Final Report on TAES Water Conservation and Soil Management Project

to

Texas Water Resources Institute

C. Allan Jones, Director

October 27, 2003

Name of Project: Restoration of Hydrologically Dis-functional Rangeland Watersheds, Wildlife Habitats, and Improved Pastures in Western Texas

Geographic Area of the Project: southern Rolling Plains, northern and western Edwards Plateau, eastern Trans Pecos land resource areas

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Abstract

Results from small-plot, preliminary experiments installed in 1995 - 1996 indicated that ripping with a single-shank, parabolic ripper alone or in conjunction with seeding of forage grasses could greatly enhance rainfall infiltration into crusted, severely degraded, termite-infested rangeland soils, facilitate a major increase in forage production, and increase the carrying capacity of degraded rangelands 3.5 to 4 fold. These very positive results during a severe drought stimulated great interest in water conservation technology for restoration of severely degraded rangelands among researchers, ranchers, natural resource managers, and government agencies. Funding from the Texas Agricultural Experiment Station's Water Conservation and Soil Management Project during 2001 - 2003 facilitated the installation of 25 field experiments or demonstrations that have resulted in considerable refinement of existing technology and development of new technology for restoration of severely degraded, termite-infested rangeland in western Texas. Data collected to date have shown that wing ripping and disk diking resulted in rainfall infiltration to a 38 to >60 in. soil depth, compared to only 18 in. on untreated rangeland in a tarbush (*Fluorensia cernua*) plant community in the Trans Pecos region of Texas. Data generated in field trials have shown that wing ripping and disk diking can be installed on 15- to 30-ft horizontal spacings for only $1.67 to $5.50 per acre. A 1-row grass seeder has been developed to facilitate seeding of desirable forage grasses simultaneously with wing ripping or disk diking for a cost of only $1.10 to $2.40 per acre, depending upon the horizontal spacing. The insecticide fipronil has been identified as a highly effective treatment for management and control of desert termites (*Gnathamitermes tubiformans*), which contribute significantly to the downward desertification spiral on degraded rangeland by consuming mulch, litter, and standing vegetation. Completion of the research that has been initiated with funding from the TAES Water Conservation and Soil Management Project will greatly enhance the knowledge base on rangeland restoration technology and facilitate development of effective marketing programs to expedite the transfer of rangeland restoration and desert termite management technology to ranchers, rangeland resource managers, and natural resource management agencies. Preliminary results from this research have stimulated the USDA Natural Resources Conservation Service to develop technical guidelines for ripping and contour furrowing and include these treatments for cost-sharing under the EQIP program in 2003. EQIP contracts are currently being developed for the wing ripping of thousands acres of degraded rangeland in western Texas. Many ranchers in western Texas have already begun ripping or wing ripping at their own expense as a result of the research and demonstration projects described in this report.

The Problem

A high percentage, perhaps as much as 75%, of the rangeland watersheds, wildlife habitats, and improved pastures in the western half of Texas are “at risk” due to the impacts of drought and concomitant attacks by desert termites or grasshoppers. The combined effects of prolonged drought, termites and/or grasshoppers and, in some cases, previous management have created hydrologically dis-functional ecosystems that are unable to absorb and store rainfall and recover naturally when rainfall events occur. Vast landscapes are now dominated by annual grasses and forbs and may be beyond the threshold for natural recovery because the mortality of perennial, warm-season grasses has been extremely high and little or no mulch, standing dead vegetation, or deep-rooted grasses remain to facilitate rainfall infiltration. Without intervention, this conversion of vast landscapes from warm-season, perennial grass dominance to cool-season, annual forb/grass dominance will have long-term negative impacts on water availability/quality, wildlife habitat, livestock production, and sediment yield into the State’s streams, rivers, and reservoirs. Repairing the hydrological processes on these vast landscapes will restore the land for watersheds, wildlife habitat, livestock production, recreation, aesthetics, and real estate, while encouraging the economic viability of rural communities.

Desert termites (*Gnathamitermes tubiformans*) have played a key role in the current, severe desertification cycle via their removal of mulch, litter, standing dead plants, live plants, and the feces of livestock and wildlife from the soil surface. Removal of the vegetative cover leaves the soil surface unprotected from the energy of raindrop impact, resulting in excessive intertill erosion, the destruction of surface soil aggregates, soil puddling, inadequate rainfall infiltration, excessive loss of water to overland flow, and excessive silt loads in runoff water. Strategies for control of desert termites on rangelands or pastures have not been developed, but some highly effective termiticides are currently available for field evaluation.

Water conservation practices which modify the soil micro-relief and fracture impervious soil layers, such as ripping (sub-soiling), wing ripping, and contour furrowing, can be highly effective when integrated with appropriate grazing and weed management strategies, in restoring healthy hydrological cycles and productivity of degraded wildlands and pasture lands. These soil modifications function as temporary “substitutes” for vegetative cover relative to on-site conservation of water, soil, and organic materials. Mechanical soil treatments, if properly installed and spaced, function on the principle of “runoff farming” (i.e., water harvesting), a method developed over 4,000 years ago that involved collecting runoff water from higher elevations with characteristically low infiltration rates for application to small fields in valleys. The limited natural rainfall in arid and semiarid regions can be more effectively used for forage production by using mechanical soil disturbances to collect runoff water from hydrologically dysfunctional rangeland and concentrating the water in bands or “patches” across the landscape. These forage production zones will be in contour bands where treatments such as ripping, wing-ripping, contour furrowing or diking are installed on the contour or in equally spaced patches where pitting is used. “Patchiness” or a banded vegetation pattern is essential for achieving acceptable levels of productivity in arid and semiarid landscapes because if the scant amount of rainfall is spread uniformly over the entire surface there would rarely be enough water in the soil profile to meet the minimum requirements for generating significant “pulses” of growth among the desirable, perennial forage species. Research on rangeland ripping at the San Angelo Center during the current drought has shown that rangeland can be ripped 15 - 18 in. deep, on the contour on 20- to 30-ft. spacings, for <$4/acre. A 5-in. rainfall event infiltrated >5 ft. deep along rips compared to only about 10 in. on unripped areas. Herbage production was almost 1700 lb/acre on ripped landscapes compared to only 400 lb/acre on untreated rangeland in mid August 2001. Ripping increased the livestock carrying capacity to about 29 animal units/section compared to about 8 animal units/section on unripped rangeland.

Accomplishments

Water Conservation and Rangeland Restoration Treatments - San Angelo Center Efforts (Darrell Ueckert, project leader):

We purchased a Bison SVH-1 single shank, parabolic ripper and have used it in numerous experiments and field trials. The 2.63-in.-wide, replaceable cutting tip on this implement and the parabolic design of the ripper shank causes considerable uplifting of the soil and fractures any subsurface hardpans that may be present. Rips are installed to a depth of 18 - 20 in. on the contour on 15- to 30-ft horizontal spacings. Ripping increases surface roughness and leaves a narrow furrow, but we observed in field experiments/demonstrations that the rips often settled in quickly during intense rainfall events on soils with low clay contents and where perennial grass cover was absent and there were no remaining crowns and root systems of dead perennial grasses. However, rips often remained intact and functional for several seasons on sites where crowns and root systems of perennial grasses were present and where soil clay content was higher. The “take-home” lesson learned is that ripping treatments should be installed long before rangeland degradation has proceeded to the “bare ground” stage.

We learned that wing ripping, i.e., attaching a furrow opener to the shank of the Bison SVH-1 ripper, created more substantial and long-lasting surface roughness than did simple ripping. Wing ripping is advantageous, compared to contour furrowing, because this method fractures any subsurface hardpans that may be present and thus increases the porosity of the subsoil to a depth of 18 - 20 in., thereby facilitating rapid and deep rainfall infiltration. Wing ripping creates furrows about 12-in. wide and 5-6 in. deep below the normal soil elevation, thus providing for greater rainfall retention than that achieved with ripping. Furthermore, wing ripping creates ridges of soil about 5 in. above the normal soil elevation on both sides of the furrow. These soil ridges provide greater resistance to runoff than is achieved with ripping. The surface roughness achieved with wing ripping is less prone to be destroyed by intense rainfall events compared to that achieved with simple ripping. However, on sites with no or very sparse perennial grass cover or grass crowns and root systems, we found that surface runoff very frequently breaches the wing rips and that they often settle in during intense rainfall events, leaving little capacity for resisting runoff or for retaining rainfall.

Since wing-rips also frequently “settle in” rapidly on sites devoid of grass cover and where excessive amounts of surface runoff flow onto treated areas from adjacent, higher elevations, we perceived a need for a soil modification method which would provide even greater resistance to surface runoff. The method we have selected for this is “disk diking”. Disk diking is achieved by attaching two sets of opposing disk bedders to the tool bar on a farm tractor with the leading set of disks set farther apart than the trailing set of disks. This implement is similar to those used for creating the dikes between borders used for flood irrigation. We had the implements necessary for disk diking already on hand at the San Angelo Center. The disk diker creates a broad-based ridge of soil about 6 in. above the normal soil elevation and about 4 ft wide at the base with a furrow about 3 in. deep on each side of the soil ridge. Disk dikes are installed on 15- to 30-ft horizontal spacings. We have observed much less breaching of disk dikes by surface runoff compared to wing-rips. However, frequent breaching of dikes has occurred where surface runoff from adjacent, untreated areas flowed onto diked rangeland. The “take-home” lesson learned is that mechanical soil treatments should be installed first on the upper slopes of degraded rangeland to avoid the destructive, cascading effects of excessive surface runoff from adjacent, higher elevation range sites. Data collected to date suggest that the depth of rainfall infiltration is less for disk diking compared to wing ripping, apparently because disk diking does not fracture the subsoil layers. However, disk diking may be advantageous over wing-ripping, relative to germination and emergence of seeded grasses, because the soil surface may remain wet longer following rainfall events. Disk diking is advantageous over ripping and wing-ripping where large rocks or stumps are present in the soil because the disks will ride over these obstacles which can cause the shear pin to break on the ripper shank. Disk diking is also advantageous over ripping and wing-ripping when soils are very dry and compacted because it creates less draft on the tractor. Estimates of efficiency of the disk diker on a very dry, hard soil in a tarbush community east of Fort Stockton, Texas are shown in Table 1.

Table 1. Estimated efficiency of the disk diker pulled by a 55-hp rubber-tired tractor in 3rd gear in a very dry, hard desert soil near Fort Stockton, Texas on June 19, 2003. Tractor cost estimated at $11.67/hr and labor cost estimated at $10/hr. Estimates were calculated from the time (minutes) required to pull the disk diker distances of 2500 ft (4 samples).

Space between dikes (ft)	Efficiency (acres/hr)	Cost ($/acre)
15	6.47	$3.35
20	8.63	$2.51
25	10.78	$2.01
30	12.94	$1.67

We are using a 5-ft soil probe made of 0.25-in.-diameter steel rod to estimate the depth of rainfall infiltration along the above-described soil disturbances and on adjacent untreated rangeland. This probe can be pushed into a moist soil quite easily, but can not be pushed into dry soil layers. At one study site in the Trans Pecos region east of Fort Stockton, Texas about 12 inches of rain were received in numerous rainfall events during the period August 29 - October 11, 2003. Using the soil probe on October 20, 2003, we found that the average depths of rainfall infiltration was 18 in. on untreated rangeland, 46 to 49 in. in the furrow on the upslope side of dikes spaced 15, 20, or 30 ft apart, 58 in. in wing-rips spaced 15 ft apart, and >60 in. in wing rips spaced 30 ft apart. In addition to determining the maximum depth of rainfall infiltration, the soil probe is also used at 1-ft or 2-ft spacings upslope and downslope from the mechanical soil disturbances to characterize the rainfall infiltration patterns within the band of soil influenced by these mechanical soil treatments. Profiles of the depth of rainfall infiltration on 2-ft spacings upslope and downslope from wing rips and dikes are shown in Table 2.

Table 2. Average depth of infiltration (in.) of approximately 12 in. of rainfall during August 29 - October 11, 2003 in a tarbush community east of Fort Stockton, Texas estimated with a 60-in. soil probe on October 20, 2003. Means calculated from measurements on five different wing rips or dikes for each spacing. Average depth of infiltration on five adjacent, undisturbed areas was 18 in.

Distance from rip or dike	Wing rips 15-ft spacing	Disk dikes 15-ft spacing	Disk dikes 20-ft spacing	Disk dikes 30-ft spacing	Wing rips 30-ft spacing
16 ft upslope				15	22
14 ft upslope				20	18
12 ft upslope				19	26
10 ft upslope			17	16	29
8 ft upslope	26	31	17	19	22
6 ft upslope	36	33	28	24	24
4 ft upslope	49	42	38	31	42
2 ft upslope	57	49	49	47	58
Furrow or dike	58	43	40	38	>60
2 ft downslope	56	36	32	29	59
4 ft downslope	32	16	11	13	30
6 ft downslope	22	16	14	12	14
8 ft downslope	23	19	11	13	14
10 ft downslope			12	12	14
12 ft downslope				13	13
14 ft downslope				13	14
16 ft downslope				13	15

Due to the sparcity of desirable perennial grasses on most of the degraded rangeland in western Texas, seeding was deemed to be a highly desirable practice to use in conjunction with the installation of soil modifications. To facilitate the capability to install soil disturbances and simultaneously seed the disturbed soil with adapted, desirable grasses, we purchased a single-row grass planter with separate seed boxes for chaffy and small, slick grass seeds from the Truax Company in Minneapolis, Minnesota and constructed a frame that allows the seeder to be attached to our Bison SVH-1 ripper or to the disk diker implement. We utilized a hydraulic motor with a speed control device to power the seed delivery and seed agitator mechanisms in the Truax grass seed planter. The hydraulic motor is powered by the hydraulic system of the tractor. A flexible seed-delivery tube was attached to the Truax seeder and ropes running from the seed tube to the roll-over protection structure of the tractor allow the tractor operator to deliver the seed into "safe" microsite where grass seed germination and subsequent seedling emergence and establishment will be most probable, i.e., where water will stand the deepest and the most often. With ripping or wing-ripping, the seed tube can be positioned to drop the grass seeds either into the disturbed soil on the upslope side of the furrows or directly into the furrows. With disk diking, the seed tube is positioned to drop the grass seeds into the furrow on the upslope side of the dike. A looped log chain is dragged behind the seed delivery tube to cover the grass seed and to firm up the seedbed. The cost for seeding along rips, wing rips, or dikes is quite low because the Truax seeder is calibrated to seed a 1-ft-wide band and these bands are generally spaced 15, 20, or 30 ft apart (see Table 3 below), thus only 6.7%, 5%, or 3.33% of the total area is seeded for these spacings, respectively. Thus far, grass seedling establishment following seeding by this method has been quite limited, apparently because of the lack of closely spaced, effective rainfall events during spring-early summer and/or because of excessive competition of annual weeds that rapidly establish on the soil disturbances.

Table 3. Estimated costs for wing ripping or wing ripping + seeding with a 55-horsepower rubber-tired tractor in 2nd gear on 15-, 20-, and 30-ft spacings in dry compacted soil, with seeding rate of 1/4 the normal rate each of B. Dahl old world bluestem, Haskell sideoats grama, Lometa Indiangrass, and blue panicum ($2.38/acre seed cost for 15-ft spacing). Cost for tractor estimated at $11.67/hr and labor cost estimated at $10/hr.

Space between furrows (ft)	Efficiency (acres/hr)	Cost for wing ripping only ($/acre)	Cost for wing-ripping + seeding ($/acre)
15[1]	4	$5.50	$7.90
20[2]	5.3	$4.20	$5.90
30[2]	8	$2.80	$3.90

[1]Estimated from work done in three fields, 15 to 20 acres in size, at the Carlsbad Research Area in late July - early August 2002.

[2] Calculated from the actual field data, assuming that efficiency for 20-ft and 30-ft spacings would be 1.33X and 2.0X that for 15-ft spacing, respectively. Costs for 20-ft and 30-ft spacing were calculated by dividing the cost for 15-ft spacing by 1.33 and 2.0, respectively. Values have been rounded off.

The goal when installing rips, wing-rips, or dikes is to establish dense bands of perennial bunch grasses - which are nature's very effective mechanism for conserving water, soil, and organic materials. We learned in trials installed in 1995 - 1996 that weeds such as annual broomweed, ragweeds, and croton often dominate the bands of soil along rips and wing-rips that have been enriched with water and organic materials and that these persistent infestations interfere with establishment and production of desirable, warm-season, perennial grasses. With this background knowledge, several of the experiments and trials installed during 2001 - 2003 were designed to facilitate the comparison of perennial grass establishment along rips and wing-rips with and without weed management. Herbicide treatments, including picloram at 0.13 or 0.25 lb/acre, 2,4-D at 0.5 or 1.0 lb/acre, and picloram at 0.13 lb/acre + 2,4-D at 0.5 lb/acre have been installed as broadcast sprays along 12-ft-wide bands along rips and wing-rips in several experiments to evaluate the efficacy of these treatments for enhancing establishment of perennial bunch grasses. Preliminary observations have indicated that weed management usually enhances the establishment of both resident and seeded perennial grasses along the soil disturbances.

Table 4 displays the array of experiments and/or demonstrations on mechanical water conservation treatments installed in western Texas by researchers at the San Angelo Center that were partially funded by the TAES Water Conservation and Soil Management Project.

Table 4. Research experiments and demonstration plots installed by personnel TAES scientists at the San Angelo Center and TCE cooperators during 2001 - 2003. Counties denoted by * indicate cooperative research/demonstration at the request of County Agricultural Extension Agents or Extension Range Specialists.

Date	Ranch	County	Treatment Comparisons
Jan. 2002	S Ranch (John Cargile)	Tom Green	Ripping with 80-hp dozer: seeding vs. no seeding and weed control with 2,4-D + picloram vs. no weed control
Mar.5-10, 2002	Neal Woodward Ranch	Pecos*	Ripping vs. wing ripping with 85-hp dozer, seeding vs. no seeding of rips and wing rips
Mar. 11, 2002	Darrell Ueckert Ranch	Jones	Ripping vs. wing ripping with 75 hp tractor, and weed control with 2,4-D + picloram vs. no weed control
Mar. 15, 2002	Llano County Land	Tom Green	Ripping w/o seeding vs. ripping + seeding with 55-hp tractor, weed control with 2,4-D + picloram vs. no weed control
Mar. 21, 2002	Bill Zuberbueller Ranch	Val Verde*	Wing ripping + seeding with 55-hp tractor vs. no treatment
Mar. 27, 2002	TT Ranch	Crockett*	Ripping + seeding vs. wing ripping + seeding with 55-hp tractor vs. no treatment
Mar. 28, 2002	Wagon Wheel	Upton*	Wing ripping + seeding with 85 hp dozer vs.

	Ranch		no treatment
Continued on	next page.		
Apr. 3, 2002	YT Ranch	Ector*	Wing ripping + seeding with 55-hp tractor vs. no treatment
Apr. 18, 2002	Lynn Glass Ranch	Howard*	Ripping + seeding vs. wing ripping + seeding with 55-hp tractor
Apr. 22, 2002	John Sweeten Ranch	Edwards	Ripping vs. wing ripping with 55-hp tractor, weed control with 2,4-D + picloram vs. no weed control
May 21, 2002	Otto Gottschalk	Runnels*	Ripping on 30-ft spacings + seeding with 55-hp tractor, weed control with 2,4-D + picloram vs. no weed control
July 10-19, 2002	Carlsbad Research Area	Tom Green	Wing-ripping + seeding on 15-ft spacings with 55-hp tractor vs. no treatment on degraded rangeland, weed control with picloram at 0.25 vs. 0.13 lb/ac vs. no weed control
July-Aug. 2002	Carlsbad Research Area	Tom Green	Determined efficiency and cost for wing ripping alone and with seeding in degraded tame pastures
Jan. 14-22, 2003	Nat and Jimmy Read Ranch	Crockett	Wing ripping with 55-hp tractor vs. no treatment, seeding in furrows vs. in soil ridge upslope from furrow, weed control with picloram at 0.13 or 0.25 lb/acre vs. no weed control
Mar. 3-5, 2002	Tongue River Ranch	King* & Cottle	Wing rip + seeding with 55-hp tractor vs. Lawson aerator + seeding with dozer vs. no treatment
Apr. 21-22, 2003	John Cargile Ranch	Irion	Ripping vs. wing ripping vs. disk diking with 55-hp tractor, seeding in furrows vs. in soil ridge upslope from furrow, vs. no seeding
June 11-19, 2003	Neal Woodward Ranch	Pecos	Wing ripping (15 & 30 ft spacings) vs. disk diking (15, 20 & 30 ft spacings), all seeding in furrows with 55-hp tractor
Oct. 1-2, 2003	Dora & Jim Wright Ranch	Menard*	Wing ripping with 55-hp tractor, seeding in furrows vs. seeding in soil ridge upslope from furrow

Water Conservation and Rangeland Restoration Treatments - Rangeland Ecology and Management Department Efforts (Steve Whisenant, project leader):

ALTERING HYDROLOGIC REGIME TO REVEGETATE CRUSTED SOILS ON SEMIARID RANGELAND

Study Location: The study area is located on the Middle Pasture of the Big Jim Ranch, 10.3 km north of Big Lake, in Reagan County, Texas, USA. This area lies in the semiarid portion of the Edwards Plateau of western Texas (31_16' N, 101_32' W).

Study Objectives: This study was designed to evaluate the effectiveness of both seedbed manipulations (aeration and drill seeding) and water harvesting technologies (contour furrowing) in revegetating semiarid, structurally crusted rangeland by quantifying their effects on volumetric soil water content and vegetation density. Results of this project will be useful to land managers dealing with soils with poor vegetative stands, structural soil crusts and other factors causing low infiltration rates. Land managers will be more informed as to whether water harvesting or seedbed manipulations are more appropriate for their site conditions. Also, this study will provide a better estimate of the slope length needed to capture sufficient overland flow to establish grass via water harvesting.

Experimental Design: The treatment areas were selected based on local topography, mesquite density, and edaphic conditions. The slope of the area needed to be significant enough to lend itself to overland flow. Given the crusted state of the bare soil, 1% to 2% slope was sufficient. Lower *Prosopis glandulosa* (mesquite) density was selected for ease in tractor manipulations and greater consistency of plot characteristics.

Contour furrows 15 to 30 cm deep, 100 to 180 m long and 0.73 to 1.8 m wide were created with a D5 bulldozer on June 12, 2001. Treatments were applied to four replicate blocks, each block having four furrows. Within each block, slope length above a furrow is approximately 1 m, 4 m, 11 m or determined variably by the furrow's position in relation to the watershed boundary. (Although difficult to determine in the field, the slope length above the most upslope furrow of each block was estimated to be 61 m.) The slope length above a furrow and the position of the furrow within the block are confounded. The length of each furrow was divided into four equal sections, with each section of furrow catchment area receiving a different treatment. The placement of the four treatments along each furrow was randomized, with each treatment occurring once along each furrow. Slope length above each furrow section was aerated with an AerWay agricultural aerator (creating approximately 8 x 8 x 8 cm pits) and drill seeded with a Truax Flex II Grass Drill (6 rows spaced 20.3 cm apart), drill seeded or not treated. Aeration treatments vary in their application date (June 28, 2001 or March 26, 2002). Thus, the four catchment area treatments are drill seed only, drill seed and aeration 2001, drill seed and aeration 2002 and no treatment. Drill seed treatments were applied March 12, 2002. Furrows were broadcast seeded on June 12, 2001. Broadcast seeding rates varied from 11 to 22 kg/ha. Both the drill and broadcast seed mixes consisted of *Bouteloua curtipendula* (sideoats grama) (60% by weight), *Leptochloa dubia* (green sprangletop) (10% by weight) and *Setaria leucopila* (plains bristlegrass) (30% by weight). These native, warm-season, perennial grasses are categorized as good for cattle grazing and good to fair for wildlife grazing.

Soil Moisture Data Collection: To determine whether the furrows harvest more water than control plots or the upslope treatments, soil moisture was measured using Delta T Devices' Profile Probe (PR1/4) and Campbell Scientific's Water Content Reflectometer (CS615). Both instruments measure the bulk dielectric constant of soil and relate it to volumetric soil water content. CS615s were configured to measure the average volumetric soil water content every hour from a depth of approximately 3 to 24 cm. This data was recorded on a Campbell Scientific datalogger (CR10X).

The PR1/4 is a handheld device that measures volumetric soil water content at discreet depths of 5 – 13 cm, 15 – 23 cm, 25 – 33 cm and 35 – 43 cm. At each depth 95% of the volume of soil influencing the probe's readout is located within a cylinder of soil 8 cm high with a radius of 10 cm surrounding the probe. The PR1/4 was used periodically to characterize the soil moisture after precipitation events.

Two Rain Wise rain collectors and HOBO Event Recorders were placed at the study area. Each tipping bucket and datalogger time stamped every 0.0254 mm of precipitation.

Vegetation Data Collection: Vegetation response was measured using square 0.10-m^2 quadrats during June 21 – 25, 2003. In each quadrat individual plants were counted, noted by species if known. The height of all grasses, other than *Scleropogon brevifolius* (burrograss), was measured. The height of each individual *S. brevifolius* was not measured because it did not appear to vary significantly from 4 cm (excluding inflorescence) throughout the entire study area. Three quadrats were used to quantify the density of vegetation in each plot within the contour furrows, and ten quadrats were used in the areas upslope of the furrows.

Results & Discussion: The process of analyzing the above-mentioned data is currently underway. Preliminary results indicate that the furrows were effective in harvesting water that would have otherwise been lost to runoff. As of June 25, 2003, the majority of grasses seeded in the furrows have grown to 20 cm in height. Many of them were 35 to 75 cm in height. In addition, species of *Aristida*, *Bouteloua*, *Buchloe*, *Chloris*, *Digitaria*, *Muhlenbergia* and *Panicum* have taken advantage of the furrows. The majority of the grasses growing in the furrows produced seed. Preliminary analysis of the soil moisture data supports the vegetation data.

As of June 25, 2003, the dominant grass pre- and post-treatment on the upslope areas was *S. brevifolius*. Few of the grasses seeded produced seedlings and even fewer produced plants to 10 cm in height. Little difference, if any, in the vegetative or soil moisture data will be statistically evident between the drill seed, aeration, and no treatment sections of the contributing areas upslope of the furrows.

RANGELAND BROADCAST SEEDING OVER RIPPING AND LAWSON AERATOR TREATMENTS

Additional water harvesting and seedbed preparation techniques were implemented on the Middle Pasture of the Big Jim Ranch, Reagan County, Texas. During April 2002, four replications of ripping and aerator treatments were installed and seeded with *Bouteloua curtipendula* (sideoats grama), *Leptochloa dubia* (green sprangletop) and *Setaria texana* (Texas bristlegrass) or *Sporobolus cryptandrus* (sand dropseed) by a broadcast spreader-seeder. The ripping treatments were applied on the contour and the aerator treatments were applied upslope from each of the ripping treatments.

The ripping treatments were installed with a 1.58-m spacing, two-shank ripper pulled with a D6D crawler tractor at approximately 2.4 km/hour. The shanks penetrated the soil to a depth of 35.6 to 45.7 cm. The treatments were applied on the contour in a back and forth pattern. The plots were 38.4 to 43.6 m wide, 548.6 to 609.6 m in length, and covered approximately 2.1 to 2.6 ha.

The aerator treatments were applied with a 3.0-m-wide Lawson Aerator (12247 kg) with 15.2-cm blades pulled by a D6D crawler tractor at approximately 4.0 km/hour. The aerator treatments were applied in a circular pattern, starting on the outside boundary of the plot and worked toward the center. The plots were 136.6 to 160.3 m wide, 324 to 612 m in length, and covered approximately 9.0 ha.

A seed mixture of *B. curtipendula* (El Reno) and *L. dubia* (Van Horn) was seeded to the ripping and aerator treatments at an approximate PLS rate of 4.7 and 4.5 kg/ha respectively. The mixture for the ripped areas included *S. texana* at a PLS rate of 1.1 kg/ha while the mixture for the aerated areas included *S. cryptandrus* at 1.1 kg/ha. A Turbospin (T-450) Broadcast Spreader-Seeder pulled by a 50 hp rubber wheeled farm tractor was used to apply the seed to the ripping (4-m swath) and aerator (6-m swath) treatments.

Both aeration and rip treatments were situated on the land to harvest overland flow to aid in the establishment of grasses. To date the vegetative response has been poor. Little vegetative response other than a spring flush of *Aphanostephus skirrhobasis* (lazydaisy) has been observed.

Desert Termite Management Research Efforts - San Angelo Center (Darrell Ueckert and Chris Sansone, project leaders)

Several experiments by scientists at the San Angelo Center have identified fipronil as an effective insecticide for control of desert termites (*Gnathamitermes tubiformans*). In the first experiment installed July 22, 2002, fipronil was broadcast applied in four bait formulations, including 0.02% a.i. corn cob grits, 0.0002% a.i. corn cob grits, 0.02% a.i. aspen wood chips, and 0.0002% a.i. aspen wood chips. The experiment was a randomized complete block design with three replications of plots 0.1 acre in size. The baits were applied at the rate of 0 or 1 lb per plot (= 10 lb bait/acre), resulting in fipronil rates of 0 gm a.i/acre, 0.01 gm a.i./acre, or 1 gm a.i./acre. Ten rolls of toilet paper were placed in each plot to monitor surface foraging activity of desert termites. The toilet paper rolls were examined periodically to determine whether termites were present or absent and to rank the roll relative to severity of attack by termites (0 = no feeding activity; 1 = 1-25% of the lower surface of roll attacked; 2 = 26-50% of lower surface of roll attacked; 3 = 51-75% of lower surface of roll attacked; 4 = 76-100% of lower surface of roll attacked. Results from these evaluations during the 2002 growing season (Table 5) indicated that the baits containing 0.02% a.i. fipronil (i.e., 1 gm a.i. fipronil/acre) effectively reduced surface foraging by desert termites.

Table 5. Mean percentages of toilet paper rolls with live desert termites present at various evaluation dates in 2002 following placement on August 26, 2002 onto plots treated with fipronil baits on July 22, 2002 at the Carlsbad Research Area.[1]

Treatment	Concentration & substrate	Rate (lb/ac of bait)	Date 08/28	Date 09/06[2]	Date 09/23	Date 10/15	Date 11/07	Date 11/20
Check	None	---	53.3a	96.3a	83.3a	70.0a	76.7a	70.0a
Fipronil	0.0002%corn cob grits	10	30.0abc	60.0b	80.0a	80.0a	76.7a	53.33a
Fipronil	0.0002% aspen wood	10	36.7ab	63.3b	63.3a	56.7ab	63.3a	50.0a
Fipronil	0.02% corn cob grits	10	0.00c	16.7c	10.0b	6.7c	6.7b	3.3b
Fipronil	0.02% aspen wood	10	6.7bc	16.7c	6.7b	23.3bc	6.7b	3.3b

[1]Means within a column followed by similar lower case letters are not significantly different at P = 0.05.
[2] Data on Sept. 26, 2002 were the percentage of toilet paper rolls that had been attacked by desert termites, rather than the percentage of rolls with live desert termites present at the time of observation.

Additional data collected from this experiment during the 2003 growing season indicated that the 0.02% a.i. fipronil baits continued to significantly suppress surface foraging activity by desert termites throughout most of the second growing season after application. On October 22, 2003 (15 months after treatment), termites were present in only 10% of the toilet paper rolls on plots treated with corn cob grits containing 0.02% fipronil and 16.7% of the rolls on plots treated with aspen wood chips containing 0.02% fipronil, compared to 63% on untreated plots and to 50 - 63% of the rolls on plots treated with baits containing 0.0002% fipronil.

A second study with experiments at three locations was initiated September 20, 2002 to determine if broadcast sprays of fipronil and carbaryl would reduce consumption of mulch and standing vegetation by desert termites. The experiments were arranged as randomized complete blocks with three replications. In these experiments, 50 gm (oven dry weight) of sorghum hay was placed into 24 X 25.5 in. frames made from 1 in. X 4 in. lumber. The treatments applied to the hay within these frames included fipronil at 1 gm a.i./acre, carbaryl at 1 lb a.i./acre, or no insecticide. The insecticides were applied were applied with a hand sprayer in a total volume of 350 ml/frame (947 gal/acre).

On November 20-21, 2002 we recovered the remaining sorghum hay from each experimental plot using forceps and oven dried this material to obtain gross oven dry weight. Most of the sorghum hay in check plots and carbaryl-treated plots was heavily contaminated with mud from the termite mud tubes and casts, so all the recovered material and samples of the original hay that had been kept in the laboratory were ground in a Wiley mill over a 10-mesh screen for ashing to convert all hay weights to an ash-free basis. Duplicate 2-gm samples from each sample were ashed at 600°C for 2 hr. Averaged over the three locations, of the original 44.085 gm (ash-free basis) of sorghum leaves, only 8.4 to 8.7 gm (ash-free basis) of sorghum leaves remained in untreated plots and carbaryl-treated plots, respectively, compared to 24.7 gm in plots treated with fipronil at 1 gm a.i./acre. These data are presented in the Table 6. Fipronil significantly reduced consumption of sorghum leaves by desert termites but carbaryl did not. About 44% of the ash-free sorghum leaf weight disappeared in the fipronil-treated plots, compared to 80.3% in carbaryl-treated plots and 81% in untreated plots. Biomass disappearance in the fipronil-treated plots was attributed to leaching, weathering, and to fungal and microbial decomposition, whereas biomass disappearance of the untreated and carbaryl-treated plots was attributed to these factors plus consumption by desert termites.

Table 6. Mean ash-free biomass of sorghum leaves (gm/0.395 m^2) remaining at 61 days after treatment (DAT) following treatment with fipronil, carbaryl, or no insecticide on September 20, 2002 at three sites near San Angelo, Texas.

Insecticide	Rate (a.i./acre)	Net ash-free oven-dry weight[1] (gm/0.395 m^2)
None	----	8.4b
Carbaryl	l lb	8.7b
Fipronil	1 gm	24.7a

[1] Means followed by similar lower case letters are not significantly different at P = 0.05.

Under the conditions of this field study, herbage biomass disappearance on untreated plots amounted to 904.5 kg/ha (807 lb/acre) (ash-free basis) (= 14.8 kg/ha/day) (= 13.2 lb/acre/day) while that on fipronil-treated plots amounted to 490.4 kg/ha (437.5 lb/acre) (= 8.0 kg/ha/day) (= 7.14 lb/acre/day) during the 61-day period from Sept. 20 to Nov. 20, 2002. Ash-free biomass disappearance attributed to consumption by desert termites during the 61-day period was 414.1 kg/ha (369.5 lb/acre) (= 6.8 kg/ha/day) (= 6.06 lb/acre/day).

A third experiment was installed at two locations (Carlsbad Research Area - Tom Green County, and John Cargile Ranch - Irion County) on July 1, 2003 to evaluate broadcast sprays of fipronil at 1 gm a.i./acre for desert termite control. Fipronil was applied in a total volume of 9 gal/acre of water at 20 psi pressure with a 20-ft boom sprayer equipped with 8002 flat fan nozzles. The sprayer was pulled behind a farm tractor.

Plots were 40 ft wide and of variable length. Three or four replications of the fipronil treatment and untreated control plots were included at each location. Ten rolls of toilet paper were placed onto each plot for monitoring surface foraging activity by desert termite. Evaluations of the toilet paper rolls during late summer through mid October 2003 indicated that broadcast sprays of fipronil were significantly reducing surface foraging by desert termites. On October 22, 2003, termites were present in only 10% of the toilet paper rolls on plots treated with fipronil at 1 gm a.i./acre, compared to 60% of the rolls on untreated plots (averaged over the two locations).

On July 15, 2003, a small-plot experiment with 4 replications was installed to determine if broadcast sprays of fipronil at 1 gm a.i./acre would enhance establishment of seeded grasses. These small plots were established upon the areas treated with broadcast sprays of fipronil on July 1, 2003 by the methods described above or upon adjacent untreated areas at the Carlsbad Research Area. Following seedbed preparation by ripping, roto-tilling, and hand raking, seeds of 'Lometa' Indiangrass, 'B. Dahl' oldworld bluestem, blue panicum, 'Haskell' sideoats grama, and plains bristlegrass were seeded into 1 X 1 m plots at the normal full seeding rate and covered about 1/4 in. deep. There were 4 replications of each grass species on fipronil-treated land and and 4 replications of each grass species on adjacent, untreated land. An earthen berm was constructed around each small plot to facilitate flood irrigation and the plots were mulched initially with fresh-cut juniper branches and leaves and later with bermudagrass hay. Each plot received a total of about 14 in. of supplemental water along with about 10 in. of rainfall from mid July through mid October 2003. Grass seedling emergence and establishment was very good on most of these plots. The number of live grass plants in each plot were counted in mid October 2003. These data have not been statistically, but a visual assessment indicated similar grass seedling establishment on fipronil treated land and on adjacent untreated land.

A second small-plot seeding experiment was initiated September 11, 2003 at the Carlsbad Research Area to compare emergence and establishment of fipronil-treated grass seeds to that of untreated seeds. Prior to planting, seeds of 'Lometa' Indiangrass, 'B. Dahl' oldworld bluestem, blue panicum, and 'Haskell' sideoats grama were treated with fipronil by BASF personnnel to provide fipronil rates of 1 or 5 gm a.i./acre when the grasses were planted at their normal seeding rates. Following seedbed preparation by disking and hand raking, fipronil-treated grass seeds and untreated grass seeds of each species were planted into 1 X 1 m plots as described above on September 12, 2003. Earthen berms were constructed around each plot to facilitate flood irrigation and, following mulching with bermudagrass hay, the plots were irrigated numerous times to supplement numerous rainfall events. In this experiment, the plots for fipronil-treated grass seeds were spaced 1 m apart, but 5 m space was allowed as a border between plots for fipronil-treated grass seed and those for untreated grass seed. An electric fence was erected around this study site to keep out livestock and deer. These plots will be evaluated by counting the number of live grass seedlings in each plot prior to the first frost in early November 2003.

Summary

This funding from the TAES Water Conservation and Soil Management Project has facilitated the implementation of 20 experiments that have already greatly expanded and refined the technology for using

mechanical soil disturbances to enhance the conservation of water, soil, and organic materials and expedite the restoration of degraded rangelands in western Texas. Data generated on costs for installation of wing ripping and disk diking ranged from $1.67 to $5.50 per acre, depending upon the method used and horizontal spacing. Cost for seeding desirable, adapted grasses along wing rips or dikes ranged from $1.10 to $2.40 per acre. These relatively low initial inputs and the potential for achieving 3- to 4-fold increases in livestock and wildlife carrying capacity strongly suggest that mechanical soil disturbances and seeding would be economically feasible. Data collection on these experiments will continue for several years and the final results will greatly expand our knowledge base on the values of water conservation treatments for reversing the desertification cycle on rangeland watersheds. Funding by TWRI also facilitated the installation of five experiments on desert termite management, control, and ecology. Fipronil at 1 gm a.i./acre has been identified as an effective insecticidal treatment for desert termite control at a cost of less than $1 per acre, not including application costs. An insecticide-check study demonstrated that fipronil at 1 gm a.i./acre reduced consumption of mulch, litter, and standing vegetation by desert termites by 370 lb/acre during early autumn. The completion of research described in this report will facilitate the development of an effective marketing program to expedite the transfer of valuable water conservation/desert termite management technology to ranchers, rangeland resource managers, and natural resource management agencies.

Preliminary results from the research described in this report has already stimulated significant interest in water conservation treatments among ranchers, rangeland resource managers, wildlife biologists, and the U.S.D.A. Natural Resources Conservation Service. In 2002, the USDA Natural Resources Conservation Service developed technical guidelines for ripping and contour furrowing and included these treatments for cost-sharing under the EQIP program in 2003. EQIP contracts are currently being developed for the wing ripping of thousands acres of degraded rangeland in western Texas. Many ranchers in the western half of Texas have already begun ripping or wing ripping at their own expense as a result of the research and demonstration projects described in this report.

Specific Issues Addressed:

- water management and conservation
- soil management, quality/health
- mulching (natural mulching via plant growth)
- land management related to soil and water conservation

Collaboration:

Texas Agricultural Experiment Station: (Ueckert and Whisenant - evaluate effects of water conservation treatments, seeding, herbicide treatments, etc. on vegetation recovery, runoff, infiltration, etc.; Hamilton - technology transfer to producers; Rollins - evaluate impacts of water conservation treatments on wildlife)
Texas Cooperative Extension: (Sansone - evaluate insecticides for desert termite control; McGinty - technology transfer to producers)

Entomology Department - Texas A&M University: (Roger Gold - determine colony size of desert termies and evaluate acceptability of termite baits)
Rangeland Ecology & Management Department - Texas A&M University: (Whisenant, Hamilton)
Wildlife & Fisheries Sciences Department - Texas A&M University: (Rollins)
San Angelo Center: (Ueckert, McGinty, Sansone, Rollins)