in order to best determine the type and amounts of fertilizer required. Nitrogen (N) and phosphorous (P) are the nutrients most often deficient in semi-arid regions. Potassium and other nutrients are usually adequate in soil from the Sonoran Desert region (Tucker and Day 1980).

Arid and semiarid lands are characterized by low levels of organic matter and consequently low nitrogen reserves since soil organic matter is the nitrogen carrier. Vegetation is characteristically sparse and moisture is limiting. Calcareous soils are very common throughout the arid southwest. They contain calcium carbonate throughout the plant-root zone in quantities ranging from a trace to over 50% by weight. Interspersed with these calcareous soils are sodic and potassic soils with relatively high pH values. Accumulations of soluble salts and various cation and anion combinations also occur. Some of these salts are sufficiently abundant to adversely affect nitrogen transformations as well as absorption of nitrogen by plants (Fuller 1963). Native species found growing on these sites are well-adapted to these soil conditions.

According to Munshower (1994), the application of fertilizers in disturbed land rehabilitation is a common practice. Nitrogen is the most commonly applied plant nutrient on disturbed sites. This element may be added to disturbed soil in any of the forms shown in Table 2. Nitrogen application rates need to be balanced with the species being seeded along with the particular soil being seeded into. Nitrogen application rates depend on the organic matter content of the soil as well as the amount of NO_3-N in the soil. Native, perennial vegetation indigenous to environments with low nutrient availability usually have much lower nitrogen requirements than agronomic species.

Table 2. Common Fertilizer Forms of Nitrogen (Munshower 1994)

Name	**Chemical Formula**	**%Nitrogen**
Urea	NH_2CONH_2	46
Ammonium nitrate	NH_4NO_3	35
Anhydrous ammonia	NH_3	82
Ammonium phosphate	$NH_4H_2PO_4$	12 (27% P)
Diammonium phosphate	$(NH_4)_2HPO_4$	21 (23% P)
Ammonium sulfate	$(NH_4)_2SO_4$	21 (25% S)

Munshower (1994) also states that researchers in Colorado did not recommend the addition of N to native grasslands when the soil organic matter exceeds 2% (Farmer and Richardson 1980). When the organic pool in a soil was less than 1% and soil nitrates were less than 5 µg/g, Farmer and Richardson (1980) only recommended 40 lbs/acre of N-fertilizer. Additional research by others also supports this small to no nitrogen application rate for grass species seeded on topsoiled mined materials in western coal fields (Richardson and Farmer 1983, Daily Post 1972). Another study by Bjugstad (1979) in southeastern Montana showed that the main responses to nitrogen applications were an increase in annual grass or annual weed production and decreased diversity. Legumes used in revegetation programs are beneficial nitrogen fixers and have a biological advantage over non-nitrogen fixing species (Munshower 1994).

As with nitrogen fertilization, phosphorous amendments should also be based on soil nutrient analyses. Good quality topsoil should meet the phosphorous requirements of most native species. Phosphorous deficiencies can often be observed in vegetation growing on disturbed soils in more mesic areas, on hard rock wastes, or on acid soils (Munshower 1994). Phosphate fertilization on semiarid coal mine soils commonly increased the production of annual grasses and weedy forbs and produced little or no response by the more desirable perennial grasses (Tripodi and Cheremisinoff 1980). Phosphorous is tied up by heavy metals in acid soils. Phosphorous amendments in these types of soils should prove beneficial. Since phosphorous is less soluble than nitrates, it must be incorporated into the soil to ensure good soil-root-phosphorous contact (Munshower 1994).

In general, soil amendments are not necessary or effective in arid, desert environments in promoting or enhancing plant growth. A revegetation test program by the Bureau of Land Management (BLM) in California on the Soledad Mountain Project (1997) showed that the addition of soil amendments was not beneficial. Recommendations by the Desert Restoration Task Force (Bainbridge et al. 1995) also states that soil amendments and mulches are often unnecessary in desert environments, although the addition of organic matter may increase seed germination and establishment. Mulch can provide protection from wind, reduce evaporation, increase infiltration and rainwater retention, reduce erosion, and improve plant microclimate. Materials with lots of lignin and high carbon to nitrogen ratios appear to be desirable in most desert soils. These materials provide a long-term food source for fungi and subsequent grazing by microarthropods. This grazing activity makes nitrogen available to plants. Mulches can also be used to tie up available nutrients so that the site is less suitable for invasive exotics. Native plants in the southwestern deserts are generally adapted to relatively low nutrient sites and do not respond well to the application of fertilizers. Invasive exotic species, in contrast, are often from areas of high disturbance and/or high fertility and respond very strongly to the application of fertilizers (Bainbridge 1995, St. John 1987).

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Technical Note, Amendment to Field Office Technical Guide, Update SWAPA information.

OTHER ACTIONS: Publication on using native species for mineland revegetation.

RESULTS:

1996 Planting
White bursage was propagated in both Deepots and tree pots. Declining plant heights and canopy cover was observed during the months of June and July, 1996 and was attributed to a lack of precipitation and high summer temperatures. The plants appeared to begin to recover with the arrival of summer moisture during the month of August (Figure 1). Six months after transplanting, white bursage from the tree pot containers had a significantly higher 91% survival over the white bursage from the Deepot containers which exhibited a 71% survival. Survival counts were conducted again at the end of December 1998. Survival for the white bursage remained at 91% for the tree pot containers and 71% for the Deepots.

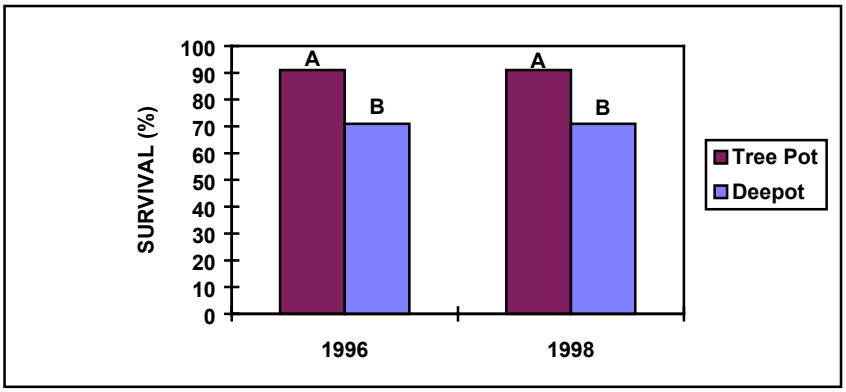

Fig. 1. March 1996 planting - survival comparison with two plant container sizes for white bursage (*Ambrosia dumosa*). Percentages with different letters are significantly different at the 0.05 level.

Fourwing saltbush was also propagated in both tree pots and Deepots. Despite a lack of substantial precipitation during the months of June and July in 1996, plant growth did not noticeably decline. However, a decrease in canopy cover was noted during this period in the plants propagated in tree pots (Figure 2). Six months after transplanting, fourwing saltbush from the tree pots had 100% survival while those from the Deepot containers had a 96% survival. At the end of 1998 the survival for this species had declined to 59% for the plants from the tree pots and 41% for the Deepots. The 1998 survival for the tree pots was significantly greater than the survival for the plants from the Deepots.

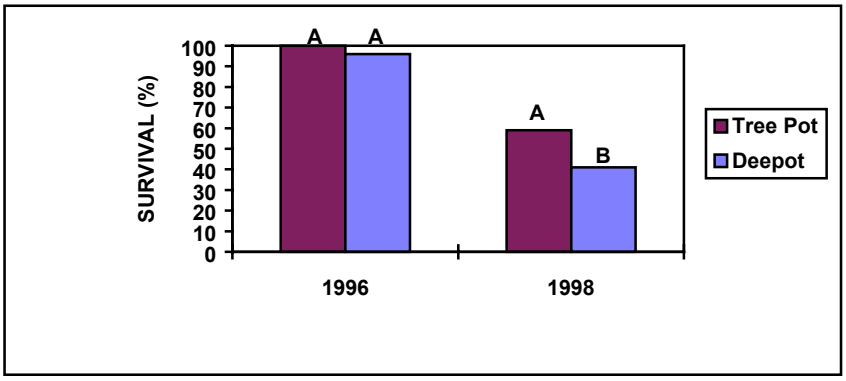

Fig. 2. March 1996 planting - survival comparison of two plant container sizes for fourwing saltbush (*Atriplex canescens*). Percentages with different letters are significantly different at the 0.05 level.

Brittlebush was also propagated in both tree pots and Deepots. This species usually drops most of its leaves during hot, dry periods to better tolerate dry conditions (Figure 3). Survival evaluations six months after transplanting revealed the brittlebush from the tree pot containers to have a significantly higher 100% survival over the brittlebush from the Deepot containers which displayed a 91% survival. Survival for this species also showed a decline by the end of 1998. The plants from the tree pots still exhibited a significantly higher 90% survival over the Deepot plants which showed a 71% survival.

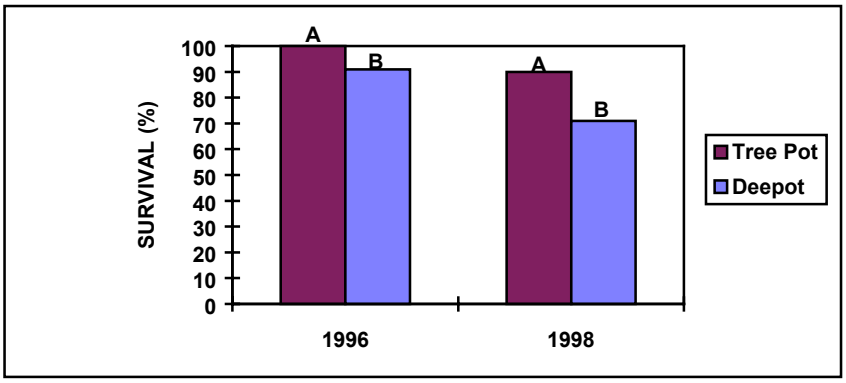

Fig. 3. March 1996 planting - survival comparison with two plant container sizes for brittlebush (*Encelia farinosa*). Percentages with different letters are significantly different at the 0.05 level.

Creosote bush was propagated in tree pots, Deepots, and conetainers. This species tolerated the transplant process well despite the hot, dry period during June and July in 1996 (Figure 4). Six months after transplanting was 94% survival from the tree pot containers, 100% from the Deepot containers and 80% from the conetainers. This species showed a slight decline in survival at the end of 1998. The tree pot containers had a 93% survival, the Deepots showed a 97% survival and 78% for the plants from the conetainers. Survival comparisons between the tree pots and Deepots revealed no significant differences. However, the plants from the conetainers revealed a significantly lower survival in comparison to the other two container sizes.

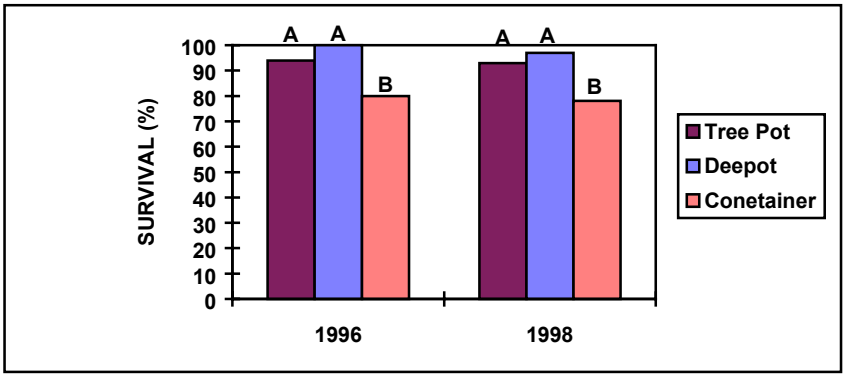

Fig. 4. March 1996 planting - survival comparison with three plant container sizes for creosotebush (*Larrea tridentata*). Percentages with different letters are significantly different at the 0.05 level.

Mesquite was propagated only in tree pot containers. Survival evaluations following six months after transplanting revealed a 78% transplant survival. At the end of 1998 the mesquite survival remained at 78%. Whitethorn acacia was propagated in tree pot containers. Survival evaluations following six months after transplanting revealed a 97% transplant survival rate. Survival for the whitethorn acacia declined to 91% by the end of 1998. Littleleaf palo verde plants propagated in tree pot containers revealed a 72% transplant survival rate six months after transplanting. By the end of 1998 this species exhibited a 70% survival (Figure 5).

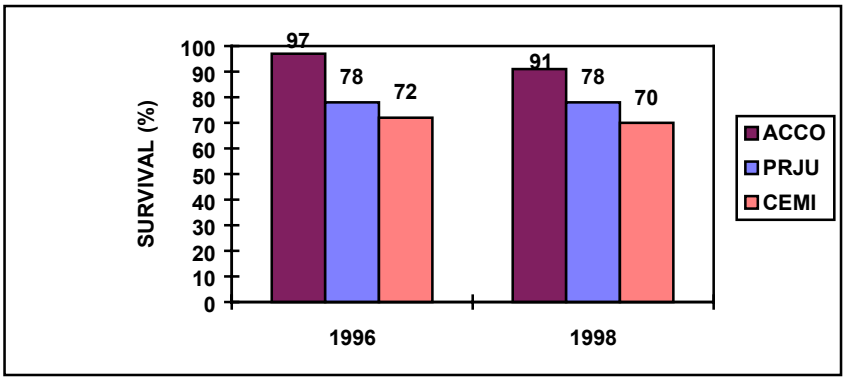

Fig. 5. March 1996 planting - comparison of survival for whitethorn acacia (*Acacia constricta* - ACCO), mesquite (*Prosopis juliflora* - PRJU), littleleaf palo verde (*Cercidium microphyllum* - CEMI) after transplanting from Tree Pot-sized containers.

Purple threeawn transplants propagated in the tree pots have also performed well at this site. Survival evaluations following six months after transplanting revealed an 87% survival rate. This species displayed a 48% survival for the transplanted materials at the end of 1998 (Figure 6). It should be noted that a large number of new seedlings and young plants were observed within the study plot.

Desert marigold and globemallow were propagated in tree pot containers. Initially both species appeared to react negatively to the transplant process which was followed by an extended period with very little to no measurable precipitation. However, during the August 1996 evaluations, these species appeared to be recovering well (Figure 6). Survival percentages six months after transplanting showed the desert globemallow to have a 95% survival and the desert marigold an 82% survival. Despite the hot, dry period during June and July in 1996, most of the plants were performing well in terms of growth and survival. At the end of 1998 the desert globemallow had fallen to a 60% survival and the desert marigold survival had declined to zero.

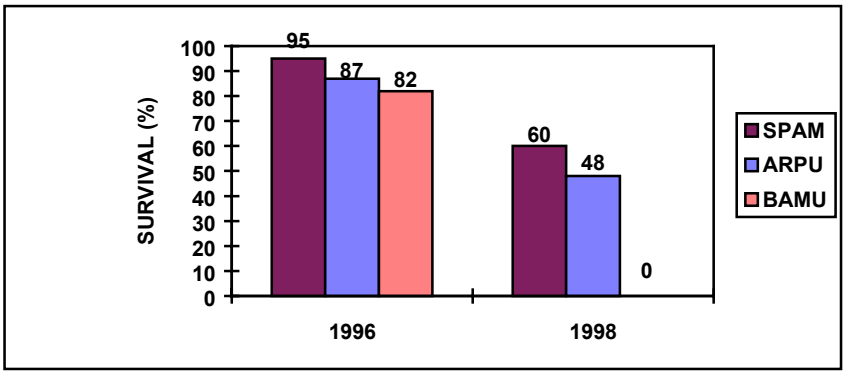

Fig. 6. March 1996 planting - comparison of survival for desert globemallow (*Sphaeralcea ambigua* - SPAM), purple threeawn (*Aristida purpurea* - ARPU), desert marigold (*Baileya multiradiata* - BAMU) after transplanting from Tree Pot-sized containers.

The Arizona lupine was the only species not to survive six months past the transplant period. This was primarily due to rabbit grazing shortly after the transplanting.

By the end of 1998, the overall plant survival percentage for this planting had declined from 83% to 65%. The plants transplanted from the tree pot containers declined from 90% to 68% survival as compared to a decline from 73% to 56% survival for plants transplanted from the Deepot containers. These declines in survival can be attributed to the plants being placed too closely together (two-foot spacing between plants) and competition for moisture and nutrients may have caused some plants to die.

From an economic standpoint, it appears to be more cost-effective to propagate plant materials in the Deepot containers. The tree pot containers require more time to modify the containers for propagation, more potting mix and more water to maintain the plants growing in them prior to transplanting.

Other studies by Tucson PMC personnel using different-sized containers for transplant projects have shown that plants grown in Deepots attain similar growth rates and size as plants grown in tree pot containers. Plants propagated in conetainers do not appear to produce sufficient root mass to allow for successful transplanting under arid conditions without supplemental irrigation. Another point to consider is that the plants grown in tree pots weigh approximately 23-25 pounds each versus approximately 3 pounds for plants in a Deepot container. The Deepot containers are easier to handle and require a much shallower hole thereby reducing time and labor during transplanting.

1997 Planting

The 1997 planting was made on the "97 NRCS Oxide Site" at the mine and conducted in two phases: (1) Spring Planting, made on May 27-28, 1997 and (2) Summer Planting, made on August 26-27, 1997. Each species was propagated in Cavity Trays in the Tucson PMC greenhouse. After sufficient growth, seedlings were transplanted into Deepots. After sufficient growth was achieved in the Deepot containers, the plants were moved to the Tucson PMC shadehouse for a 60-day hardening-off period before transplanting. At the evaluation site, plants were transplanted by hand. All containerized plants in both the Spring and Summer Plantings received approximately 1 gallon of water as they were transplanted into the evaluation site. A water truck and hose were supplied by the mine for this purpose. The evaluation site was fenced to prevent damage by animals.

By the end of 1997, the creosote bush and purple threeawn exhibited no significant differences in survival between the fertilized and unfertilized treatment areas. Creosotebush demonstrated 52.5% survival in the unfertilized plots as compared to a 35% in the fertilized plots. By December 1998, the creosote bush had declined slightly to a 50% survival in the untreated plots and remained steady at 35% in the treated areas (Figure 7).

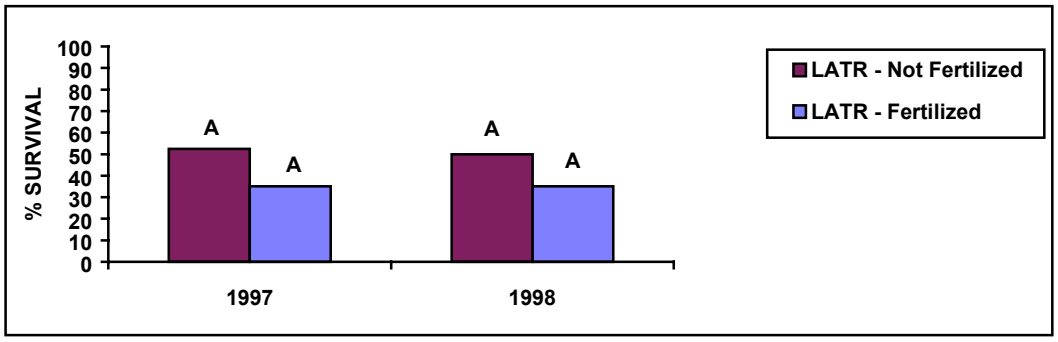

Figure 7. 1997 NRCS Oxide Site, May planting - Survival comparison for creosotebush (*Larrea tridentata* - LATR) in fertilized and unfertilized plots. Percentages with the same letter are not significantly different at the 0.05 level.

In 1997, the purple threeawn exhibited a 27.5% survival in the fertilized plots versus 5% in the fertilized plots. By the end of 1998, the purple threeawn remained at 27.5% in the untreated plots and had declined significantly to 0% survival in the fertilized plots (Figure 8).

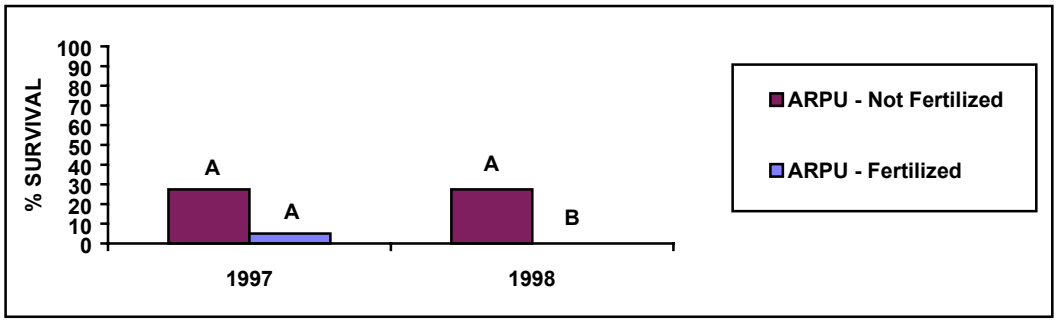

Figure 8. 1997 NRCS Oxide Site, May planting - Survival comparison for purple threeawn (*Aristida purpurea* - ARPU) in fertilized and unfertilized plots. Percentages with the same letter are not significantly different at the 0.05 level.

At the end of 1997, it was apparent that the littleleaf palo verde, fourwing saltbush, and brittlebush did not respond well to the fertilizer applications. Plants in the untreated plots exhibited significantly higher survival percentages than the treated plots. Littleleaf palo verde exhibited a 77.5% survival in the untreated plots and 32.5% survival in the treated plots. By the end of 1998 the untreated plots had declined to a 70% survival and the treated areas had fallen to 2.5% (Figure 9). At the end of 1997 the fourwing saltbush had 65% survival in the unfertilized plots versus a 12.5% survival in the fertilized plots. By December 1998 the fourwing in the untreated and treated plots remained at the same levels (Figure 10). The end of calendar year 1997 showed the brittlebush at 40% survival in the unfertilized plots as compared to 2.5% survival in the treated plots. By the end of 1998 the survival percentages remained unchanged (Figure 11).

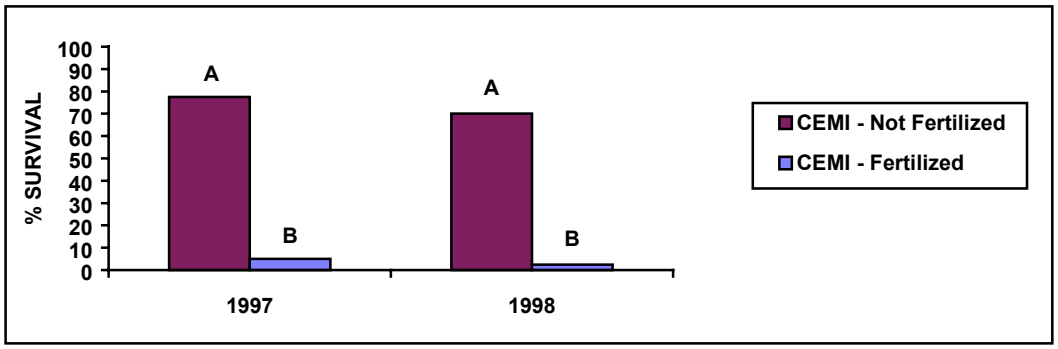

Figure 9. 1997 NRCS Oxide Site, May planting - Survival comparison for littleleaf palo verde (*Cercidium microphyllum* - CEMI) in fertilized and unfertilized plots. Percentages with different letters are significantly different at the 0.05 level.

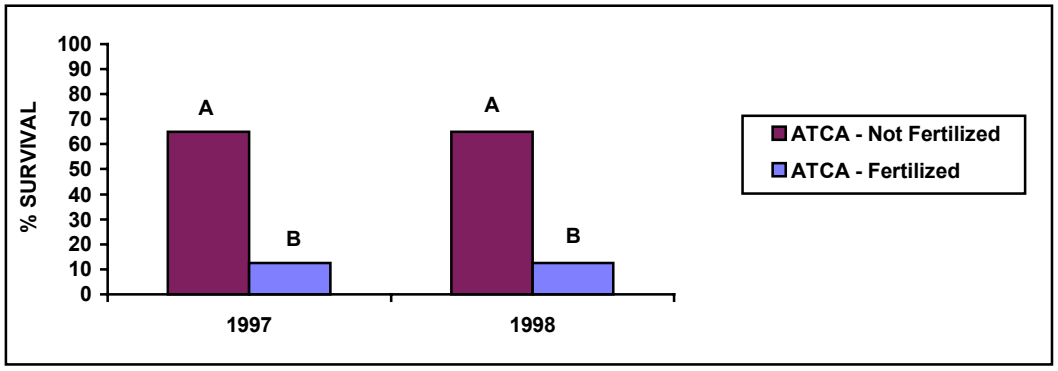

Figure 10. 1997 NRCS Oxide Site, May planting - Survival comparison for fourwing saltbush (*Atriplex canescens* - ATCA) in fertilized and unfertilized plots. Percentages with different letters are significantly different at the 0.05 level.

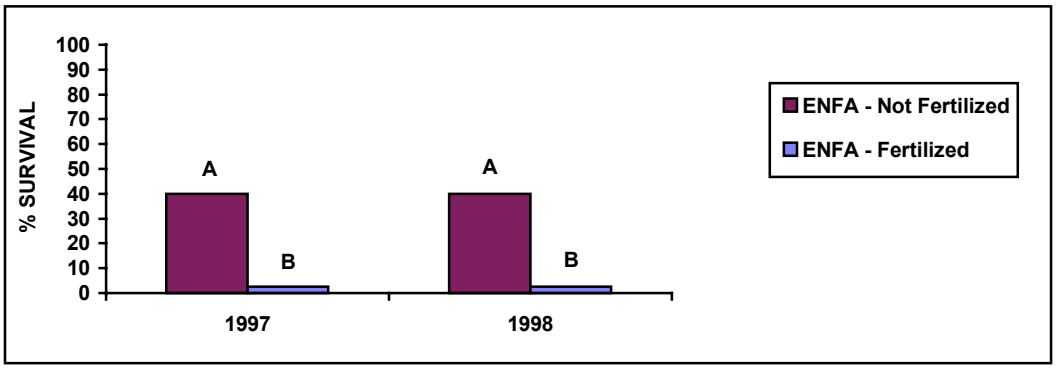

Figure 11. 1997 NRCS Oxide Site, May planting - Survival comparison for brittlebush (*Encelia farinosa* - ENFA) in fertilized and unfertilized plots. Percentages with different letters are significantly different at the 0.05 level.

In comparing the 1997 August planting time with the 1997 May planting time, littleleaf palo verde and fourwing saltbush exhibited no significant differences in survival percentage. Littleleaf palo verde exhibited 77.5% survival in the May planting and 85% in the August planting by the end of 1997. At the end of 1998, the May planting, had declined to a 70% survival and the August planting remained at 85% (Figure 12). By the end of 1997, the fourwing saltbush demonstrated a 65% survival in the May planting and a 62.5% survival in the August planting. At the end of calendar year 1998 the survival in the May planting remained the same and the August planted had declined slightly to 60% (Figure 13).

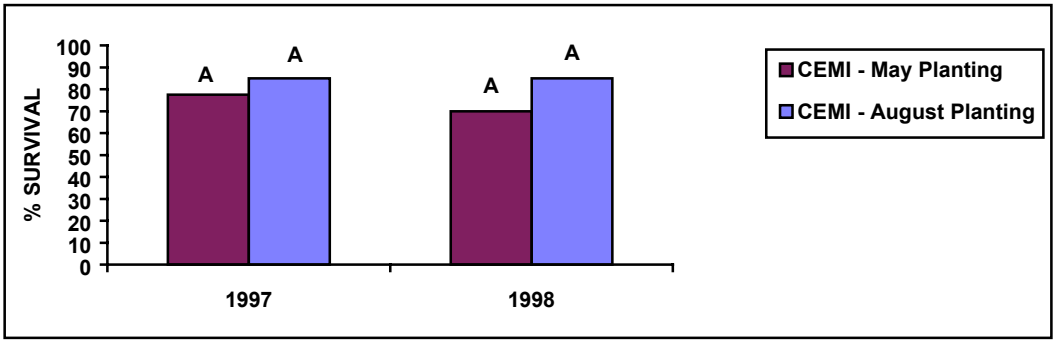

Figure 12. 1997 NRCS Oxide Site planting - Survival percentages for littleleaf palo verde (*Cercidium microphyllum* - CEMI) comparing two planting periods (May and August). Percentages with the same letter are not significantly different at the 0.05 level.

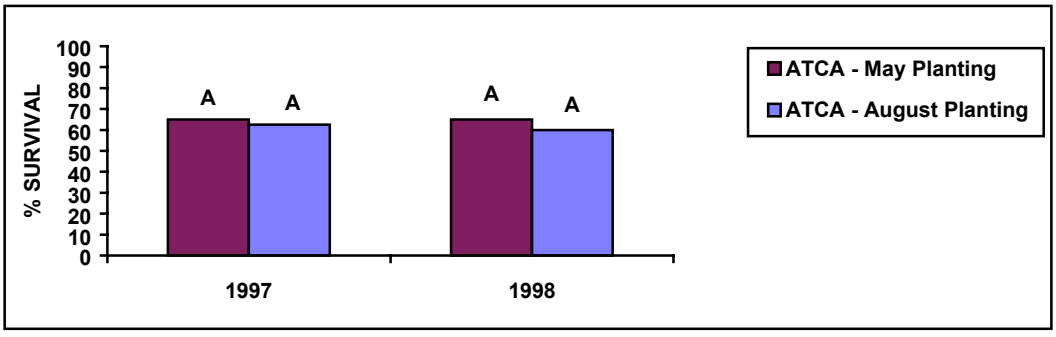

Figure 13. 1997 NRCS Oxide Site planting - Survival percentages for fourwing saltbush (*Atriplex canescens* - ATCA) comparing two planting periods (May and August). Percentages with different letters are significantly different at the 0.05 level.

By the end of the 1997 calendar year, purple threeawn and brittlebush exhibited significantly higher survival for the August planting. Purple threeawn showed an 87.5% survival in the August planting as compared to a 27.5% survival for the May planting. By the end of calendar year 1998 the purple threeawn showed an 82.5% survival for the August planting versus a 27.5% for the May planting (Figure 14). In

1997 the brittlebush demonstrated a 100% survival for the August planting versus a 40% survival for the May planting. By the end of 1998 the brittlebush survival for the August planting had fallen slightly to 95% and remained the same at 40% for the May planting (Figure 15).

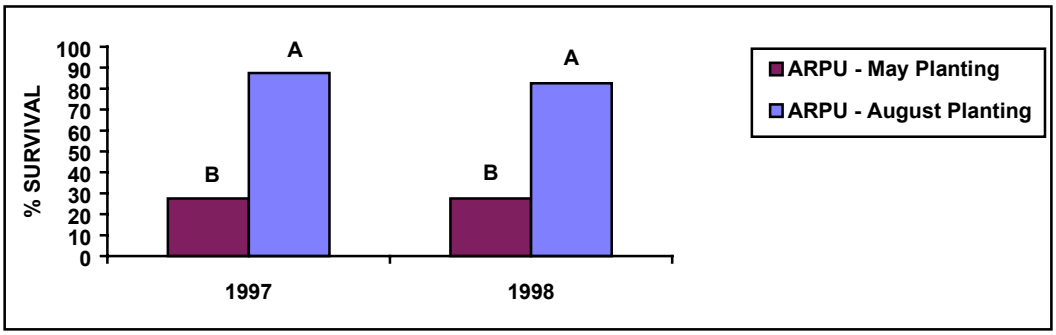

Figure 14. 1997 NRCS Oxide Site planting - Survival percentages for purple threeawn (*Aristida purpurea* - ARPU) comparing two planting periods (May and August). Percentages with different letters are significantly different at the 0.05 level.

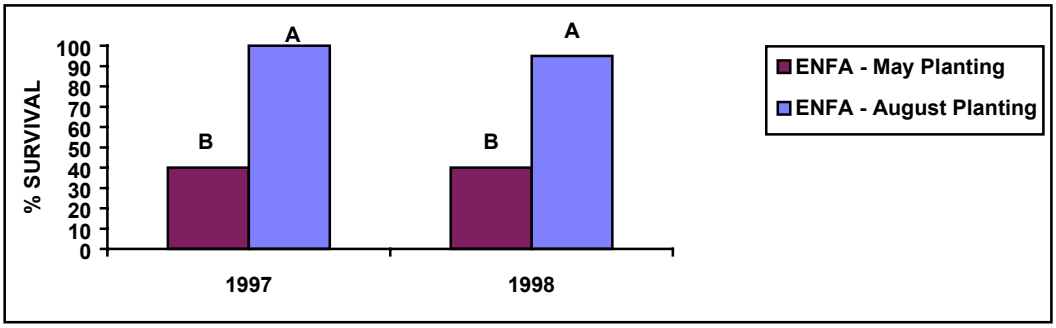

Figure 15. 1997 NRCS Oxide Site planting - Survival percentages for brittlebush (*Encelia farinosa* - ENFA) comparing two planting periods (May and August). Percentages with different letters are significantly different at the 0.05 level.

The August planting period appears more favorable to transplant establishment and survival success. This is most likely due to the higher probability of the plants receiving adequate moisture from summer rains. Transplanting during August appears to allow the plant materials adequate time to become established and acclimated to the site under more favorable conditions (e.g., higher relative humidity, summer precipitation) versus the May planting period that is traditionally followed by a hot, dry period through the month of June. Unless supplemental watering can be provided, it is recommended that transplanting be conducted in late July or early August following the onset of summer rains (Figure 16).

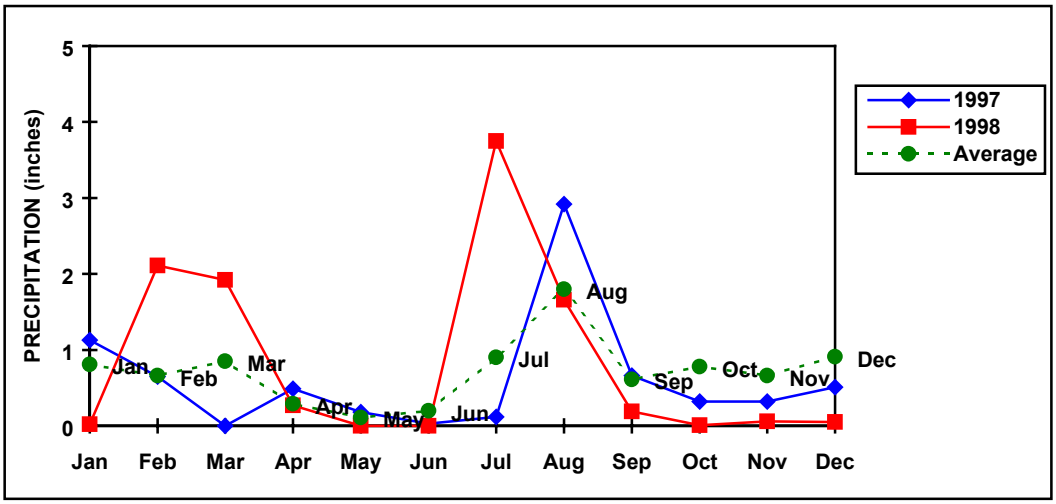

Figure 16. Cyprus Tohono Mine - monthly precipitation data for 1997 and 1998. Dashed line represents monthly average (1950-1980).

1998 Planting

The "98 NRCS Planting" was done in September 1998 using 1,880 plants. All plants were propagated in Deepots at the Tucson PMC greenhouse. On September 9-11, 1998 the plants were transplanted into a 90,000 ft^2 evaluation site. As of December 10, 1998, 83% of all individuals planted had survived. Whitethorn acacia exhibited the highest survival (100%). Mesquite had 99% survival followed by ironwood at 97%. Purple threeawn, fourwing saltbush and littleleaf palo verde all exhibited a 93% survival. Desert globemallow had a 78% survival and brittlebush rated at 73%. Desert marigold exhibited the lowest survival percentage at 69% (Figure 17). Continued monthly monitoring of this planting site through the remainder of fiscal year 1999 should provide adequate data to determine the level of success for this planting.

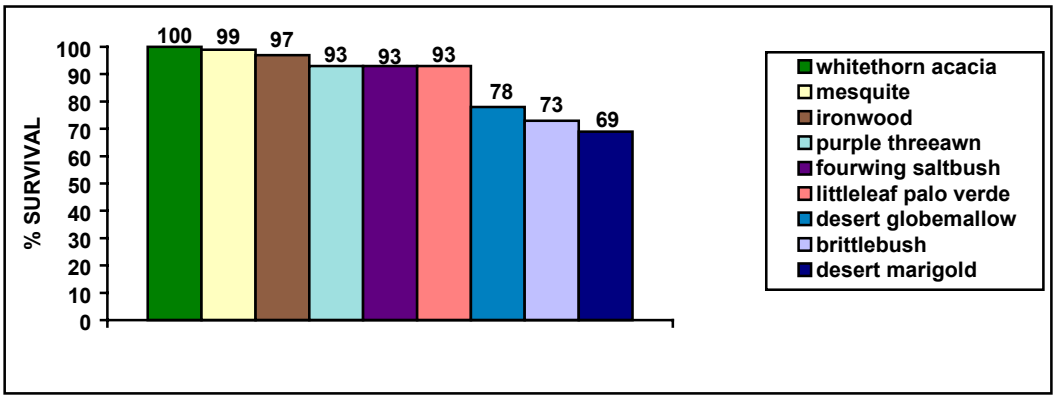

Figure 17. September 1998 planting - percent survival for all species planted as of December 10, 1998.

LITERATURE CITED

Bainbridge, D., R. MacAller and M. Fidelibus. 1995. A beginners guide to desert restoration. USDI-NPS, Denver Service Center. 48p.

Bjugstad, A.J. 1979. Bentonite mine spoils and pit reclamation. In: Proceedings from the Mineral Waste Stabilization Liaison Committee. Evelith, MN.

Copeland, O.L. 1973. Mining impacts and resource management. Transactions of the 38th N. American Wildlife and Natural Resources Conference, Mar., Wildl. Manag. Institute, Washington D.C. p.111-120.

Daily Post. Bentonite, the clay of 1,000 uses. Sept. 26, 1972. Belle Fourche, SD. p.5.

Farmer, E.E. and B.Z. Richardson. 1980. Phosphate mine dump stability and revegetation. In: Proceedings from the Symposium on Watershed Management V., II., American Society of Civil Engineers, New York. p.888.

Fuller, W.H. 1963. Reactions of nitrogen fertilizers in calcareous soils. In: Agricultural and Food Chemistry, Vol. 11:188-193.

Monsen, S.B., C.M. McKell, N.C. Frischknecht, R.B. Ferguson. 1979. Plant Materials. In: User Guide to Vegetation. Mining and Reclamation in the West. U.S.D.A. Forest Service, General Technical Report Int-64, Intermountain Forest and Range Experiment Station. Ogden, UT. pp.19-23.

Munshower, F.F. 1994. Practical Handbook of Disturbed Land Revegetation. CRC Press, Inc. Boca Raton, FL. 265p.

Richardson, B.Z. and E.E. Farmer. 1983. Revegetation of phosphate mined lands in the intermountain west. In: Proceedings from the Symposium on Watershed Management V., II., American Society of Civil Engineers, New York. P.373.

St. John, T.V. 1987. Soil disturbance and the mineral nutrition of native plants. In: Proceedings of the 2nd Native Plant Revegetation Symposium. April 15-18, 1987. San Diego, CA.

Tripodi, R.A. and P.N. Cheremisinoff. 1980. Coal ash disposal: Solid waste impacts. Technomic Publ., Westport, CT. p.18.

Tucker, T.C. and A.D. Day. 1980. Amendments and fertilizers for use in vegetative reclamation. Proceedings: Vegetative Reclamation of Mine Wastes and Tailings in the Southwest. Arizona Mining and Mineral Resources Research Institute, University of Arizona, Tucson, AZ. p7-3.

U.S. Department of Agriculture, SCS. 1973. Technical notes. Guidelines for reclamation of surface mined lands in Arizona. Environment Note No. 2. Phoenix, Arizona.

U.S. Department of the Interior, Bureau of Land Management - California. 1997. Soledad Mountain Project - Internet site: www.ca.blm.gov/GoldenQueen/pub-rev6.htm.

STUDY NUMBER: 04C9812D

BHP Bio-Solids Trial

PROJECT NUMBER: ML1.2

Improve erosion control and the quality of water leaving mined land and other disturbed sites in the western US.

STUDY TYPE: Advanced Evaluation

LAND USES: Mined lands, Rangeland

VEGETATIVE PRACTICES:

PRIMARY:	544	LAND RECONSTRUCTION, CURRENTLY MINED LAND
SECONDARY:	342	CRITICAL AREA PLANTING
TERTIARY:	550	RANGE SEEDING

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Soil	Soil condition, contaminants; excess chemical content.
SECONDARY:	Plants	Plants management; establishment, growth, and harvest.

DESCRIPTION:
Biosolids and green waste will be evaluated for their effectiveness in creating an artificial environment for plant establishment and growth on processed mined materials. "Tailings" ponds are virtual deserts with regards to providing a suitable environment for plants. Heavy metals, low pH, no microbial activity, and other factors are severe limitations which must be modified for successful plant establishment. BHP, The University of Arizona and the Tucson Plant Materials Center are evaluating different application rate of biosolids (from wastewater treatment plants) and greenwaste (composted plant trimmings from county/city landfills) and evaluate the relative success of seeding into these treatments.

DURATION OF STUDY: 1998 through 2000

STUDY LEADER: Dr. Ton Thompson -UofA, Jerry Donaldson-BHP Copper, and Bruce Munda

LOCATION: BHP Copper-San Manuel, AZ

COOPERATORS: BHP Copper Co., Tucson Field Office, Winkelman NRCD, University of Arizona, Tucson PMC.

METHODS AND MATERIALS:
Study is a randomized complete block with three replications. Treatments include four application rates of biosolids and two application rates of green waste. Evaluations will be conducted by UofA and BHP. These will include: soil physical parameters (bulk density, texture, moisture retention, soil water content, etc.), soil chemical parameters (pH, extractable metals, microbial activity, N, P, etc.), weather (temperature, wind, precipitation), and plant conditions (frequency, germination, cover, plant total N, and plant total metals). The Tucson PMC provided a seed mix for the trial (see the following table). The seeding mix incorporated eight species and was planned to be sown in July, 1998.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
TUCSON PLANT MATERIALS CENTER

Species and Seeding For BHP-San Manuel Mining Division, Bio-solids trial
Date: July 9, 1998

SPECIES	Seeds/pound	PLS rate/acre[1]	% of mix	Actual PLS rate/acre[2]	Actual PLS rate/trial
Cane bluestem	754,000	1.4	15	0.43	0.23
Yellow bluestem	400,000	2.7	15	0.82	0.44
Arizona cottontop	303,000	3.6	20	1.44	0.76
Plains bristlegrass	293,000	3.7	20	1.49	0.79
Big sacaton	1,900,000	0.5	15	0.17	0.09
Lehmann lovegrass	6,537,000	0.2	5	0.02	0.011
quailbush	450,000	0.5	5	0.05	0.03
fourwing saltbush	52,000	4.2	5	0.42	0.22

1. PLS = pure live seed. Seeding rate is based on 25 seeds/ft^2 for grasses and 5 seeds/ft^2 for shrubs.
2. Actual rate is (PLS rate) x (% mix) x (2) -- the rate is doubled for broadcast seeding

3. There are 24-960 ft^2 plots. This equals 23,040 ft^2 which is 0.53 acres. The left column represents the amount of pure live seed for each species for the trial = (actual PLS rate x 0.53).

STATUS OF KNOWLEDGE:

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Technical Note, Amendment to Field Office Technical Guide,

OTHER ACTIONS:

RESULTS:
1998
Planting was postponed due to high water content in the impoundment area. Planting was installed late and therefore poor results are expected. If results are poor the seeding will be repeated in 1999.

PROJECT: CP1.5

PROJECT TITLE: **Controlling erosion on cropland with cover cropping and residue management systems in the arid, semiarid and summer dry parts of the US**

PROBLEM STATEMENT:
Cropland in arid regions experiences soil erosion from water and wind. The land is degraded and water quality is affected. Better covercropping and residue management techniques are needed.

LAND RESOURCE REGIONS: D Western Range and Irrigated Region
J Southwestern Prairies Cotton and Forage Region

MLRA: 14-51, 58-70

LAND USES: Cropland

VEGETATIVE PRACTICES:

PRIMARY:	327	CONSERVATION COVER
SECONDARY:	340	COVER AND GREEN MANURE CROP
TERTIARY:	328	CONSERVATION CROP ROTATION

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Soil	Soil condition; tilth, crusting, water infiltration, organic
SECONDARY:	Plants	Plants suitability, other.

SCOPE/DESCRIPTION:
Studies and activities to determine cover crops, cropping systems, and residue management practices to optimize soil and water protection, food and fiber production, and economical returns. Identify and develop legumes having minimal water requirements for use as cover crops during summer fallow periods in MLRA 30 and during winter fallow periods in MLRA 40 and 41. Document and promote the benefits of using cover crops and green manure crops in cropping rotations. The Cover Crop and Green Manure practice when implemented will: protect air quality by reducing wind erosion, improve soil tilth, improve soil moisture holding capacity, and reduce soil nutrient loss.

OBJECTIVES:
Develop and/or identify summer legumes for use as a cover crop in MLRA 30. Develop and/or identify low water use cover crops. Evaluate and document the benefits associated with cover crop use in hot desert areas. Identify legumes that are adapted for use under Arizona conditions. Develop interdisciplinary/interoffice teams based upon similarity of problems and MLRA's. Teams will identify, demonstrate and promote opportunities through Field Plantings, Tech Guide updates and other activities. Western Arizona - Yuma and Parker Field Offices, SE California - El Centro, Blythe and Indio. Northwestern Arizona - Kingman, California - Apple Valley.

STATUS OF KNOWLEDGE:
Cover crops and residue management are well documented. New plant materials from breeders and foreign research programs need to be tested and their performance documented. University and other researchers often develop new treatments and uses for crop residues. The applications of these new techniques need to be tested.

PLANNED COORDINATION:
TPMC is working with Maricopa County Extension Service (Kai Umeda) in conducting joint trials on warm season legumes. These legumes are used as a cover crop/green manure crop for winter vegetables. We are also providing seed of Tropic sunn hemp (via the Hawaii PMC) and cowpeas to the Indio Field Office. The Indio FIELD OFFICE is working with Dr. Baki in identifying warm season legumes and using Dr. Baki's soybean variety for use as a green manure crop for winter vegetables.

COOPERATORS:
Universities in affected states, USDA ARS, Cooperative Extension Service and others as needed.

PROJECT LEADER: Tucson PMC, Arizona Plant Resource Specialist

STUDIES:

TUCSON, ARIZONA PLANT MATERIALS CENTER
04C9602M START: 1996 END: 2000
Cover Crop trials at TPMC and in cooperation with Maricopa County Extension Service.

STUDY NUMBER: 04C9602M

Cool Season & Warm Season Cover Crop Trials / Final Report

PROJECT NUMBER: CP1.5

Controlling erosion on cropland with cover cropping and residue management systems in the arid, semiarid and summer dry parts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Cropland

VEGETATIVE PRACTICES:
PRIMARY: 340 COVER AND GREEN MANURE CROP

SECONDARY: 328 CONSERVATION CROP ROTATION

TERTIARY: 327 CONSERVATION COVER

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Soil	Soil condition; tilth, crusting, water infiltration, organic
SECONDARY:	Air	Air quality, other.

DESCRIPTION:
This is a joint study with Kai Umeda, Vegetable Crop Specialist with the Maricopa County Extension Service. The warm-season trials are specifically evaluating a legume that can be planted, turned under prior to winter vegetables. Factors we are evaluating are biomass production and amount of nitrogen added to the soil. The cool season trial is basically a TPMC study where we are screening various legumes for biomass production and adaptability to southern Arizona. The warm-season trial included 'Tropic Sun' sunn hemp(*Crotalaria juncea*),Iron & Clay cowpeas (*Vigna unguiculata*), sesbania (*Sesbaina exaltata*), sudangrass (*Sorghum sudanense*) and kenaf (*Hibiscus cannabinus*). The cool-season trial included Purple vetch (*Vicia atropurpurea*),'Lana' woolypod vetch (*Vicia villosa* ssp. *varia*), 'Biomaster' pea (*Pisum sativum*) and Papago pea (*Pisum sativum*).

DURATION OF STUDY: 1996 through 2000

STUDY LEADER: Bruce Munda & Kai Umeda

COOPERATORS: Maricopa County Extension, NRCS

METHODS AND MATERIALS:
Warm-season cover crop trial was conducted in field 9. Soil in this field is a Grabe loam. All species were planted June 26, 1996 using a John Deere grain drill and at a depth of 1 to 1.5 inches deep. Each border is 0.45 acres in size. Sesbania was planted in borders 1 & 2 at a planting rate of 50 lb./ac (actual amount used = 50 lb.). Seed was inoculated with ISE600 Rhizobium inoculant or you can use "Sesbania Spec. 1" from Nitragin company. Four irrigations were applied to each border. The first irrigation was a pre-plant irrigation with the second irrigation following about one week after planting. Due to poor

Plant establishment the Sesbania was irrigated only twice, for a total application of 9 acre inches of water, and then disked out. The third and fourth irrigations were applied 20 days apart. The sunn hemp was planted in border 15 and 16 at a rate of 50 lb./ac and was inoculated with 'cowpea' or ISE200 type

inoculant. Cowpeas were planted in borders 17 and 18 at a rate of 60 lb./ac and were inoculated with 'cowpea' or ISE200 type inoculant. Total amount of water applied was 24 acre inches for the cowpeas and sunn hemp. Cool-Season Cover Crop Trial. This trial was installed on December 10, 1996. Biomaster peas were planted in field 9 borders 1 & 2 and field 4 border 16 at a rate of 100 lb./ac. Papago peas were planted in field 9 border 17 & field 4 borders 13,14,&15 at a rate of 100 lb./ac. Both peas were inoculated with pea/vetch or ISE500 type inoculant. Lana vetch was planted in field 9 border 3 & 4, field 5 borders 1 & 2 and field 3 borders 10 and 11. Purple vetch was planted in field 9 border 18 & 19, field 3 borders 6,7,8 & 9. Planting rate was 80 lb./ac and the inoculant used was the pea/vetch type or ISE500. A John Deere grain drill was used to plant the cool-season species at a depth of 1/2 to 3/4 inches deep. All species were planted dry and irrigated up. Parameters measured for both legume trials are number of plants established, height and biomass production. 1997 observations will include length of flowering.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Amendment to cover crop standards and specifications, Technical Note.

OTHER ACTIONS: Plant Guide and/or fact sheet.

1996 RESULTS:

WARM SEASON LEGUMES

Results from Extension Service trials: Stand--sesbania was 2.25 plants/3 ft of drill row, sunnhemp was 20 plants/3 ft of drill row and cowpeas were 6.8 plants/ 3 ft of drill row; Yield(fresh weight)--sudangrass 19,816 lb/A, sunnhemp was 10,551 lb/A, sesbania was 7,794 lb/A, cowpeas was 5,184 lb/A and kenaf was 2,390 lb/A. The above yields were from trials at the MAC farm. Following the harvest of these crops cabbage, broccoli, and barley were planted. Visual observations of these crops indicated that sudangrass inhibited growth of all three crops. The three vegetable crops planted after the leguminous cover crops and kenaf did not exhibit measurable differences in growth. No supplemental fertilizers were applied to the fall planted crops at planting time. The leguminous cover crops had all exhibited growth of nitrogen-fixing nodules at the time of harvest and presumably provided nitrogen to the vegetable crops.

Results from TPMC trial: Stand--(7/29/1997) Sesbania was 0.21 plants/ft^2, sunnhemp was 3.5 plants/ft^2 and cowpeas was 1.8 plants/ft2; Yield--(9/06/1996) Sesbania was disked out due to poor plant establishment, Cowpea was 9,255 lb/A, Sunnhemp was 7,002 lb/A; Height--(9/06/1996) Cowpea was 27.2 inches, Sunnhemp was 63.7 inches. Approximately 1 in 5 cowpeas plants were observed to have nitrogen-fixing nodules while only 1 in 17 plants for sunnhemp were observed to have nodules. Cowpeas were observed to have slight insect, whitefly and leafhopper, activity while sunnhemp was observed to little to no whitefly and leafhopper activity. Quantity of irrigation water applied to the sunnhemp and cowpeas trials was 24 acre inches.

TPMC RESULTS

SPECIES	DENSITY* (PLTS/FT^2) 33 DAP	PLANT HT (IN) 33 DAP	PLANT HT (IN) 102 DAP	YIELD (LB/A) 102 DAP
SESBANIA	0.21	5.75	disked out	disked out
SUNNHEMP	3.5	7.5	63.7	7,002
COWPEA	1.8	9.1	27.2	9,255

* Density and first height measurements taken from an average of seven 5 ft^2 subplots within each replicate.

** Yield and final height measurements taken from an average of three m^2 plots within each replicate.

MAC RESULTS (Extension Service)

Date	Crop	Observation	
01 Jul 1996	sesbania	plant at 60 lb/A	
	cowpea	plant at 80 lb/A	
	sunnhemp	plant at 80 lb/A	
	kenaf	plant at 80 lb/A	
	sudangrass	plant at 80 lb/A	
29 Jul (28 DAP)	sesbania	12-in height*	2.2 plants/3 ft row**
	cowpea	5.1-in height	8.5 plants/3 ft row
	sunnhemp	8.8-in height	23.7 plants/3 ft row
	kenaf	3.6-in height	23 plants/3 ft row
	sudangrass	23.4-in height	47.8 plants/3 ft row
03 Sep (70 DAP)	sesbania	6-8 ft height	7,794 lb/A***
	cowpea	1-2 ft height	5,184 lb/A
	sunnhemp	4-5 ft height	10,551 lb/A
	kenaf	1-3 ft height	2,390 lb/A
	sudangrass	6 ft height	19,816 lb/A

Irrigation dates: 01, 22 Jul and 20 Aug.
* Height measurements taken from average of 10 plants of each replicate
**Stand counts taken from 10 subplots of each replicate
***Yields taken from 3 ft X 50 ft area within each replicate

COOL SEASON LEGUMES

Papago peas and the Biomaster peas were planted on December 10 while the purple and Lana vetch were planted on December 16. Plants germinated within 2 weeks after planting. Due to the cool temperatures all of the plantings exhibited very slow growth. A more appropriate planting time would be October.

1997 RESULTS

SPECIES	DENSITY* (PLTS/FT^2)	PLANT HT (IN)	YIELD (LB/A) FRESH WGT.	WATER APPLIED (AC. IN.)
Biomaster Pea	4.7	32.5 (135 DAP)	8,756[1]	7" - loam soil 21" loamy sand
Papago Pea	8.8	42.9 (150 DAP)	4,634[2]	10" - loam soil 18" - sandy loam
Lana Vetch	16.3	28.3 (160 DAP)	3,982[3]	8.5" - loam soil 12.5" - sandy loam
Purple Vetch	16.3	25.3 (160 DAP)	9,318[4]	9" - loam soil 14.7" - loamy sand

The Biomaster peas are a short season cover crop. The crop was mature by April 24. We found numerous nitrogen fixing nodules on all of the plants we dug up. The Papago peas were fully matured by the first of

[1 & 4] Plants were green and still actively growing
[2 & 3] Plants were matured and this weight reflects a dry weight versus fresh weight

May and again we found numerous nodules on the roots of all the plants we dug up. Plant density for both of the peas was not sufficient to effectively suppress all of the weeds. However, the Papago peas did have fewer weeds versus the Biomaster pea. Lana vetch was the best performer with regards to plant density, ground cover and weed suppression. Fields were completely covered and gave very effective control on London rocket and other winter weeds. We found an abundance of nodules which would lead one to assume that of the four species this one would have the highest nitrogen production. Purple vetch had the same plant density but did not provide similar ground cover and weed suppression as Lana vetch. Numerous root nodules were found but not as abundant as Lana. Purple vetch remained green until the end of June.

1998 RESULTS

SPECIES	DENSITY* (PLTS/FT^2)	PLANT HT (IN) 99 DAP	PLANT HT (IN) 160 DAP	YIELD (LB/A) FRESH (4/13/98)/ DRY WGT (5/12/98).	WATER IRRIG (AC. IN.) & RAIN[1]
Biomaster Pea	19.2	10.9	17.4	20,089 / 4,327	5.4 / 10.36”
Papago Pea	14.0	11.9	29.1	26,649 / 5,602	7.1 / 10.36”
Lana Vetch	8.7	3 to 7	21.9	34,984 / 7,303	5.4 / 10.36”
Hairy Vetch	13.6	1 to 2	17.7	14,147 / 2,155	3.6 / 10.36”

1 = Inches of rainfall from November 1997 through March 1998 (El Nino event)

The 1998 plantings involved all the same species as used in 1997 except for Purple vetch which was replaced by Hairy vetch. Yields were considerably higher versus the 1997 results. This is probably due to the amount of rain that was received due to the El Nino event of 1998 and the longer growing season due to the lower temperatures in March through April. All species were planted on November 4, 1997 using a grain drill with a row spacing of 7 inches. Planting rate was 80 bulk pounds per acre and seed was sown to a depth of 0.5 inches. Biomaster peas began flowering on 2/5/98 and finished flowering on 3/8/98. Root nodules were very common within 2 to 3 inches of the soil surface and were generally 1” x 1” in size. Papago peas started flowering about 2/23/98 and finished on 3/27/98. Root nodules were similar the biomaster peas in abundance and location below the soil surface but were 1/2” x 1/2” in size. Lana vetch started flowering on 3/15/98 and finished flowering on 4/27/98. Root nodules were numerous but smaller as compared to the Papago peas. Lana vetch provided the best stand and ground cover which in turn provided excellent control of mustard. Hairy vetch did not grow well until late March which allowed a excellent stand of mustard to develop. Flowering did not start until 3/14/98 and was turned under on 4/14/98. Root nodules were small and not as numerous as the other legumes.

In summary, if a short season winter cover crop is desired then the Biomaster pea is a good candidate while if the goal is weed suppression then Lana vetch is a clear winner. However, if a longer season winter cover crop is desired then Purple or Hairy vetch should be considered as well as the Papago peas.]

STUDY NUMBER: 04C9704M & 04C9705M

Winter Forage Cover Crop Trials/Final Report

PROJECT NUMBER: CP1.5

Controlling erosion on cropland with cover cropping and residue management systems in the arid, semiarid and summer dry parts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Cropland

VEGETATIVE PRACTICES:
PRIMARY: 340 COVER AND GREEN MANURE CROP

SECONDARY: 328 CONSERVATION CROP ROTATION

TERTIARY: 327 CONSERVATION COVER

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Soil	Soil condition; tilth, crusting, water infiltration, organic
SECONDARY:	Air	Air quality, other.

DESCRIPTION:

Soil improvement benefits from leguminous cover crops are well documented. However, traditional southwestern cotton farming practices have not utilized cover crops for a number of reasons including increased production costs and the lack of a productive, high forage quality, short season legume. Blowing dust and potential PM-10 violations are growing concerns in many of the cotton producing areas in Arizona. Mohave Valley experiences its highest wind velocities and lowest rainfall from December to February which coincides with the fallow period between cotton crops. Winter cover crops, which could provide a profitable hay crop, have been suggested as a best management practice to reduce fugitive dust emissions. Also, some growers are becoming interested in growing cotton organically. Cover crops that will supply nitrogen and fit the time available between cotton crops need to be identified and evaluated. The objectives of these trials were to evaluate various winter cover crops for forage production, forage quality as hay for the horse or dairy cows market, and their suitability as a cover crop following cotton.

Seco barley is a water efficient “one irrigation barley” grown for forage, grain, and as a cover crop in south central Arizona. Multi-cut berseem clover has been grown as a fall sown winter hay crop in California deserts and can produce 10-12 tons of high quality hay in 8 cuttings during the period from 1 Dec through July when sown by October. Biomaster pea is a winter forage with high nutritive quality, is well adapted to climates with mild winters, and becomes quickly established. Lana woolypod vetch is commonly grown as a green manure crop and its spreading, viney growth habit provides a fast ground cover. Hairy vetch is used in the eastern United States as a fall sown green manure crop for summer vegetables.

DURATION OF STUDY: 1997 through 1998

STUDY LEADER: Art Meen, Tim C. Knowles, and Bruce Munda

LOCATION: Marana, AZ, and Mohave Valley, AZ

Materials and Methods:

Trials were conducted at the Tucson Plant Materials Center (PMC), Tucson, AZ, Bill Worthy farms, Marana, AZ and Victor Wakimoto farms on the Fort Mohave Indian Reservation near Bullhead City, AZ. The Marana and Fort Mohave Indian Reservation trials were sown following the 1997 cotton crop. Soils at these sites were listed as highly erodible land (HEL). On HEL soils it is desirable to maintain an adequate cover during the winter and spring months to reduce wind erosion.

Traits evaluated included: height, formation of nitrogen fixing nodules, stand, and biomass production. Species planted at the PMC were: hairy vetch, Lana vetch, Papago pea, and Biomaster pea. Species planted at Worthy farms were: Papago pea, Lana vetch, and Biomaster pea. Species planted at the Wakimoto farms were: Biomaster pea, Lana vetch, Seco barley, and Berseem clover. A *Rhizobium* inoculant was added to all species except Seco barley. A sticking agent was used to ensure a good bacteria coating on the seed. Multi-cut berseem clover was pre-inoculated, coated, by the seed vendor.

At the PMC, crops were sown on 03-05 Nov. 1997 in four borders totaling 1.0 acres for each species except hairy vetch which was sown in two borders totaling 0.5 acres. All species were drill seeded at 70-80 lb/A at a depth of 0.5-1.0 inches. One irrigation was applied following planting. Soils are Anthony loamy fine sand and Comoro fine sandy loam. Plantings did not receive supplemental fertilization.

At Worthy farms, crops were sown on 01 Jan 1998. Each species was planted in two-acre blocks at 75-80 lb/A at a depth of 0.5-1.0 inches. Sowing was delayed due to a late cotton harvest and heavy precipitation during Dec. 1997. Soils are Gila sandy loam and Vinton loamy sand. One irrigation was applied after sowing. This trial received subsequent irrigations but these were not recorded. Supplemental fertilizations, if any, were not recorded.

At Wakimoto farms, crops were sown on 25 Dec. 1997 into 6 inch rows. Each forage was planted into one three acre border. Biomaster pea and Seco barley were each sown at 75 lb/A at a depth of 0.5-1.0 inches. Lana vetch was sown at 90 lb/A and 0.5 inches deep. Berseem clover was sown at a rate of 25 lb/A and 0.5 inches deep. Soils are Lagunita sand in the south half of the field and Holtzville silty clay in the north half of the field. Due to differences in production for each soil type, yield and quality measurements were conducted for both soil types. The planting received one irrigation on 02 Jan 1998 with 15 gallons of urea ammonium (UAN32) applied with the irrigation water. Two hundred pounds of ammonium phosphate (16-20-0) was broadcast applied and disked in preplant. Emergence occurred by mid-January for all four crops.

All clipping measurements were conducted with a 9.6 ft^2 frame. Four frames were clipped for each species, border, and soil type. Fresh weight was recorded in grams which allowed for conversion to pounds per acre by multiplying the fresh weight by 10.

STATUS OF KNOWLEDGE:

LITERATURE CITED:

TECHNOLOGY TRANSFER PRODUCTS: Paper

FOTG ACTIONS: Update cover crop information

OTHER ACTIONS: Technical Note

Results and Discussion

At the PMC, 100 days after planting (DAP), stand and height measurements were taken (Table 1). Height and fresh weight measurements were made on 14 Apr 1998, 162 DAP, and dry weight measured on 12 May 1998 (Table 1). Hairy vetch did not initiate vigorous growth until late March, allowing a good stand of

mustard to establish. Flowering did not begin until 13 April. Nodules were found but they were few and small. Lana vetch had the highest fresh and dry weight yields among all species tested at the PMC. Lana vetch covered the ground and out-competed emerging mustard seedlings. Lana vetch initiated flowering on 15 Mar and finished flowering the end of April. On 13 Apr, Lana vetch plants had numerous small nodules. These grew well through the spring and matured in mid-May. Papago pea had the second highest fresh weight yield. Plants grew well throughout the season and competed well with mustard especially where the stand was uniform and thick. Papago pea began flowering on 23 Feb and finished flowering on 27 April. Nodules were abundant with many measuring 1/2 inch in diameter. Plants had matured by mid-May. Biomaster pea initiated flowering on 23 Feb. This variety had the largest nodules of all the species with some nodules measuring 1 inch in diameter. Nodules were common in the upper 2-3 inches of the soil but were found as deep as 6 inches. Biomaster pea had the shortest growing season with fruit set by 13 April and matured plants by the end of April.

At Worthy farms on 2 Mar, 46 DAP, stand and height measurements were taken (Table 2). These plots were not clipped until 13 May, 118 DAP. At this time all of the species had matured. Due to warm temperatures in May, the soil's low water holding capacity, and infrequent irrigation's, biomass yields were low (Table 2). Plant height measurements were not taken. Biomaster pea performed best in terms of yield, followed by Lana vetch and Papago pea. However, the Biomaster pea was planted close to an existing wheat crop and probably benefited from excess irrigation water. Nodules were found on all species but were smaller and not as numerous as those found at the PMC.

At Wakimoto farms on 19 Feb, 50 DAP, height and stand density was measured (Table 3). Height and yield measurements were taken on 26 Mar, 91 DAP, (Table 4). Forage quality, for all crops, was measured on 11 Mar 1998 for both soil types (Table 5). Only one cutting was possible for the production period going from 25 Dec through 26 Mar for all four forages. Spring forage yields were poor during the short production period for berseem clover sown on either soil and Biomaster pea sown on the silty clay soil. Highest forage yields resulted from sowing Biomaster pea or Lana vetch on the sandy soil and Seco barley or Multi-cut berseem clover on the silty clay soil (Table 4). Multi-cut berseem clover was slow growing and produced low tonnage and relatively lower quality hay, compared to the other forage crops. This was due to the late planting date which resulted in very slow establishment. Lana vetch produced ample tonnage and good quality hay but due to its low, spreading, growth habit it was too short to cut for hay with a mechanical harvester or swather. However, it provided a fast ground cover and would make an excellent green manure crop with its relatively high tonnage and very high nitrogen content. Seco barley was also a fast growing ground cover and produced high tonnage compared to the other forages. However, it had a relatively poor hay quality. Grown under the conditions of this study, it would be a good choice for a residue/ erosion control crop. Biomaster pea had relatively high hay tonnage, high protein levels, and low acid detergent fiber levels, compared to the other forages grown in this study. It was not harvested mechanically for hay, but seemed to cure well enough to put up an acceptable bale. Nodules were found on the all of the legumes with Biomaster pea having the largest at approximately 1/4 inch in diameter.

In summary, Biomaster pea, Lana vetch, and Papago pea have potential as winter cover crops. Biomaster pea, due to its shorter growing season, may be the best suited variety. Forage yield potentials for the above crops will be reevaluated during 1998-99.

Acknowledgments

Appreciation is extended to Bill Worthy Farms and Victor Wakimoto Farms for their efforts in conducting these trials.

Table 1. Winter Cover Crops at the Tucson Plant Materials Center

Forage	Stand (plts/ft^2) (100 DAP) 11 Feb 1998	Height (in) (100 DAP) 11 Feb 1998	Height (in) (162 DAP) 13 Apr 1998	Fresh Weight (lb/A) (162 DAP)	Dry Weight (lb/A)
Hairy vetch	6.8	1.5	17.7	14,147	2,155

Papago pea	7.0	11.9	29.1	26,649	5,602
Biomaster pea	9.6	10.9	17.4	20,089	4,327
Lana vetch	4.4	5.0	21.9	34,984	7,303

Table 2. Winter Cover Crops at Bill Worthy Farms

Forage	Stand (plts/ft^2) (46 DAP) 2 Mar 1998	Height (in) (46 DAP) 2 Mar 1998	Fresh Weight (lb/A) (118 DAP)	Dry Weight (lb/A)
Biomaster pea	1.9	4.6	8,125	3,275
Papago pea	2.4	2.3	1,875	1,275
Lana vetch	6.5	3.0	6,625	3,375

Table 3. Winter Cover Crops at Victor Wakimoto Farms measure 11 Mar 1998 (76 DAP)

Forage	Soil Type	Ground Cover (%)	Plants / ft^2	Height (in)	Width (in)	Dry Weight (lb/A)
Biomaster pea	sand	54	4.4	13.6	8.8	752
	silty clay	55	6.6	10.4	6.0	618
Lana vetch	sand	73	7.7	0.8	7.4	360
	silty clay	51	6.8	0.8	6.8	205
Seco barley	sand	65	13.4	10.4	6.0	794
	silty clay	90	10.3	16.8	7.2	2108
Multi-cut berseem clover	sand	65	30.6	2.8	3.2	351
	silty clay	67	25.2	2.8	3.4	329

Table 4. Winter Cover Crops at Victor Wakimoto Farms

Forage	Soil Type	Height (in) (50 DAP) 19 Feb 1998	Height (in) (91 DAP) 26 Mar 1998	Fresh Weight (lb/A) (91 DAP)	Dry Weight (lb/A)
Biomaster pea	sand	6.0	18.0	4,750	3,119
	silty clay	4.5	15.0	2,940	1,701
Lana vetch	sand	2.5	6.0	4,310	3,686
	silty clay	2.5	5.0	3,560	2,552
Seco barley	sand	7.0	16.0	2,840	2,835
	silty clay	7.0	32.0	8,940	7,860
Multi-cut berseem clover	sand	1.0	4.0	1,030	659
	silty clay	1.0	6.0	3,050	1,701

Table 5. Winter Cover Crops Victor Wakimoto Farms: Forage Quality Analysis

Forage	Neutral Detergent Fiber (%)	Acid Detergent Fiber %)	Crude Fiber (%)	Crude Protein (%)	Nitrogen (%)

Biomaster pea	27.8	23.3	18.4	23.6	3.8
Lana vetch	26.6	21.1	16.7	30.3	4.8
Seco barley	41.7	25.4	20.0	15.6	2.5
Multi-cut berseem clover	31.5	19.4	15.4	19.2	3.1

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TUCSON PLANT MATERIALS CENTER

STUDY NUMBER: 04F9707R

'Pete' Eastern Gamagrass Field Planting / Final Report

PROJECT NUMBER: CP1.5

Controlling erosion on cropland with cover cropping and residue management systems in the arid, semiarid and summer dry parts of the U.S.

STUDY TYPE: Comparative Evaluation

LAND USES: Cropland, Pastureland

VEGETATIVE PRACTICES:
PRIMARY: 512 PASTURE AND HAYLAND PLANTING

SECONDARY: 327 CONSERVATION COVER

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants suitability, other.
SECONDARY:	Animals	Animals habitat, food.

DESCRIPTION:
This field planting is being conducted to evaluate the adaptability of 'Pete' Eastern gamagrass as a pasture and/or silage plant in southern Arizona. Evaluation factors to be recorded are: soil type, irrigation frequency & amount, percent stand, dormancy or frost date, yield and cooperators comments concerning management and suitability.

DURATION OF STUDY: 1997 through 2000

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: Paul Palmer, Farmer; Douglas Field Office and Manhatten PMC.

METHODS AND MATERIALS:
We provided 95 lbs of Pete which will be seeded in early June at a rate of 10 pounds per acre and at a depth of 1 inch. Seed will be drill planted and irrigated up using a center pivot irrigation system. Seed quality is 99.82 pure seed, germination = 21 5 with 47% other viability and PLS = 67.88 %. Dormancy is a problem with eastern gamagrass seed. We followed Manhatten PMC stratification procedures which are: presoak the seed for 20 minutes in a 10:1 water/Clorox solution, rinse, presoak seed (in a burlap sack) with a 0.5% thiram mixture for a minimum of 12 hours, rinse, and store in a cold environment for a minimum of 6 weeks. We stored our seed in the PMC cooler which maintains the temperature at 35 °F and the RH at 35%. Seed lot information--Lot # SFD-93-0&0, pure seed = 99.8%, germ = 21%, other viability = 47%, PLS = 67.88%. Evaluation factors will include: planting date, percent stand, height at end of growing season, dormancy date and yield.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Update FOTG with regards to the pasture/hayland practice.

OTHER ACTIONS:

RESULTS

1997

'Pete' eastern gamagrass was planted on June 25, 1997 at a rate of 10 pounds per acre. The planting was irrigated with a center pivot sprinkler system. Seed was sown to a depth of 1.0 inches. The planting was irrigated approximately every 5 days. The planting was inspected on July 18, 1997 and we found just a few established seedlings. We considered the planting a failure. We had retained a small amount of seed at the PMC and tried germinating (July & August) the seed in the greenhouse under an intermittent mister system. We had very poor germination, with less than 90 seeds germinating out of 6 trays (98 cells/tray) and 3-4 seeds per cell. Mr. Palmer would still be interested in gamagrass if we could secure a seed lot with good germination.

STUDY NUMBER: 04F9708M

'Seco' Barley Field Planting / Final Report

PROJECT NUMBER: CP1.5

Controlling erosion on cropland with cover cropping and residue management systems in the arid, semiarid and summer dry parts of the U.S..

STUDY TYPE: Comparative Evaluation

LAND USES: Cropland

VEGETATIVE PRACTICES:
PRIMARY: 340 COVER AND GREEN MANURE CROP

SECONDARY: 327 CONSERVATION COVER

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Soil	Soil condition, other.
SECONDARY:	Soil	Soil condition; tilth, crusting, water infiltration, organic

DESCRIPTION:
This field planting will compare 'Seco' against 'Solum' with the objective to see which cultivar is best adapted to the Elfrida area concerning biomass production, silage and/or grazing.

DURATION OF STUDY: 1996 through 1997

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: Paul Palmer, Douglas Field Office

METHODS AND MATERIALS:
January 17, 1997 approximately 350 lbs. of Seco was delivered to Mr. Palmer. Seeding rate was 60 lbs. per acre with seed drill seeded to a depth of 3/4 to 1 inch deep. Planting will be evaluated of stand, irrigation frequency and quantity, and production.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Update FOTG on cover crop practice.

RESULTS
1997
Trial was sown on 3/15/97. Species included were Seco, Solum, and Barcot. All received 24" of irrigation. Barcot received 200 units of N, Seco and Solum each received 100 units of N. Planting was evaluated on 6/12/97. Barcot had an average of 6 kernals per spike and an average height of 16", Seco was in the hard dough stage with an average of 8 kernals per spike and an average height of 24" (one border of seco did not receive nitrogen and its average height was 12", 4 kernals per spike, and was in the hard dough stage, Solum had an average height of 27" and 8 kernals per spike. Number of kernals is per spikelet row for the

above plants. Seco was seeded at 60-80 lbs/A, Solum 80lbs/A, and Barcot was sown at 160lbs/A. All were sprayed with 2,4D to control broadleaf weeds. Nitrogen was in the anhydrous ammonia NH3+ form. Typical yields for barley in this area have been 8,000lb/A. Unfortunately, when the plots were harvested yields were not kept separate. Mr. Palmer did indicate that Solum had a higher yield than Seco. Of course this is to be expected since it was developed for higher yields vs. Seco and the flowers were in the milky stage vs. Seco being in the soft or hard dough stage and generally had more kernals per spike.

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STUDY NUMBER: 04C9810M

'Donegal' Soybean Trial / Final Report

PROJECT NUMBER: PH4.1
Improving the production and soil protection with warm season plants in the arid and semi-arid parts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Cropland

VEGETATIVE PRACTICES:
PRIMARY: 340 COVER AND GREEN MANURE CROP
SECONDARY: 327 CONSERVATION COVER

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Soil	Soil condition, other.
SECONDARY:	Soil	Soil condition; tilth, crusting, water infiltration, organic

DESCRIPTION:
This is a cultural evaluation of 'Donegal' soybeans. Mr. Palmer is interested in improving the quality of his hay operation by adding a productive warm-season legume.

DURATION OF STUDY: 1998 through 1998

STUDY LEADER: Bruce Munda

LOCATION: Arizona PMC

COOPERATORS: Paul Palmer, Douglas Field Office, and Dr. Thomas E. Devine, ARS

METHODS AND MATERIALS:
Provided 5 pounds of soybean seed (from Dr. Devine) which was planted on June 26, 1998. Evaluations will include: amount of water applied, height, yield, date harvested, susceptibility to lodging, insects, and diseases.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Update FOTG on cover crop practice.

RESULTS
1998
Seed was sown on 30" rows with a corn planter on June 26, 1998. Stand establishment was good some grazing by rabbits was observed but was not considered detrimental. Amount of water applied was not recorded. Visual observations by Mr. Palmer indicated that there was little to no insect damage, no observed lodging, or disease damage. Due to the small area planted Mr. Palmer was unable to conduct yield measurements. As of October 1, 1998 the Donegal variety has not performed to Mr. Palmers expectations. The plants were 36 inches tall, not much taller than commercial soybeans. It does not appear that this variety has performed as it has in the eastern states.

STUDY NUMBER: 04C9811M

Woolypod Vetch Strain Trial

PROJECT NUMBER: CP1.5

Controlling erosion on cropland with cover cropping and residue management systems in the arid, semiarid and summer dry parts of the US.

STUDY TYPE: Comparative Evaluation

LAND USES: Cropland

VEGETATIVE PRACTICES:
PRIMARY: 340 COVER AND GREEN MANURE CROP

SECONDARY: 328 CONSERVATION CROP ROTATION

TERTIARY: 327 CONSERVATION COVER

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Soil	Soil condition; tilth, crusting, water infiltration, organic
SECONDARY:	Air	Air quality, other.

DESCRIPTION:

Soil improvement benefits from leguminous cover crops are well documented. However, traditional southwestern cotton farming practices have not utilized cover crops for a number of reasons including increased production costs and the lack of a productive, high forage quality, short season legume. Blowing dust and potential PM-10 violations are growing concerns in many of the cotton producing areas in Arizona. Winter cover crops have been suggested as a best management practice to reduce fugitive dust emissions. Also, some growers are becoming interested in growing cotton organically. Cover crops that will supply nitrogen and fit the time available between cotton crops need to be identified and evaluated. The objective of this trial is to evaluate various strains of Woolypod vetch for forage production.

Woolypod vetch, *Vicia villosa*, is commonly grown as a green manure crop and its spreading, viney growth habit provides a fast ground cover. Eight strains of woolypod vetch were planted at the Tucson PMC as well as Lockeford PMC, University of California at Davis, and Solano County, CA.

DURATION OF STUDY: 1998 through 2000

STUDY LEADER: Walter Graves and Bruce Munda

LOCATION: Tucson PMC, AZ

Materials and Methods:

Eight strains of Woolypod vetch were sown on February 2, 1998. Strains included: PI 547068, 'Lana', 'AU Earlycover', NSSL 4639, CA-95-4, PI 308876, 'NAMOI', and SCO-5233. The planting is a randomized complete block with three replications. Strains were sown using the four row plot planter and seeds were sown to a depth of 0.5". Planting was installed at the Tucson PMC in field two border five. Evaluations taken were: height and number of plants per foot of row on 3/14/98 and yield on 6/25/98. Yield samples were taken using a $9.6ft^2$ plot frame which harvested 2 to 3 rows within each replication. Each plot was 13' long by 6' wide and had four 16" rows.

STATUS OF KNOWLEDGE:

LITERATURE CITED:

TECHNOLOGY TRANSFER PRODUCTS: Technical note

FOTG ACTIONS: Update cover crop information

OTHER ACTIONS:

Results and Discussion

Height and density measurements were taken on 3/14/98 and yield measurements were taken on 6/25/98. NSSL 4639 had the highest yield followed by PI 308876 and 'Lana'. The NSSL 4639 line is close to the original material from the 'Lana' variety. This material was stored at the Fort Collins Seed Storage Laboratory since 1959. See the following table for height and yield information.

A persistent problem with these trails has been rabbits! They prefer vetch plants over barley and peas. Small plantings such as these strain trails must be fenced to exclude rabbits. AU Earlycover appears to be the most palatable of the eight strains and was severely grazed to the point that all of the plots had no biomass for the yield evaluation.

This trail will continue in the spring of 1999.

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INTERCENTER VETCH STRAIN TRIAL/PLANTED 2/2/98 AND HARVESTED 6/25/98

Species	Rep. #	height (in) 3/14	No. plts/foot of row (3/14)	Ave. dry weight yield (g)	estim. yield/ lbs per acre
PI 547068	one	2.2	4.6	162	
	two	2.2	5.7	181	
	three	2.0	4.4	153	
	Average	**2.1**	**4.9**	**165.3**	**1,653**
Lana	one	1.9	5.0	192	
	two	1.9	5.0	196	
	three	2.0	5.5	207	
	Average	**1.9**	**5.2**	**198.3**	**1,983**
AU Earlycover	one	0.8	4.8	no data	
	two	1.0	4.6	no data	
	three	0.6	5.2	no data	
	Average	**0.8**	**4.9**	**no yield/grazed by rabbits**	
NSSL 4639	one	1.9	6.0	283	
	two	1.9	4.9	258	
	three	2.0	4.4	253	
	Average	**1.9**	**5.1**	**264.7**	**2,647**
CA-95-4	one	1.3	3.4	162	
	two	1.7	3.3	156	
	three	1.6	3.5	164	
	Average	**1.5**	**3.4**	**160.7**	**1,607**
PI 308876	one	1.9	4.5	198	
	two	1.7	4.6	211	
	three	1.9	4.6	215	
	Average	**1.8**	**4.56**	**208.0**	**2,080**
NAMOI	one	1.3	3.2	130	
	two	2.5	3.3	138	
	three	1.6	3.2	129	
	Average	**1.8**	**3.2**	**132.3**	**1,323**
SCO-5233	one	1.7	3.9	152	
	two	1.5	6.0	176	
	three	1.6	5.5	168	
	Average	**1.6**	**5.1**	**165.3**	**1,653**

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NATURAL RESOURCES CONSERVATION SERVICE
TUCSON PLANT MATERIALS CENTER

STUDY NUMBER: 04F9408R

Heaton Farms Field Planting

PROJECT NUMBER: CP7.1

Improving plant production on saline soils in the western states

STUDY TYPE: Comparative Evaluation

LAND USES: Pastureland, Hayland

VEGETATIVE PRACTICES:
PRIMARY: 512 PASTURE AND HAYLAND PLANTING

	RESOURCE	CONSIDERATION/PROBLEM
PRIMARY:	Plants	Plants suitability, plants are not well adapted to site.
SECONDARY:	Soil	Soil condition, other.

DESCRIPTION:
The field planting was designed to evaluate 2 pasture and hayland grass alternatives to tall wheatgrass on saline-sodic soils. "Newhy" hybrid wheatgrass (*Elytrigia repens* x *Pseudoroegneria spicata*) and "RS-Hoffman" quackgrass (*Elytrigia repens*) were planted on November 1, 1994 in three borders of a small irrigated field. "Spredor 3" and "Cimarron VR" alfalfa varieties are also part of the trial.

DURATION OF STUDY: 1994 through 1999

STUDY LEADER: Fredonia Field Office & Tucson PMC

LOCATION: Arizona PMC

COOPERATORS: Fredonia Field Office, Gene Heaton (farmer), Tucson PMC

METHODS AND MATERIALS:
Study is evaluating three seeding strategies. First, seeding "Newhy" hybrid wheatgrass and "RS-Hoffman" quackgrass individually, second is seeding the two grasses after seeding the alfalfa varieties "Spredor 3" and "Cimarron VR" and third is seeding the grasses before seeding the alfalfa. Border A is split with half seeded to "Newhy" and half to "RS-Hoffman". Border D is split with half seeded to "Spredor 3" and "Newhy" and half seeded to "Spredor 3" and "RS-Hoffman". Border E is split between Newhy with Cimarron VR and RS-Hoffman with Cimarron VR. The grasses were seeded at a rate of 7-8 #/acre and were drill seeded using a rangeland drill. Seeding depth was 1/2 to 3/4 inches deep. The alfalfa was broadcast seeded at a rate of 10-12 #/acre. Soil has a clay loam texture. Two soil samples were analyzed one from borders D and E and the second from border A. The first sample has a pH of 8.6, electrical conductivity (EC) was 11.0 mmhos/cm and exchangeable sodium percentage (ESP) was 12.2 %. This sample places borders D and E on the break between saline and saline-sodic. Alfalfa is considered moderately sensitive to salts, and germination is reduced by 50% when EC is 8-13 mmhos/cm. The second sample had a pH of 8.6, EC of 12. mmhos/cm, and ESP of 16%. This sample places border A well into the saline-sodic category. This will be a good test for these alternative grasses. Even tall wheatgrass, with yield reduction threshold of 7.5 mmhos/cm for EC, loses some productivity on these sites.

TECHNOLOGY TRANSFER PRODUCTS:

FOTG ACTIONS: Update pasture planting practice, especially for saline-sodic soils

OTHER ACTIONS: Fact sheet on planting recommendations for saline-sodic soils.

RESULTS:

1995
This trial was initiated during one of the wettest years on record. From October 1994 through September 1995 the area received 16.22 inches of precipitation. The planting area was also irrigated lightly in early April with a heavier irrigation applied in early May 1995.

The first evaluation was conducted on March 8, 1995. Both grasses were emerging with the alfalfa just starting to germinate. By March 28 the grass seedlings were up and appeared to be well established. There were a few scattered alfalfa seedlings in the 2-leaf stage.

The third evaluation was on April 26, 1995. Border A had a fairly consistent stand of both grasses, with no apparent difference between the two species. In borders D and E the grasses appeared to be a little spotty. This was attributed to the difficulty of evenly planting a small amount of seed through a range drill. There were very few Spredor 3 seedlings in Border D, where the weed competition was very heavy. There were a few more Cimarron VR seedlings in Border E, but alfalfa emergence was very disappointing.

By June 21, 1995 the trial grasses had begun to seed out and the alfalfa, although still pretty thin, was growing well. There was a lot of competition in all borders from annuals, desert saltgrass, perennial Hordeum, and tall wheatgrass. Border A also had a lot of black greasewood coming up.

The final evaluation was conducted on September 14, 1995. Both varieties of grass have established well, with no apparent difference between them. Many of the plants have flowered and produced seed. The alfalfa stands are better than originally thought. There are still many bare patches, with the Cimarron VR established itself better than the Spredor 3. There are some new seedlings that have germinated with late summer rains. Some of the mature plants have produced seed. Gene Heaton plans to graze the field in November. Utilization levels will be kept light. It is hoped that we can get some seed trampled in the soil surface. The field trial will be monitored during grazing to see if the cattle have any species preference.

1996
Many of the fields in the Fredonia area are alkaline, severely limiting the type of pasture or crops that can be grown. Officially, these soils are called saline or saline-sodic. Tall wheatgrass grows fairly well on these soils and is used extensively as a pasture grass. However, it can be hard to manage with mature forage being relatively unpalatable to livestock, and makes only fair hay. The purpose of this field trial is to try "Newhy" hybrid wheatgrass and "RS-Hoffmann" quackgrass on these soils, to see if they will perform well enough to be considered as alternatives to tall wheatgrass. Both species are very palatable for grazing and make excellent hay. Two alfalfa varieties, "Cimarron VR" and "Spredor 3", were also planted to see if they would establish under saline conditions. All species were planted in the fall of 1994, to germinate in the spring of 1995. "Cimarron VR" alfalfa is looking promising. The stand is poor in places but very good in others. This variety has excellent pest and disease resistance, and is also tolerant to prolonged periods of wet soils. "Spredor 3" does not appear to well adapted to saline-wet soils. It is a low-growing variety developed for grazing, and hopefully will start to spread by rhizomes. Both grass species appear to doing well. The saline soils have a good stand on the upper end of the field, and a fair stand at the bottom. This difference is partly due to more water available at the top end of the field. There appears to be a limit to the level of salts these grasses can withstand. On the truly saline-sodic soils both grass species have had poor establishment. The grasses are starting to spread by rhizomes, and it will be interesting to see how well they compete with weeds and other undesirable plants that are starting to grow on these soils. "Newhy" hybrid wheatgrass is available from commercial sources.

1998

Both wheatgrass hybrids, Newhy & RS-Hoffman, as well as the Cimarron VR alfalfa appear to well established on the saline soils while all of these species are exhibiting poor establishment and productivity on the saline-sodic soils. It is difficult to tell the hybrid wheatgrasses apart. It is too early to determine if these species are well adapted and should be added to the FOTG for adapted pasture forages. Art Meen will continue observations to determine persistence and ability to spread.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
TUCSON PLANT MATERIALS CENTER

STUDY NUMBER: 04C9813Z

Evaluation of a Rapid Method for Evaluating Broad-Sense Heritability (BSH) Using Data from Stands of Equidistantly Planted Genotypes

PROJECT NUMBER: CP1.5
Controlling erosion on cropland with cover cropping and residue management systems in the arid, semiarid and summer dry parts of the US.

STUDY TYPE: Comparative evaluation

LAND USES: Cropland

VEGETATIVE PRACTICES:

PRIMARY:	340	COVER AND GREEN MANURE CROP
SECONDARY:	328	CONSERVATION CROP ROTATION
TERTIARY:	327	CONSERVATION COVER

	RESOURCE	**CONSIDERATION/PROBLEM**
PRIMARY:	Soil	Soil condition: tilth, crusting, water infiltration, organic
SECONDARY:	Air	Air quality, other.

DESCRIPTION: Our goals in this pilot study were to determine whether: 1) it was feasible to grow individual wheat plants to maturity on 30-cm spacing; and 2) if data taken from these plants could be used to generate BSH estimates comparable to those from the difference method.

Status: Two contiguous blocks of spring wheat, each containing 576 plants (in 24 × 24 grid on 30-cm centers with one row of border plants surrounding the block) were sown at the center in December 1997. One block included 100 plants each from two inbred parents (MT-9408 and 'McNeal') along with 376 plants of their F_2. Plants were placed randomly within the grid and their genetic identities maintained. Estimates of BSH can be generated using data from this plot by the difference method. The other block was sown entirely to the same F_2. BSH will be estimated using data from this block using a technique we have developed using cross-pollinated plants.

Data were collected on height, and stem and spike number per plant at harvest in June 1998. Spikes from each plant were bagged and will be threshed in fall 1998. Based on comparison of the two BSH estimates for agronomically important traits, a planting at the Tucson PMC including at least two replications of each of the two treatments described above will be contemplated for early winter 1998.