Mike Pellant

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Contents

Arid Land Seeding

Carlton H. Herbel, *Chairman*

(Reported by Harold Wiedemann, Texas A&M University)

Farm-Tractor Front-Mounted Grubber

A newly designed grubbing blade developed for front-mounting on a rubber-tire tractor and patterned after the low-energy grubber's blade (crawler tractor) appears very promising for controlling junipers 2 to 5 feet tall. Preliminary data indicate only a slight reducing in acre-per-hour performance, while total investment will be approximately one-half. Fuel consumption is 72 percent less than that of a crawler tractor.

The farm tractor tested was a 60-horsepower John Deere 2440 with automatic reverse, foot-controlled throttle, 146 front-end loader frame, and special high-ply, used airplane tires adapted for farm tractors. The crawler tractor previously evaluated was a 65-horsepower John Deere 450-B.

The rubber-tire grubber averaged 6.3, 1.3, and 0.6 (acres per hour in densities of 50, 250, and 500 trees per acre. Production rates were computed using the curvilinear regression prediction equation Log Y = 2.49 - Log X (r = .97) when Y = production (ac/hr) and X = densities/ac.

The unit appears well suited to controlling extensive acreages of small junipers infesting previously cleared areas.

Farm tractor front-mounted grubber.

Experimental Disk-Chain

Tests in 1979 compared disk-chaining to smooth chaining for low-cost seedbed preparation on rough, log-littered, root-plowed rangeland where heavy-duty offset disks and grass drills would have been unable to operate successfully. The disk-chain was significantly better than a smooth chain in both clay and sandy loam soils, using 1 or 2 pounds of kleingrass per acre aerially seeded. The greatest improvement was in clay loam soil, where the disk-chain had 71 percent more plants per acre, and plots developed an average of more than 0.5 plants per square foot.

In drawbar tests, a 24-inch disk welded to alternate links of 34 pounds per foot chain averaged 215 ± 39 pounds pull per disk when pulled at a 45-degree diagonal between two tractors traveling at 3 mph. Linear regression equations for predicting pulling requirements, as influenced by angle of pull or operating mass (variation in disk blade and chain weight), are presented in ASAE Paper No. 80-1551, by H.T. Wiedemann and B.T. Cross. This information is useful for construction and productivity calculations. Predicted pulling costs using a D-8H and D-6C tractor (at $140 per hour) is $6.50 per acre.

In 2 years of testing, both types of chains operated successfully on log-littered, root-plowed sites. The disk-chain, however, appears to increase the potential of establishing good grass stands, especially in tighter soils and when rainfall is less than normal. Results of disk-chaining follow more closely the results of offset disking but costs and energy use appear to be reduced by half.

Land Imprinting Activities

By Robert M. Dixon, Science and Education Administration—Agricultural Research, Tucson, Ariz. (Presented by Harold Wiedemann, Texas A&M University)

In July 1976, a prototype rangeland imprinter was tested on creosotebush-infested rangeland near Tombstone, Ariz. When operating on the contour, its angular teeth bite deeply into the soil leaving interconnected water-shedding and water-absorbing imprints. The prototype rangeland imprinter was designed to concentrate and aid in deeply infiltrating rainwater, making more of this limited water resource available for germinating seeds and establishing seedlings.

Preliminary sprinkling infiltrometer results indicate that the shedding and absorbing imprints are performing as designed. Fitted Kostiakov equations indicate that 1-hour infiltration volumes for the shedding and absorbing imprints are 3.7 and 11 centimeters, whereas the corresponding infiltration rates are 2.2 and 6.9 centimeters per hour. Based on U.S. Weather Bureau data, it was determined that this system has sufficient capacity to control a 1-hour, 100-year maximum intensity rainstorm without allowing any runoff loss from the system.

Widespread use of rangeland imprinters is expected in the near future based on the numerous requests that are being received for construction plans. Some use is already occurring.

Ralph Wilson, who operates the Falcon Valley Ranch just north of Tucson, Ariz., used a homemade rangeland imprinter in a successful revegetation effort last year. Before imprinting in March 1980, his degraded rangeland was largely barren with a few scattered cactuses, half shrubs and shrubs, and virtually no grass. His homemade rangeland imprinter is much simpler in design than the prototype rangeland imprinter used near Tombstone, but functioned quite well, nevertheless.

The imprinting roller is 4 feet in diameter and 12 feet long, with 8- by 8-inch angle welded axially on its outer circumference. A commercial broadcast seeder was mounted on the tow frame and set to hurl Lehmann lovegrass seed beneath the imprinting roller at the rate of 2 pounds per acre. A good rain came at the end of July, germinating the Lehmann lovegrass seeds. By September 12th the grass was already knee-high and was forming seed heads.

The resulting dense grass cover can make efficient use of rainwater by rapidly and deeply infiltrating it to nourish and cool plants instead of being lost to surface evaporation and runoff.

Converted sheepsfoot roller imprints a 9-foot width.

Besides buying a commercial imprinter or fabricating one, another way to get an imprinter is to convert roller-type machines used for other purposes such as sheepsfoot rollers. These converted machines can make a deep impression, even on a hard packed dirt road. Conversion entails merely the replacement of compacting feet with 6- by 6-inch angle irons. In a similar manner, rolling brush cutters can be converted to land imprinters. The Water and Power Resources Service, El Paso, Tex., did this. The converted land imprinter is seeding grass on a flood-plain bench at Carbollo Reservoir, N.Mex. Cutting blades were replaced with 6- by 6-inch angle irons.

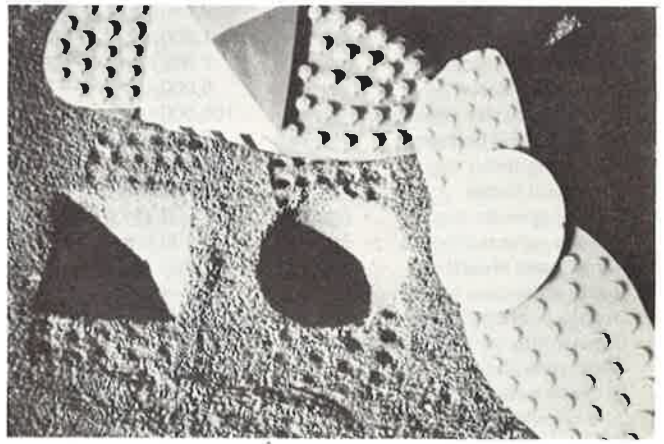
Converted rolling chopper imprints a 21-foot width.

In southwest Texas, rancher-industrialist Joe Brown has a large-scale revegetation effort underway. Using large imprinters fabricated by the Brown Tool Co., he treated 900 acres of shrub-infested rangeland in March 1980 and now, reportedly, has a good stand of grass from rains that came in early July.

Now let's think small. Bonding small imprint teeth to the soles of jogging shoes produces a pair of foot imprinters or more descriptively, "rain dance shoes." Although they can't make rain, they can make rain grow more grass. Walking at a normal rate produces a stable seedbed and seedling cradle every ¾ second that will concentrate seeds, rainwater, and finely divided plant litter at a point. It is this gravitational routing of resources to a common point that should result in more efficient use of limited rainwater for seed germination and seedling establishment.

The foot imprinter is a labor intensive device that has some inherent advantages over a hand hoe. It produces a more stable seedbed and seedling cradle, and it leaves hands free to do the seeding. As a simple do-it-yourself project, the "rain dance shoe" makes imprinting technology available to the backyard gardener or to labor abundant societies.

Future research will be directed to developing imprinting tooth geometries and imprinting patterns that can make wetter seedbeds and seedling cradles through more efficient use of the limited rainfall in arid lands.



Converted jogging shoes and their imprints.

More information may be obtained by writing to:

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2000 East Allen Rd.
Tucson, AZ 85719

Plant Materials

Wayne Everett, *Chairman*

The Plant Materials Workgroup has revised its committee membership, developed 1980-82 objectives and activities, and initiated development of a cultivar source listing of plants currently recommended for range, critical areas, and reclamation plantings.

In 1980, the Soil Conservation Service (SCS) completed a study of alternatives for operating, financing, and managing plant materials centers. Based on 2,212 public responses, SCS recommended that the centers continue to be operated as an SCS program. The public responses were more than 90 percent in favor of SCS continuing to operate them. Potential and willing cooperating State agencies were not available to operate the centers while continuing to maintain a nationally coordinated program.

The plant materials program has been funded and retained as an SCS program with provisions for maintenance and replacement of equipment and facilities for FY 1982.

The tables below list the SCS cooperative cultivar releases to December 1980 and the commercial seed and plant production of these releases to July 1979.

Table 1.--*Commercial production of SCS released plant varieties—1979*

Varieties released by SCS Plant Materials Center	Production			Retail value		Seeding or planting rate per acre	Amount of acres that could be treated based on 1979 production
	Seed	*Plants*	*Vegetative (bushels-sprigs) grasses*	*Unit price*	*Total value*		
Grasses							
Akaroa orchardgrass	10,000	—	—	.65/lb	6,500	5 lb	2,000
Alamo switchgrass	35,500[1]	—	—	18.00/lb	639,000	2 lb	17,750
Aldous little bluestem	2,400[1]	—	—	6.75/lb	16,200	8 lb	300
Alkar tall wheatgrass	5,000	—	—	1.00/lb	5,000	8 lb	625
Amur intermediate wheatgrass	24,000	—	—	1.80/lb	43,200	8 lb	3,000
Arriba western wheatgrass	16,000	—	—	4.50/lb	72,000	8 lb	2,000
A-68 Lehmann lovegrass	6,000	—	—	3.79/lb	22,740	1 lb	6,000
A-84 Boer lovegrass	1,000	—	—	9.00/lb	9,000	1 lb	1,000
Barton western wheatgrass	58,000	—	—	5.25/lb	304,500	20 lb	2,900
Bend sand lovegrass	2,400[1]	—	—	2.75/lb	6,600	2 lb	1,200
Blackwell switchgrass	90,560[1]	—	—	5.50/lb	498,080	5 lb	18,112
Blando brome	80,000	—	—	3.50/lb	280,000	4 lb	20,000
Bromar Mt. Brome	15,000	—	—	2.00/lb	30,000	6 lb	2,500
Cape American Beachgrass	—	1,935,000	—	65/1,000	125,775	19,000 plt	102
Catalina weeping lovegrass	500	—	—	1.75/lb	875	1 lb	500
Caucasian bluestem	2,900[1]	—	—	8.68/lb	25,172	1.2 lb	2,417
Cave-in-Rock switchgrass	11,840[1]	—	—	5.50/lb	65,120	5 lb	2,368
Cheyenne indiangrass	2,500[1]	—	—	5.60/lb	14,000	5 lb	500
Chiwapa millet	1,000	—	—	.50/lb	500	15 lb	67
Cimarron little bluestem	2,600[1]	—	—	6.75/lb	17,550	8 lb	325
Covar sheep fescue	5,000	—	—	3.50/lb	17,500	4 lb	1,250
Critana thickspike wheatgrass	106,000	—	—	5.70/lb	604,200	6 lb	17,667
Draylar upland bluegrass	5,000	—	—	2.50/lb	12,500	4 lb	1,250
Dove proso millet	55,200	—	—	.50/lb	27,600	15 lb	3,680
Durar hard fescue	165,400	—	—	2.25/lb	372,150	4 lb	41,350
El Reno sideoats grama	217,500[1]	—	—	3.50/lb	761,250	6 lb	36,250
El Vado spike muhly	4,000[1]	—	—	8.00/lb	32,000	1 lb	4,000
Garden sand bluestem	3,750[1]	—	—	5.85/lb	21,938	12 lb	313
Garrison creeping foxtail	23,224	—	—	4.00/lb	92,896	4 lb	5,806
Goshen prairie sandreed	5,233[1]	—	—	9.35/lb	48,929	4 lb	1,308
Greenar intermediate wheatgrass	13,000	—	—	1.25/lb	16,250	8 lb	1,625
Green sprangletop	5,400[1]	—	—	3.25/lb	17,550	1.7 lb	3,177
Grenville switchgrass	1,600[1]	—	—	3.00/lb	4,800	3 lb	533
Jose tall wheatgrass	15,000	—	—	1.80/lb	27,000	10 lb	1,500
Kanlow switchgrass	4,800[1]	—	—	5.50/lb	26,400	5 lb	960
Kaw big bluestem	19,200[1]	—	—	6.10/lb	117,120	6 lb	3,200
Killdeer sideoats grama	1,795[1]	—	—	5.70/lb	10,232	6 lb	299
Kleberg bluestem	7,500[1]	—	—	8.00/lb	60,000	1.2 lb	6,250
KR bluestem	25,000[1]	—	—	8.68/lb	217,000	1.2 lb	20,833

[1]Seed production and sales on PLS (pure live seed) basis.

Varieties released by SCS Plant Materials Center	Production			Retail value		Seeding or planting rate per acre	Amount of acres that could be treated based on 1979 production
	Seed	*Plants*	*Vegetative (bushels-sprigs) grasses*	*Unit price*	*Total value*		
Grasses							
Largo tall wheatgrass	2,500	—	—	1.00/lb	2,500	10 lb	250
Latar orchardgrass	167,000	—	—	1.25/lb	208,750	4 lb	41,750
Limpograss, Bigalta	—	—	2,500,000 bu	1.40/bu	3,500,000	37 bu	67,568
Limpograss, Greenalta	—	—	200,000 bu	1.40/bu	280,000	37 bu	5,405
Limpograss, Redalta	—	—	2,000,000 bu	1.40/bu	2,800,000	37 bu	54,054
Llano buffelgrass	300[1]	—	—	15.00/lb	4,500	2 lb	150
Llano indiangrass	1,000[1]	—	—	4.00/lb	4,000	5 lb	200
Lodorm green neddlegrass	2,283[1]	—	—	4.76/lb	10,867	6 lb	381
Lovington blue grama	13,000[1]	—	—	6.50/lb	84,500	1.5 lb	8,667
Luna pubescent wheatgrass	255,900	—	—	2.00/lb	511,800	10 lb	25,590
Magnar basin wildrye	340	—	—	5.00/lb	1,700	6 lb	57
Manchar smooth brome	168,000	—	—	.90/lb	151,200	6 lb	28,000
Mandan-759 pubescent wheatgrass	48,235	—	—	1.39/lb	67,047	7 lb	6,891
Medio bluestem	7,500[1]	—	—	12.00/lb	90,000	1 lb	7,500
Newport Kentucky bluegrass	718,000	—	—	1.50/lb	1,077,000	4 lb	179,500
Nezpar Indian ricegrass	5,520	—	—	10.00/lb	55,200	6 lb	920
Nogal black grama	500[1]	—	—	20.00/lb	10,000	1 lb	500
Nordan crested wheatgrass	13,307	—	—	.76/lb	10,113	6 lb	2,218
Nueces buffelgrass	4,000[1]	—	—	15.00/lb	60,000	2 lb	2,000
Osage indiangrass	7,500	—	—	5.60/lb	42,000	12 lb	625
Palar wilman lovegrass	400	—	—	9.04/lb	3,616	2 lb	200
Paloma Indian ricegrass	30,300	—	—	13.00/lb	393,900	6 lb	5,050
Pastura little bluestem	3,250[1]	—	—	6.75/lb	21,938	4 lb	813
Pensacola bahiagrass	1,052,925[1]	—	—	.65/lb	684,401	20 lb	52,646
Perla koleagrass	1,000	—	—	2.40/lb	24,000	5 lb	2,000
Pierre sideoats grama	2,646[1]	—	—	5.70/lb	15,082	6 lb	441
P-27 Siberian wheatgrass	12,600	—	—	2.50/lb	31,500	6 lb	2,100
Premier sideoats grama	3,300[1]	—	—	3.50/lb	11,550	5.5 lb	600
Redondo Arizona fescue	6,800	—	—	6.00/lb	40,800	2 lb	3,400
Regar bromegrass	220,400	—	—	2.30/lb	506,920	18 lb	12,244
Rosana western wheatgrass	52,800	—	—	5.40/lb	285,120	7 lb	7,543
Selection 75 kleingrass	650,000[1]	—	—	6.92/lb	4,498,000	2 lb	325,000
Sherman big bluegrass	10,000	—	—	1.50/lb	15,000	4 lb	2,500
Shoreline common reed	—	500	—	.20 ea	100	—	1
Sodar streambank wheatgrass	49,500	—	—	4.00/lb	198,000	14 lb	3,536
Tegmar dwarf intermediate wheatgrass	11,600	—	—	3.30/lb	38,280	16 lb	725
Texoka buffalograss	29,000[1]	—	—	9.00/lb	261,000	16 burrs	1,813
Tioga deertongue	25,800	—	—	7.00/lb	180,600	20 lb	1,290
Topar pubescent wheatgrass	16,250	—	—	1.75/lb	28,438	8 lb	2,031
Transvala dwarf pangola	—	—	250 bu	2.00/bu	500	40 bu	6
Tufcote bermudagrass	—	—	7,650 bu	3.50/bu	27,775	12 bu	638
T-4464 buffelgrass	200,000[1]	—	—	1.60/lb	320,000	2 lb	100,000
Vaughn sideoats grama	51,750[1]	—	—	3.50/lb	181,125	6 lb	8,625
Vinall Russian wildrye	2,815	—	—	.80/lb	2,252	6 lb	469
Viva galleta	500[1]	—	—	30.00/lb	15,000	1.5 lb	333
Whitmar beardless wheatgrass	37,400	—	—	6.25/lb	233,750	8 lb	5,343
Wilmington bahiagrass	1,320[1]	—	—	.85/lb	1,122	20 lb	66
Wimmera-62 ryegrass	150,000	—	—	.55/lb	82,500	6 lb	25,000
Woodward sand bluestem	600[1]	—	—	5.85/lb	3,510	6 lb	100
Zorro annual fescue	250[1]	—	—	5.00/lb	1,250	4 lb	63

Varieties released by SCS Plant Materials Center	Production: Seed	Production: Plants	Production: Vegetative (bushels-sprigs) grasses	Retail value: Unit price	Retail value: Total value	Seeding or planting rate per acre	Amount of acres that could be treated based on 1979 production
Legumes							
Aeschynomene americana jointvetch	240,000	—	—	.60/lb	144,000	8 lb	30,000
Amclo arrowleaf clover	49,200	—	—	2.00/lb	98,400	8 lb	6,150
Arlington sericea lespedeza	14,000	—	—	2.00/lb	28,000	30 lb	467
Ballclover	1,500	—	—	1.50/lb	2,250	5 lb	300
101 bicolor lespedeza	—	4,000	—	20/1,000	80	4,900 plt	1
Bobwhite soybean	6,700	—	—	.76/lb	5,092	6 lb	1,116
Cascade birdsfoot trefoil	1,000	—	—	3.00/lb	3,000	4 lb	250
Chemung crownvetch	7,000	—	—	10.00/lb	70,000	12 lb	583
Emerald crownvetch	151,000	—	—	8.00/lb	1,208,000	10 lb	15,100
Emerald crownvetch	—	346,225	—	50/1,000	17,311	4,900 plt	87
Florigraze peanut	—	—	2,350 bu	4.00 bu	9,400	40 bu	59
Kalo dwarf English trefoil	3,000	—	—	3.00/lb	9,000	6 lb	500
Lana vetch	134,000	—	—	.75/lb	100,500	10 lb	13,400
Lathco flatpea	20,446	—	—	8.00/lb	163,568	30 lb	681
Lutana milkvetch	11,500	—	—	2.50/lb	28,750	8 lb	1,438
Mackinaw birdsfoot trefoil	1,850	—	—	3.00/lb	5,500	6 lb	308
Marshfield big trefoil	3,250	—	—	3.00/lb	9,750	4 lb	813
Meechee arrowleaf clover	13,700	—	—	2.00/lb	27,400	8 lb	1,713
Natob bicolor lespedeza	50	—	—	7.00/lb	350	2 lb	25
Thornsby bicolor lespedeza	—	500,000	—	20/1,000	10,000	4,900 plt	102
Thunberg lespedeza	30	—	—	8.00/lb	240	2 lb	15
Va-70 shrub lespedeza	13,500	185,000	—	10.00/lb+ 22.00/1,000	139,070	10 lb+ 4,900 plt	1,388
Wilton rose clover	5,000	—	—	2.00/lb	10,000	6 lb	833
Woody Plants							
Arnot bristly locust	80	358,400	—	15/lb+225/1,000	81,840	1,200 plt	299
Barranco desertwillow	20	5,000	—	1/ea	5,000	—	—
Bighorn sumac	—	5,000	—	1/ea	5,000	—	—
Cardan green ash	—	17,100	—	250/1,000	4,275	—	—
Cardinal autumn olive	—	4,006,000	—	250/1,000	1,001,500	500 plt	8,012
Corto Australian saltbush	300	75,000	—	10/lb+1.00/plt	78,000	4,900 plt	15
Emerald Sea shore juniper	—	18,930	—	700/1,000	13,251	4,000 plt	5
Flame Amur maple	—	106,300	—	300/1,000	31,890	—	—
Imperial carolina poplar	—	35,850	—	250/1,000	8,963	—	—
Jemez New Mexico Foresteria	10	10,000	—	1/ea	10,000	—	—
King Red Russian olive	200	15,000	—	1/ea	15,000	—	—
Midwest Manchurian crabapple	—	41,630	—	150/1,000	6,245	—	—
Pink Lady winterberry enonymus	—	73,050	—	150/1,000	10,958	500 plt	146
Rem-Red Amur honeysuckle	—	226,050	—	225/1,000	50,861	500 plt	452
Roselow crabapple	—	2,835	—	10 plt	28,350	—	—
Sawtooth oak	—	22,600	—	6/plt	135,600	—	—
Shubert chokecherry	—	10,000	—	250/1,000	2,500	—	—
Streamco purpleosier willow	—	251,575	—	450/1,000	113,209	—	—
Forbs & Others							
Aztec Maximilian sunflower	100[1]	—	—	15/lb	1,500	¼ lb	400
Bandera Rocky Mountain penstemon	6,000	—	—	35/lb	210,000	2 lb	250
Eureka thickspike gayfeather	100	—	—	45/lb	45,000	1 lb	100
Kaneb purple prairieclover	4,000	—	—	27.50/lb	110,000	1 lb	4,000
Nekan picther sage	900	—	—	25/lb	22,500	1 lb	900
Prairie Gold Maximilian sunflower	3,500	—	—	20/lb	70,000	¼ lb	14,000
Sunglow grayhead prairie coneflower	2,400	—	—	35/lb	84,000	1 lb	2,400
Total	5,783,329	8,251,045	4,710,250	—	$25,941,936	—	1,334,027

Table 2.--*Formal releases—grasses*

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation: *Primary*	Agency Participation: *Other*	PMC
Agropyron dasystachyum	Critana	thickspike wheatgrass	(P-15581)	MT	1971	SCS	MT, AES	Bridger
Agropyron desertorum	Nordan	crested wheatgrass	(Mandan) 571	Dickinson, ND	1953	ARS	SCS	Bismarck
Agropyron elongatum	Alkar	tall wheatgrass	98526	USSR	1951	SCS	ID,WA, AES	Pullman & Aberdeen
Agropyron elongatum	Jose	tall wheatgrass	150123	Australia	1965	SCS	NM, AES	Los Lunas
Agropyron elongatum	Largo	tall wheatgrass	109452	Turkey	1961	SCS	UT, AES	Los Lunas
Agropyron inerme	Whitmar	beardless bluebunch wheatgrass	421022	Whitman Co., WA	1946	SCS	WA, ID, OR, AES	Pullman& Aberdeen
Agropyron intermedium	Amur	intermediate wheatgrass	131532	China	1952	SCS	—	Los Lunas
Agropyron intermedium	Greenar	intermediate wheatgrass	98568	USSR	1945	SCS	WA,ID,OR, AES	Pullman & Aberdeen
Agropyron intermedium	Tegmar	dwarf intermediate wheatgrass	109219	Turkey	1968	SCS	WA,ID, AES	Aberdeen & Pullman
Agropyron riparium	Sodar	streambank wheatgrass	421021	Grant Co., OR	1954	SCS	WA,ID,AES	Aberdeen & Pullman
Agropyron sibiricum	P-27	Siberian wheatgrass	108434	USSR	1953	SCS	ID,AES	Aberdeen & Pullman
Agropyron smithii	Arriba	western wheatgrass	(C-30)	Flagler, CO	1973	SCS	CO & NM AES	Los Lunas
Agropyron smithii	Barton	western wheatgrass	421274	Barton Co., KS	1970	SCS	KS, AES, ARS	Manhattan
Agropyron smithii	Rosana	western wheatgrass	(P-15582)	Forsyth, MT	1972	SCS	MT, AES	Bridger
Agropyron spicatum	Secar	bluebunch wheatgrass	440921	ID	1980	SCS	WN, ID, OR, MT, WY, AES	Pullman
Agropyron trachycaulum	Primar	slender wheatgrass	421023	Beebe, MT	1946	SCS	WA, ID, OR, AES	Pullman
Agropyron trichophorum	Luna	pubescent wheatgrass	106831	USSR	1963	SCS	NM, AES	Los Lunas
Agropyron trichophorum	Topar	pubescent wheatgrass	107330	USSR	1953	SCS	WA,ID,OR, CA,AES	Pullman & Aberdeen
Alopecurus arundinaceus	Garrison	creeping foxtail	(NDG-772)	McLean Co., ND	1959	SCS	WY,AES	Bridger & Bismarck
Ammophila breviligulata	Cape	American beachgrass	421130	Barnstable Co., MA	1970	SCS	Cook College	Cape May
Andropogon gerardi	Kaw	big bluestem	421275	Flinthills, KS	1950	KS, AES	SCS	Manhattan
Andropogon hallii	Elida	sand bluestem	(NM-14)	Elida, NM	1963	SCS	NM,AES	Los Lunas
Bothriochloa ischaemum	Ganada	yellow bluestem	107017	USSR	1979	SCS	CO,AZ,NM, AES	Los Lunas
Bouteloua curtipendula	Butte	sideoats grama	(NEBR. 37)	Holt, Platte Cos., NE	1958	ARS	SCS & NE, AES	—
Bouteloua curtipendula	El Reno	sideoats grama	421281	El Reno, OK	1944	SCS	KS, AES	Manhattan
Bouteloua curtipendula	Premier	sideoats grama	(G-433)	Mexico	1960	TX,AES	SCS, ARS	—
Boutelous curtipendula	Trailway	sideoats grama	(NEBR. 52)	Holt Co., NE	1958	ARS	SCS & NE, AES	—
Bouteloua curtipendula	Uvalde	sideoats grama	(A-2969)	Knippa, TX	1950	AZ, AES	SCS	Tucson
Bouteloua curtipendula	Vaughn	sideoats grama	(A-3603)	Vaughn, NM	1940	SCS	NM, AES	Los Lunas
Bouteloua eriopoda	Nogal	black grama	(NM-44)	Socorro, NM	1971	SCS	NM, AES	Los Lunas
Bouteloua eriopoda	Sonora	black grama	(A-4567-2)	AZ, NM	1965	ARS	AZ,AES,SCS	Tucson
Bouteloua gracilis	Hachita	blue grama	439880	NM	1980	SCS	NM,CO,AES	Los Lunas
Bouteloua gracilis	Lovington	blue grama	(A-12424)	Lovington, NM	1963	SCS	NM, AES	Los Lunas
Bromus biebersteinii	Regar	meadow brome	172390	Turkey	1966	SCS	ID,WA,AES	Aberdeen
Bromus carinatus	Cucamonga	mountain brome	(P-11117)	Cucamonga, CA	1949	AES CA	SCS	Pleasanton[1]
Bromus cartharticus	Prairie	rescuegrass	(P-13088)	New Zealand	1946	AES, CA	SCS	Pleasanton
Bromus inermis	Elsberry	smooth brome	(MI-2626)	MO, IA	1954	SCS	MO, AES	Elsberry
Bromus inermis	Fischer	smooth brome	(M2-10203)	Shenandoah, IA	1943	IA, AES	SCS	—
Bromus inermis	Manchar	smooth brome	109812	China	1943	SCS	ID,WA,AES	Pullman & Aberdeen
Bromus marginatus	Bromar	mountain brome	421024	Pullman, WA	1946	SCS	WA,ID,OR, AES	Pullman

[1] Plant operations have been transferred from Pleasanton, CA, to the Plant Materials Center, Lockeford, CA.

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation		PMC
						Primary	*Other*	
Bromus mollis	Blando	soft chess	(P-11657)	San Ramon, CA	1954	AES,CA	SCS	Pleasanton
Buchloe dactyloides	Texoka	buffalograss	(W2)	KS, OK, TX	1974	OK, AES	KS & TX, ARS, SCS	Manhattan & Knox City
Calamovilfa longifolia	Goshen	prairie sandreed	(P-15588)	Goshen Co., WY	1976	SCS	MT, WY AES	Bridger
Cenchrus ciliaris	Llano	buffelgrass	(Ex. Hybrid Africa No. 331)		1977	AES,TX SEA	SCS	—
Cenchrus ciliaris	Nueces	buffelgrass	(Ex. Hybrid Africa No. 2-1)		1977	TX,AES, SEA	SCS	Knox City
Cynodon dactylon	Tufcote	bermudagrass	(BN-4198)	S. Africa	1967	SCS	SEA, MD AES	National
Dactylis glomerata	Akaroa	orchardgrass	(P-7113)	New Zealand	1953	AES, CA	SCS	Pleasanton
Dactylis glomerata	Latar	orchardgrass	111536	USSR	1957	SCS	ID & WA AES	Pullman & Aberdeen
Dactylis glomerata	Pomar	orchardgrass	111537	USSR	1966	SCS	ID, AES	Aberdeen
Dactylis glomerata	Sandia	orchardgrass	(NY-NI-2569)	Germany	1953	SCS	NM, AES	Los Lunas
Echinochloa frumentacea	Chiwapa	Japanese millet	(MS-181)	India	1965	SCS	MS, AES	Coffeeville
Ehrharta calycina	Mission	perennial veldtgrass	187309	Australia	1962	CA,	SCS	Pleasanton
Elymus cinereus	Magnar	basin wildrye	(P-5797)	Saskatchewan, Canada	1979	SCS	ID, AES	Aberdeen
Elymus giganteus	Volga	mammoth wildrye	108491	USSR	1949	SCS	—	Pullman
Elymus triticcides	Shoshone	beardless wildrye	434040	WY	1980	SCS	ID,WY,AES	Bridger
Eragrostis curvula var. conferta	Catalina	boer lovegrass	203347	S. Africa	1969	ARS	AZ,AES SCS	Tucson
Eragrostis curvula var. conferta	A-84	boer lovegrass	(A-84)	S. Africa	1950	SCS	AZ, AES	Tucson
Eragrostis lehmanniana	A-68	lehmann lovegrass	(A-68)	S. Africa	1950	SCS	AZ, AES	Tucson
Eragrostis lehmanniana	Kuivato	lehmann lovegrass	(L-38)	S. Africa	1976	ARS	SCS,AZ,AES	Tucson
Eragrostis lehmanniana	Puhuima	lehmann lovegrass	(L-28)	S. Africa	1976	ARS	SCS,AZ,AES	Tucson
Eragrostis lehmanniana X E. trichophora	Cochise	atherstone lovegrass	276033	S. Africa	1979	SCS	AZ, AES	Tucson
Eragrostis superba	Palar	Wilman lovegrass	276055	S. Africa	1972	AZ, AES	SCS, ARS	Tucson
Eragrostis trichodes	Bend	sand lovegrass	421377	KS, OK	1971	KS, AES	ARS, SCS	Manhattan
Eragrostis trichodes	Nebraska-27	sand lovegrass	(NEBR. 27)	Holt Co., NE	1949	ARS	SCS,NE,AES	—
Eragrostis trichodes var. pilifera	Mason	sandhill lovegrass	(T-338)	Mason, TX	1971	SCS	TX, AES	Knox City
Festuca arizonica	Redondo	Arizona fescue	(NM-5)	Los Alamos, NM	1973	SCS	NM & CO AES	Los Lunas
Festuca megalura	Zorro	annual fescue	421020	Lockeford, CA	1977	CA, AES	SCS	Lockeford
Festuca ovina	Covar	sheep fescue	109497	Turkey	1977	SCS	WA, OR, ID, AES	Pullman
Festuca longifolia	Durar	hard fescue	421025	OR	1949	SCS	WA, OR ID, AES	Pullman
Hermarthria altissima	Bigalta	limpograss	299995	S. Africa	1978	SCS	FL, AES	Brooksville
Hemarthria altissima	Greenalta	limpograss	299994	S. Africa	1978	SCS	FL, AES	Brooksville
Hemarthria altissima	Redalta	limpograss	299993	S. Africa	1978	SCS	FL, AES	Brooksville
Hilaria jamesii	Viva	galleta	(A-12413)	Newkirk, NM	1979	SCS	CO,NM,AES	Los Lunas
Lolium rigidum	Wimmera 62	annual ryegrass	(P-11419)	Australia	1962	CA, AES	SCS	Pleasanton
Muhlenbergia wrightii	El Vado	spike muhly	(NM-199)	Park View, NM	1973	SCS	CO,NM,AES	Los Lunas
Oryzopsia hymenoides	Nezpar	Indian ricegrass	(P-2575)	Whitebird, ID	1978	SCS	AES, ID	Aberdeen
Oryzopsis hymenoides	Paloma	Indian ricegrass	(C-42)	Pueblo, CO	1974	SCS	AZ, CO, NM, AES	Los Lunas
Panicum antidotale	A-130	blue panicum	(A-130)	Australia	1950	SCS	AZ, AES	Tucson
Panicum clandestinum	Tioga	deertongue	(NY-4950)	(a blend)	1975	SCS	PA, AES NY, AES	Big Flats
Panicum coloratum	Selection 75	kleingrass	166400	S. Africa	1969	SCS	TX, AES	San Antonio[2]
Panicum hemitomon	Halifax	maidencane	(MS-2138)	NC	1974	SCS	MS, AES	Coffeeville
Panicum miliaceum	Dove	proso millet	196292	India	1972	SCS	GA, AES	Americus
Panicum virgatum	Alamo	switchgrass	(PMT-788)	TX	1978	SCS	AES, TX	Knox City
Panicum virgatum	Blackwell	switchgrass	421520	Blackwell, OK	1944	SCS	KS, AES	Manhattan
Panicum virgatum	Cave-in-Rock	switchgrass	(MI-5845)	Southern, IL	1974	SCS	MO, AES	Elsberry
Panicum virgatum	Kanlow	switchgrass	421521	Wetumka, OK	1963	KS, AES	SCS, ARS	Manhattan
Panicum virgatum	Nebraska 28	switchgrass	(NEBR. 28)	Holt Co., NE	1949	ARS	SCS, NE AES	—
Paspalum notatum	Pensacola	bahiagrass	(AM-1629)	Pensacola, FL	1944	SCS	FL, AES	Americus
Paspalum notatum	Wilmington	bahiagrass	(AM-1284)	Wilmington, NC	1971	SCS	—	Americus & Coffeeville

[2]Plant Materials operations now carried out by the Plant Materials Center, Knox City, TX.

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation		PMC
						Primary	*Other*	
Phalaris arundinacea	Ioreed	reed canarygrass	422030	Composite	1946	IA, AES	SCS	—
Phalaris tuberosa	Perla	koleagrass	202480	Morocco	1970	AES, CA	SCS	Pleasanton
Phragmites australis	Shoreline	common reed	(PMT-2376)	Lawrence, TX	1978	SCS	TX, AES	Knox City
Poa ampla	Sherman	big bluegrass	420127	Sherman Co., OR	1945	SCS	WA, ID, OR, AES	Pullman
Poa bulbosa	P-4874	bulbous bluegrass	420128	Pullman, WA	1956	SCS	ID, AES	Pullman
Poa canbyi	Canbar	canbyi bluegrass	(P-851)	WA	1979	SCS	ID,OR,AES	Pullman
Poa glaucantha	Draylar	upland bluegrass	109350	Turkey	1951	SCS	WA, AES	Pullman
Poa pratensis	Cougar	Kentucky bluegrass	421029	Denmark	1965	SCS	WA, AES	Pullman
Poa pratensis	Newport	Kentucky bluegrass	421030	Lincoln Co., OR	1958	SCS	WA,OR, AES	Pullman
Schizachyrium scoparium	Aldous	little bluestem	421553	Flinthills, KS	1966	KS, AES	ARS, SCS	Manhattan
Schizachyrium scoparium	Cimarron	little bluestem	(K-152)	W. KS, OK	1979	SCS	KS, AES, SEA	Manhattan
Schizachyrium scoparium	Pastura	little bluestem	(NM-272)	Pecos, NM	1963	SCS	NM, AES	Los Lunas
Sorghastrum nutans	Llano	Indiangrass	(NM-275)	Elida, NM	1963	SCS	NM, AES	Los Lunas
Sorghastrum nutans	Osage	Indiangrass	421594	KS, OK ACES	1966	KS,	SCS, ARS	Manhattan
Stripa viridula	Green Stripa	green needlegrass	(Reg. No 2)	Mandan, ND	1946	ARS	SCS	—
Tripsacum dactyloides	K-24	eastern gamagrass	(K-24)	KS, OK	1974	SCS	KS, AES	Manhattan

Table 3.--*Formal releases--Legumes and Forbs*

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation		PMC
						Primary	*Other*	
Arachis glabrata	Florigraze	perennial forage peanut	118457	Brazil	1978	SCS	FL, AES	Brooksville
Astragalus cicer	Lutana	cicer milkvetch	66515	Sweden	1969	SCS	MT,WY,AES	Bridger
Coronilla varia	Chemung	crownvetch	(NY-669)	Natural selection from composite	1964	SCS	NY, AES	Big Flats
Coronilla varia	Emerald	crownvetch	32305	USSR	1961	SCS	IA, AES	Elsberry
Desmodium aparines	Kuiaha	desmodium	(HA-201)	Syn. Cross	1969	SCS	HA, AES	Hawaii
Glycine sp.	Bobwhite	soybean	—	Blend	1975	MO. Dept. Cons.	SCS, ARS, MO, AES	Elsberry
Helianthus Maximiliani	Aztec	Maximilian sunflower	(T-1564)	TX	1978	SCS	TX, AES TX Parks	Knox City
Helianthus Maximiliani	Prairie Gold	Maximilian sunflower	(K-1425)	KS	1978	SCS	KS,NE, AES	Manhattan
Lathyrus sylvestris	Lathco	flatpea	(NY-1157)	WA	1972	SCS	NY,PA,AES	Big Flats
Lespedeza bicolor	Natob	bicolor lespedeza	(BN-2279)	China	1952	SCS	MD, AES ARS	National
Lespedeza cuneata	Appalow	sericea lespedeza	(KY-520)	Japan	1978	SCS	KY, AES	Quicksand
Lespedeza virgata	Ambro	virgata lespedeza	218004	Japan	1971	SCS	GA, AES	Americus
Liatris pycnostachya	Eureka	thickspike gayfeather	(K-1417)	KS	1975	SCS	NE, AES	Manhattan
Linum lewisii	Appar	Lewis flax	445972	SD	1980	SCS	USFS, ID, AES	Aberdeen
Lotus corniculatus	Cascade	birdsfoot trefoil	421026	France	1954	SCS	WA, AES	Pullman
Lotus corniculatus	Mackinaw	birdsfoot trefoil	340799	IA	1971	SCS	—	Rose Lake
Lotus corniculatus var. arvensis	Kalo	dwarf English trefoil	234670	France	1976	OR,WA, AES	SCS	Corvallis
Lotus pedunculatus	Marshfield	big trefoil	48636	New Zealand	1971	OR, WA, AES	SCS, ARS	Corvallis
Penstemon strictus	Bandera	Rocky Mountain penstemon	(PM-NM-628)	NM	1973	SCS	NM, AES	Los Lunas
Petalostemum purpureum	Kaneb	purple prairieclover	(NDL-54)	KS	1975	SCS	NE, AES	Manhattan
Ratibida pinnata	Sunglow	grayhead prairie-coneflower	(K-1153)	KS	1978	SCS	KS,NE,AES	Manhattan
Salvia azurea var. grandiflora	Nekan	pitcher sage	(K-1408)	KS	1975	SCS	NE, AES	Manhattan
Trifolium hirtum	Wilton	rose clover	(FC-23014)	Turkey	1967	CA, AES	SCS	Pleasanton
Trifolium vesiculosum	Amclo	arrowleaf clover	234210	Italy	1971	SCS	GA, AES	Americus
Trifolium vesiculosum	Meechee	arrowleaf clover	233782	Italy	1966	SCS	MS, AES	Coffeeville
Vicia dasycarpa	Lana	woollypod vetch	117430	Turkey	1956	CA, AES	SCS	Pleasanton

Table 4.--*Formal releases, Woody*

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation *Primary*	Agency Participation *Other*	PMC
Acer ginnala	Flame	Amur maple	(MI-891)	Eastern Asia	1978	SCS	—	Elsberry
Atriplex canescens	Marana	fourwing saltbush	(PL-324)	San Diego Co., CA	1979	SCS	CA, AES, & CA Dept. F&G	Lockeford
Atriplex canescens var. aptera	Wytana	fourwing saltbush	346419	Roundup, MT	1976	SCS	MT,WY,AES	Bridger
Atriplex lentiformis	Casa	quailbush	(PL-595)	San Benito Co., CA	1979	SCS	CA, AES, & CA Dept. F&G	Lockeford
Atriplex semibaccata	Corto	Australian saltbush	(P-15653)	Naturalized stand, AZ	1977	SCS	AZ, AES	Tucson
Cercocarpus montanus	Montane	mountain-mahogany	(NM-715)	NM	1978	SCS	NM,CO,AES NM Hwy	Los Lunas
Chilopsis linearis	Barranco	desert willow	(NM-778)	TX	1977	SCS	NM, AES, NM Hwy	Los Lunas
Elaeagnus angustifolia	King-Red	Russian-olive	(WY-292A)	Afghanistan	1978	SCS	NM,CO,AES NM Hwy	Los Lunas
Elaeagnus umbellata	Cardinal	autumn olive	(BN-270)	Manchuria	1961	SCS	—	Big Flats
Elaeagnus umbellata	Elsberry	autumn olive	(MI-6369)	SE Asia	1979	SCS	—	Elsberry
Euonymus bungeanus	Pink-Lady	winterberry euonymus	62418	China	1973	SCS	KS, AES	Manhattan
Fraxinus pennsylvanica	Cardan	green ash	Mandan-12002	MT	1979	SCS	SEA-AR	Bismarck
Forestiera neomexicana	Jemez	New Mexico forestieria	(A-12044)	Carlyle, NM	1978	SCS	NM,CO,AES NM Hwy	Los Lunas
Isomeris arborea var. globosa	Dorado	bladderpod	(PL-261)	Los Angeles Co., CA	1979	SCS	CA, AES, & CA Dept. F&G, ARS	Lockeford
Juniperus conferta	Emerald Sea	juniper	323932	Japan	1971	SCS	ARS	Cape May
Lonicera maackii	Cling-Red	Amur honeysuckle	(MI-4701)	Eastern Asia	1979	SCS	———	Elsberry
Lonicera maackii	Rem-Red	Amur honeysuckle	(NJ-918)	MD	1970	SCS	———	Cape May
Malus baccata var. mandshurica	Midwest	Manchurian crabapple	(ND-282)	Asia via Canada	1973	SCS	———	Bismarck
Malus sargenti	Roselow	sargent crabapple	(Mich-1339)	Japan	1978	SCS	———	Rose Lake
Populus canadensis var. eugenei	Imperial	Carolina poplar	432347	Faribault, MN	1979	SCS	———	Rose Lake
Rhus aromatica var. serotina	Konza	aromatic sumac	PMK-32	KS	1980	SCS	KN,NB,AES NB G&P, KN F&G	Manhattan
Rhus trilobata	Bighorn	skunkbush sumac	(WY-843)	Basin, WY	1979	SCS	NM,CO,AES, & NM Hwy	Los Lunas
Robinia fertilis	Arnot	bristly locust	(NY-3018)	NY	1969	SCS	———	Big Flats
Salix purpurea	Streamco	purpleosier willow	(NY-2178)	NY	1975	SCS	NY Dept Env. Cons.	Big Flats
Yucca elata	Bonita	soaptree yucca	(NM-748)	NM	1978	SCS	NM,CO,AES	Los Lunas

Table 5.--Informal releases, grasses

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation *Primary*	Agency Participation *Other*	PMC
Andropogon annulatus	Kleberg	bluestem	——	King Ranch, TX	1944	SCS	———	San Antonio, TX, Nursery
Andropogon annulatus	Pretoria 90	bluestem	188926	S. Africa	1954	SCS	———	San Antonio, TX, Nursery
Andropogon caucasicus	Caucasian	Caucasian bluestem	78758	USSR		SCS	———	Manhattan
Andropogon hallii	Garden	sand bluestem	(NB-378)	composite	1961	SCS	———	Manhattan
Andropogon hallii	Cherry	sand bluestem	———	Cherry Co., NE	1961	SCS	NE, AES	———
Andropogon nodosus	Angleton	bluestem	34934	Poona, India	1924	Substation 3 Angleton, TX	SCS	———
Andropogon nodosus	Gordo	bluestem	190302	S. Africa	1957	SCS	———	San Antonio, TX, Nursery
Andropogon nodosus	Medio	bluestem	(T-20011)	Bee County, TX	1954	SCS	———	San Antonio, TX, Nursery
Bothriocloa ischaemum	El Kan	yellow bluestem	(KG-495)	Elk Co., KS		SCS	———	Manhattan
Bothriocloa ischaemum var. songarica	King Ranch	bluestem	(T-3487)	King Ranch, TX	1941	SCS	TX, AES	San Antonio, TX, Nursery
Bouteloua curtipendula	Pierrre	sideoats grama	(PM-SD-251)	Stanley Co., SD	——	SCS	———	Bismarck
Bouteloua curtipendula	Kildeer	sideoats grama	(ND-89) (& ND-143)	ND	——	SCS	———	Bismarck
Bromus catharticus	Chapel Hill	rescuegrass	(FC-38369)	Commercial	1947	SCS	———	Chapel Hill, NC, Nursery[3]
Bromus catharticus	Nakuru	rescuegrass	195476	S. Africa	——	SCS	———	Americus
Cenchrus ciliaris	Blue	buffelgrass	133898	S. Africa	1952	SCS	———	San Antonio, TX, Nursery
Cenchrus ciliaris	T-4464	buffelgrass	153671	S. Africa	1949	SCS	———	San Antonio TX, Nursery
Echinochloa colonum	Baldwin	junglerice	(AM-430)	Baldwin Co., AL	——	SCS	———	Thorsby, AL, Nursery[3]
Eragrostis curvula	A-67	lovegrass	(A-67)	Tanganyika, Africa	——	SCS	———	Tucson
Eragrostis lehmanniana	Lehmann	lovegrass	(A-68)	S. Africa	1950	AZ, AES	SCS	Tucson
Festuca arundinacea	Asheville	tall fescue	(SC-20-764)	Asheville, NC	1952	SCS	———	Americus
Festuca arundinacea	Goar	tall fescue	(P-13847)	Hungary	1946	SCS	CA, AES	Lockeford
Leptochloa dubia	Marfa	green sprangletop	———	Marfa, TX	——	SCS	———	San Antonio, TX, Nursery
Oryzopsis miliacea	———	smilograss	———	Mediterranean Region	1947	CA, AES	———	Pleasanton
Panicum antidotale	T-15327	blue panicgrass	(T-15327)	selection from A-130 blue panic	1949	SCS	———	Woodward, OK, Tucson, AZ Nurseries[3]
Panicum antidotale	———	blue panicgrass	(A-130)	Australia	1950	AZ,AES	SCS	Tucson
Panicum antidotale	———	blue panicgrass	142284	Australia	1949	SCS	———	Tucson
Panicum ramosum	Browntop	millet	———	———	1950's	SCS	———	———
Panicum texanum	Artex	Texas millet	(F-639)	Blountstown, FL	——	SCS	———	Brooksville
Panicum virgatum	Grenville	switchgrass	(A-5669)	Grenville, NM	1940	SCS	———	Los Lunas
Paspalum nicorae	Amcorae	brunswickgrass	202044	Argentina	1969	——	———	———
Phalaris tuberosa var. stenoptera	———	hardinggrass	(P-11740)	Australia	1946	CA, AES	———	Pleasanton
Sorghastrum nutans	Cheyenne	Indiangrass	———	Supply, OK	1945	SCS	———	Manhattan
Sorghum sundanense	Wild	sudangrass	(SC-20-833)	Clewiston, FL	1950	SCS	———	Americus
Shorghum vulgare var. drumondii	Tombigbee	chickencorn	(SC-26-104)	Epes, AL	1950	SCS	———	Americus
Trichachne californica	PMT-389	Arizona cottontop	(PMT-389)	Van Horn, TX	1961	SCS	———	Knox City

[3]SCS nurseries were predecessors to the Plant Materials Centers. Arcadia, FL; Chapel Hill, NC; Thorsby, AL; Gretna, VA; and Woodward, OK, are no longer active.

Table 6.--*Informal releases, legumes and forbs*

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation		PMC
						Primary	*Other*	
Aeschynemonene americana	F-149	American jointvetch	(F-149)	Arcadia, FL	--	SCS	----	Arcadia, FL[3]
Desmodium perplexum	Clanton	tickclover	434012	Clanton, AL	1958	SCS	----	Thorsby, AL
Indigofera hirsuta	Davis	hairy indigo	(F-1369)	FL	1962	SCS	----	Thorsby, AL
Indigofera hirsuta	Late	hairy indigo	----	----	--	SCS	----	Arcadia, FL
Lespedeza bicolor	Thorsby	bicolor lespedeza	(AM-313)	----	1954	SCS	----	Thorsby, AL
Lespedeza bicolor	100	bicolor lespedeza	----	----	1947	SCS	----	Chapel Hill, NC, Nursery
Lespedeza bicolor	101	bicolor lespedeza	----	----	1947	SCS	----	Chapel Hill, NC
Lespedeza cuneata	Arlington	sericea lespedeza	----	----	1939	SCS	----	Chapel Hill, NC
Lespedeza thunbergii	VA-70	shrub lespedeza	90664, 82480, 69812,	Manchuria	1952	SCS	----	Gretna, VA[3]
Lespedeza thunbergii	----	thunberg lespedeza	(AM-167)	----	--	SCS	----	Thorsby, AL
Lupinus angustifolius	Orlando	blue lupine	(F-114)	Orlando, FL	1963	SCS	----	Arcadia, FL
Lupinus elegans	Armex	Mexican lupine	185099	Mexico	1962	SCS	----	Arcadia, FL
Trifolium michelianum	Mike	clover	120136	Turkey	1952	SCS	----	Thorsby, AL
Trifolium nigrescens	Ball	clover	120132	Turkey	1957	SCS	----	Thorsby, AL
Vicia lutes	Dadeville	yellow vetch	(AM-87)	Dadeville, AL	1969	SCS	----	Americus
Vigna sinense	Thorsby	cowpea	(AM-4)	Chilton Co., AL	1954	SCS	----	Thorsby, AL
Vigna sinense	Tory	cowpea	(MS-130)	Columbus, MS	1949	SCS	----	Thorsby, AL

Table 7.--*Informal releases, woody*

Scientific name	Cultivar	Common name	PI or other No.	Source	Released	Agency Participation		PMC
						Primary	*Other*	
Quercus acutissima	Athens	sawtooth oak	(AM-261)	Univ. of GA, Athens	--	SCS	----	Americus

Disturbed Land Reclamation (Western "Sub" Group)

Ron Younger, *Chairman*

(Reported by Thane Johnson, BLM)

The Western Subgroup representatives have a variety of topics to report on: rangeland equipment, research progress, plant materials, and revegetation issues. The Disturbed Land Reclamation Workgroup met following the Sunday afternoon session with persons interested in the reference area revegetation compliance issue and asked to be included as participants in the workgroup. About 17 people attended this session. An issue paper was formulated by the group and is published under Ken Brakken's presentation, "Need to Develop Alternative Methods to Judge Revegetation Success." Arlo Dalrymple, OSM, related that the use of reference areas for evaluating disturbed and reclamation success is an accepted concept. However, the surface mining regulations only require this procedure as an alternative for the regulatory authority. If the State regulatory authority prescribes another procedure for measuring the success of revegetation, the prescribed procedure can be accepted. The main point at issue is that an accepted procedure be used to measure disturbed land revegetation success for a prescribed period of time.

Strip revegetation research and monitoring of revegetation success along lineal areas, such as disturbed areas along pipelines, were proposed by Randall Chappel, who is environmental coordinator of the Alaska pipeline project through Canada. This is a very timely proposal that concerns many of the workgroups considering the numerous pipeline projects in the entire North American Continent. Presentations relating to lineal vegetation procedures, research projects, and adapted equipment are welcome for the 1982 VREW.

The Western Subgroup report consists of these presentations:

- Reference Area Concept—Ken Brakken, ERT, Inc.
- Native Plant Developments—Claire Gabriel, Native Plants, Inc.
- Tree Pad Transport—Jim Smith, Colorado State University.
- Utah Reclamation—Cy McKell, Utah State University.
- Project Work in Wyoming—Don Calhoun, D&C Consultants.

Need to Develop Alternative Methods to Judge Revegetation Success

By Ken Brakken, ERT, Inc., Fort Collins, Colo.

The coal industry is currently experiencing a difference of opinion with the Office of Surface Mining (OSM) over parts of the Federal coal mining regulations. The difference of opinion I am referring to is the controversy over methods to judge success of revegetation prior to bond release of reclaimed coal mined lands. Public Law 95-87 was signed into law in August 1977. Section 515(b)(19) of that law requires that operators establish, on the regraded areas and all other affected areas, a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area, capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area. An exception to this is that introduced species may be used in the revegetation process where necessary and desirable.

Two sets of regulations were promulgated to implement the law. The first set of regulations were called the interim regulations and took effect in May 1978. The second set of regulations, the permanent regulations, take effect as coal States submit regulatory programs and gain regulatory authority (primacy). Most of the Western States have obtained primacy and, therefore, the permanent regulations are in effect.

The interim program specified that reference areas would be used for judging revegetation success, while the permanent regulations allow the use of reference areas or technical standards published by the U.S. Department of the Interior or Agriculture. Therein lies the problem. There are no published USDI or USDA technical standards that can be immediately applied to judging success of revegetation on surface mines. Although the Office of Surface Mining recently has begun to encourage operators to propose alternate methods, there is now only one OSM-sponsored method to evaluate revegetation reference areas.

The law and regulations permit post-mining land use changes to higher and better uses. In this case, different vegetation types will be substituted for those previously existing; therefore, a pre-mining reference area would not be appropriate, since a change in vegetation would be intended. The operator could propose a new standard, but the regulatory authorities should invest some time and effort in developing alternative methods also, if for no other reason but to provide continuity and direction.

A second reason for promoting the use of other alternatives to reference areas is that the operator may wish to improve forage and wildlife values with no change in land use, and the use of reference areas in some cases is illogical. For example, if the permit area has been overgrazed and poor quality shrubs are dominant, it may be desirable to reduce shrub density and promote grasses and forbs. It is, therefore, not logical to refer to an area in poor condition to judge revegetation success. It appears impractical that coal operations may be planting trees and shrubs while adjacent land owners and public land managers are eradicating those same trees and shrubs on adjacent lands.

An ad hoc committee, the Committee to Develop Alternative Methods to Judge Success of Revegetation of Coal Mined Lands, met at the Tulsa VREW on February 8 and 9, 1981. The committee observed that:

- Flexibility has been incorporated into OSM's permanent rules and regulations with respect to standards for measuring success of revegetation of disturbed land.
- The Office of Surface Mining has emphasized the use of reference areas as the means to be used for measuring success of revegetation.
- OSM has indicated that other standards of success will be considered in lieu of reference areas, if the permittee can demonstrate that the standards are satisfactory.

- OSM and the state regulatory authorities should immediately begin developing alternative measures to judge revegetation success.

- Simplification of the reference area concept may include: (1) a change to measurement of only density (live stems per unit area) in the shrub, half-shrub, and tree components of a community or vegetation type; (2) measure only cover in the grass and forb component; and (3) provide for approval of the seeding and planting mixture by the regulatory authority to meet vegetation diversity and post-mining land use requirements, but there would be no diversity comparison for bond release purposes.

- It appears that the reference area concept as proposed by OSM rewards inadequate sampling and penalizes intensive sampling.

The committee is soliciting participation by interested individuals. Those wishing to propose alternatives or review draft proposals please call Don Manning at (303) 758-1700, ext. 269 in Denver or write Don at Pittsburg and Midway Coal Mining Co., 1720 South Bellaire St., Denver, CO 80222.

Inoculation of Tubelings with Mycorrhizae to Aid Plant Establishment

By Claire Gabriel, Native Plants, Inc., Salt Lake City, Utah

Most native plants have adapted to growth on low fertility soils through a mutually advantageous association with certain beneficial soil fungi. Such associations are termed "mycorrhizae" (fungus root), and they are formed when a mycorrhizal fungus infects a plant root forming microscopic bridges between root and soil. The fungus obtains from the plant an energy source in the form of fixed carbon. The plant, in turn, may benefit from enhanced soil uptake of phosphorus to a variety of root diseases. These advantages invariably yield increased plant growth and survival.

Chris Cull, from Utah State University, will present a paper at the Society for Range Management meetings later in the week documenting significant increases in survival and growth of inoculated plants on mine spoil.

Soil disturbances resulting from severe erosion, long-term clearing, topsoil stockpiling, or fumigation can reduce the natural complements of mycorrhizal fungi in soils. Revegetation can be slowed, unless efforts are made to reintroduce and manage these important microbes.

At Native Plants, Inc., Dr. Tim Wood is working to inoculate our containerized plants with mycorrhizae. He hopes to offer this amendment as a regular feature of our nursery plants in the future. Additional research is directed at pelletizing seed with mycorrhizal inoculum and at developing micorrhizal soil amendments.

Gasoline Plants: A New Post-Mining Crop

At Native Plants, Inc., we are researching new hydrocarbon crops that have crude oil flowing in their veins. The milky sap of some plant species, when extracted, is chemically similar to crude oil and can be put to all the same uses. Since some of the many species we are examining are widely adapted weeds (e.g., *Asclepias speciosa,* milkweed) or grow on marginal land (e.g., *Chrysothamnus nauseosus*, rubber rabbitbrush), they are potentially new agronomic crops for arid or marginal land.

Transport Machine for Transplanting Vegetation[1]

By James L. Smith, professor, and Jon P. Workman, research associate, Department of Agricultural and Chemical Engineering, Colorado State University, Fort Collins; Kent A. Crofts, manager of reclamation and environment, Energy Fuels Corp., Steamboat Springs, Colo.

Introduction

During the 1980 season, approximately 60,000 square feet of mature vegetation was transplanted on the Energy Fuels Mine near Steamboat Springs, Colo. The vegetation was transplanted in pads using a modified front-loader bucket with an effective area of 75 square feet.

Analysis of the productivity of the front loader indicated that over 80 percent of the time involved in transplanting was used to travel between the plant source area and the transplant area. With operating costs of approximately $90 per hour for the front loader, it was evident that transplanting costs could have been significantly reduced and productivity increased by the development of a machine to transplant and place several pads of vegetation in a single trip.

In addition to reducing costs and increasing productivity, the transporter could significantly increase the flexibility of the transplanting operation. A front loader could be used for short time periods to remove and stockpile pads of vegetation. The pads could then be picked up and moved to the transplant area with the transporter. The transporter would be used strictly for reclamation and its operation would not conflict with mining activities.

Transporter Design and Operation

The experimental transporter (fig. 1) was fabricated by modifying a Hesston Model 20 Stackmover. The machine, as originally manufactured, was intended to load, transport, and unload haystacks. The transporter consisted of the following components:

1. A tilt-bed trailer having a surface area of 170 square feet. The surface was covered with Lucite SAR to reduce sliding friction between the pads and trailer.

2. A pickup roller for separating the loose pads from the ground (fig. 2).

[1]This research was supported in part by the U.S. Bureau of Mines, Spokane Mining Research Center.

3. A chain conveyor system for sliding vegetation pads across the top of the trailer (fig. 2).

4. A set of tracks under the rear of the trailer to pull the trailer under the pad (fig. 3).

5. A 22-horsepower air-cooled gasoline engine mounted on the front of the trailer. The engine supplied power to a hydraulic system which activated the tilt cylinders on the trailer, and powered the conveyor and track drive.

The mechanical components were synchronized so the pad was moved onto the trailer (fig. 4) as the tracks pulled the trailer under the pad. When unloading, the pad was unloaded from the trailer at the same rate the tracks pushed the trailer forward. The maximum tilt angle of the trailer was approximately 15 degrees. Less than 10 hydraulic horsepower was required to operate the transporter.

Figure 1.--Experimental tree pad transporter.

Figure 2.--Pickup roller and conveyor.

Figure 3.--Tracks.

Figure 4.--Loading pad on transporter.

Transporter Evaluation

Two modes of operating the transporter were evaluated. First, the pads of vegetation were placed on the transporter with the front loader. They were then moved to the transplant site and unloaded. The second mode of operating the transporter was to pick up loose pads, transport them to the transplant site, and unload them.

In general, operation of the transporter was very satisfactory. It was capable of performing all of the desired functions, although some improvements could be made. It was most successful in handling pads of dense grass. This was expected because the dense root mat tended to hold the pad together. However, most of the damage was done during removal by the front-loader bucket, and the additional damage caused by the transporter was relatively minor.

Transporter Use for Moving Roots

The transporter is well suited for moving plants such as Gambell oak, which exhibit good rootsprouting tendencies. The above-ground portions of the plants could be removed mechanically. Simply knocking them over and scraping them off with the front loader would be satisfactory. The roots could then be dug by the front loader and placed on the transporter along with soil in which the mature plants were growing. Using the transporter, the roots would be moved to the transplant site and deposited. Action of the transporter in unloading would spread the roots and keep most of them covered with soil.

Suggested Improvements

Improvements in performance of the transporter could be made in the following areas:

1. The structural integrity, dimensions, and lift capacity of the trailer should be increased so the transporter can carry four or five pads with a total weight of approximately 25 tons.

2. The chain conveyor should be redesigned so the conveyor slats cover the entire width of the trailer. This would require moving the conveyor drive and tracks to the sides of the trailer.

3. The rear of the trailer should be redesigned to aid in picking up the pads.

4. Side rails or guards should be provided to keep the pads intact as they are transported.

5. The drive system should operate somewhat slower than the present system. Approximately 25 hydraulic horsepower should be available on the redesigned transporter.

Land Reclamation Methods and Plant Materials for Arid Sites

By C.M. McKell (Logan, Utah) and Gordon Van Epps (Ephraim, Utah), Utah State University

Disturbance of harsh sites in the arid Southwestern United States requires methods and plant materials unique from those employed in areas of more favorable climate. Our work at the Henry Mountain Coal Field in southcentral Utah and on a processed oil shale disposal pile at Anvil Points, Colo., features the use of container-grown plants to avoid the hazards of seedling establishment and growing plants in a topsoil-filled trench in the shale disposal pile. Greatest success is experienced with plant species adapted to drought, salinity, and wide temperature extremes. Some of the most favorable species tested were *Atriplex confertitolia, Atriplex cuneata, Kochia prostrata,* and *Elymus junceus.*

A Reclamation Contractor's Experiences with Equipment

By Don Calhoun, D & C Reclamation, Lander, Wyo.

D & C Reclamation performs contract revegetation work for mining companies, oil companies, pipeline contractors, highway contractors, and private landowners.

The basic machine we use for reclamation seeding is the rangeland drill. For the wide variety of conditions on which we operate, we feel it is the best and most versatile seeding machine. We own two of these drills. On large seeding jobs, these drills are pulled in tandem, using a two-drill cart, by a large John Deere tractor (7020) that is four-wheel drive with duals all the way around. With this combination of equipment, we can seed up to 120 acres in 1 day. We also have special trailers for these equipment packages. The machinery can be loaded or unloaded in 15 minutes. In the work that we do it is quite important that our equipment be highly mobile.

The next seeding machine that we use is the Hodder gouger (developed by VREW). This machine has some real advantages and some disadvantages. For certain soil and climatic conditions it is excellent. In order for the machine to create basins of the desired shape it is necessary for the soil to be reasonably soft. If the area has been recently topsoiled or if the soils are naturally light and soft it will do a fine job. The advantages of using this machine include the concentration of available moisture, reduction of the effects of wind on new seedlings, and the creation of a favorable microclimate for new seedlings. Disadvantages include the operating speed, which is slow. It is possible to seed from 1½ to 2 acres per hour. The present hydraulic system seems too delicate, complicated, and is difficult to regulate. More work needs to be done on this machine, but the basic principle involved is great.

Rangeland drill is the most versatile seeding machine operated by D&C Reclamation.

The next machine we use is the hydroseeder. We generally do not advocate using this machine in this area due to the soils and climate, however, there are special conditions that require it. These include very steep areas and small sites where it is not feasible to use larger machinery. Costs are high and the production rate is low, but there are situations where it is the only way to go.

Another machine we use in drill hole reclamation is a Case Skidster (similar to a Bobcat). The work involves pulling PVC casing, plugging the hole with cement, smoothing the ground surface, and seeding the site. The Case Skidster is an amazing machine for jobs of this type. It can move a lot of dirt, pull the casings, smooth out the site, and move to the next one in a matter of a few minutes.

We also use backhoes for the larger drill hole reclamation jobs where it is necessary to reestablish the natural contours of the land after roads have been built along hillsides to reach the drill sites. We use a Case 580 for the smaller sites and a John Deere 690B tracked backhoe for the large sites. The John Deere has a 5-foot bucket with a 1-yard capacity. It can move a large amount of soil and rock. And the beauty of using these machines is that there is little or no secondary disturbance.

The reclamation work we do is quite variable and so is the machinery we use. I am also sure that this variety will increase as time passes. It seems like there is always a new challenge in this work that must be met.

Hodder gouger makes depressions in soil and simultaneously seeds area to establish plant cover. Depressions create favorable microclimate that traps moisture and protects against wind.

Disturbed Land Reclamation (Eastern "Sub" Group)

Willis Vogel, *Chairman*

The purpose of this report is to discuss some concerns with the establishment of woody plant species on surface-mined lands in the Eastern United States, and to speculate on the needs for equipment and procedures that may be helpful in establishing woody plants.

Much of the early effort to revegetate surface-mined lands in the eastern coal regions was with the planting of tree seedlings on spoil banks that were ungraded, unamended, and not seeded to herbaceous vegetation. Many of these plantings made 30 to 50 years ago were reasonably successful; the planted trees in combination with the volunteer trees and understory vegetation have formed young forests that today are similar in appearance to forests on adjacent unmined lands.

During the 1960's and 1970's, tree planting became a relatively minor part of revegetating surface-mined lands. The establishment of herbaceous ground cover for erosion control and esthetics was emphasized and required by regulatory agencies in most States. Also, grasses and legumes usually were cheaper and easier to establish than woody plants and avoided the labor problems associated with the planting of tree seedlings. In some places the herbaceous vegetation has been used for pasture and hay.

In the past few years, Federal regulations on surface mining and reclamation have caused a renewed interest in planting woody species. Herbaceous cover still is essential for the control of erosion in all post-mining land uses, but where planted with trees, herbaceous cover can jeopardize the survival and growth of the woody plant seedlings. Other actions required by the new regulations also seemingly contribute to problems in establishing woody plants; especially those requirements for intensive earth moving and land shaping that sometimes cause compaction of the minesoils and apparently hinder establishment of planted seedlings. Thus, with these physical encumberances and the usual economic and labor-related problems, tree planting is not an attractive revegetation alternative.

Several actions are needed to improve chances of successfully establishing and growing woody species, including changes in those earth-moving practices that obviously hinder survival and growth of seedlings. But where these practices are continued, greater use of existing methods of testing of new methods and equipment may be needed for alleviating physical problems on minesoils, especially soil compaction and erosion caused or induced by the intensive earth-moving practices.

Special techniques will be required for establishing woody species planted in conjunction with herbaceous cover. The procedure that probably will be most used in the East is to establish herbaceous cover first and plant the woody species later. But planting tree and shrub seedlings into established herbaceous cover normally affords the least chance for their survival. Therefore, using herbicides or tillage to kill or control herbaceous cover in strips or spots seems to be the most likely method of reducing herbaceous competition in preparation for planting woody seedlings, yet not reducing overall affectiveness of the herbaceous cover for controlling erosion.

Because of the kinds of equipment available, tillage is most feasibly done in strips, although an implement such as the modified Hodder gouger indicates that spot preparation is possible. Herbicides also can be applied in strips or spots, but some modification of existing spray equipment may be required, especially for spot application.

Techniques also are needed for successfully establishing woody plant seedings that will be planted at the same time as the herbaceous species are sown. To reduce early competition from herbaceous species, planting the woody species and herbaceous species in alternate strips is a feasible method for combination plantings on areas where equipment for applying seed and fertilizer can be used. With this method the seed and fertilizer are applied in contour bands or strips about 5 to 6 feet wide. These strips alternate with strips about 2 to 3 feet wide that are not seeded but are planted to trees only. To make this technique most efficient, some modification of existing seeding, fertilizing, and planting equipment may be required. Possibly, one piece of equipment could be developed to provide both seeding and planting operations at the same time.

Because of the costs and labor problems associated with hand planting of tree seedlings, many operators are requesting information on the feasibility of direct seeding tree and shrub species. Except for black locust, establishment of woody species by direct seeding generally has had little success on surface-mined lands. A few exceptions are with the southern pine on mine spoils in the Southeast and with large-seeded species such as black walnut and bur oak in the Midwest. More research is needed on species suitable for direct seeding, and there may be a need also for the adaptation, modification, and possibly development of equipment for direct seeding on mined lands.

I believe, though, that existing seeding equipment, with modification where necessary, can be successfully used for most of the applications on surface-mined lands. For direct seeding of woody species, rangeland interseeders developed in the West and the furrow seeder developed in the Northeast are examples of equipment in use or potentially available for testing on surface-mined lands.

As another example, the forestry department at the University of Kentucky is testing a modified Cole multiflex row crop planter for direct seeding large-seeded tree species such as pin oak, white oak, and northern red oak on surface-mined lands. They found that their modified planter worked satisfactorily on relatively level areas and on loose freshly tilled spoil, but further modification was needed for use of this planter on slopes and on compacted minesoils.

In most situations that require specialized equipment, it is first a matter of informing potential users, and agencies that advise the users, that equipment suitable for reclamation work exists and often is available; or in some cases, plans for construction are available. In some situations, we as participants in VREW may be able to help a potential user borrow and test an appropriate piece of equipment.

The Eastern "Sub" Group of the Disturbed Land Reclamation Workgroup should be involved in determining needs for specialized equipment in reforestation programs in the East, and in encouraging and coordinating the use and adaptation of equipment that is currently available.

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Seed Harvesting

Stephen B. Monsen, *Chairman*

Field testing has been conducted to evaluate three new seed collectors. These hand-operated units are designed to harvest seed from native plants in the wild. All three machines use a vacuum to extract and collect seeds.

The first unit tested was constructed at the San Dimas Equipment Development Center in 1979 and has collected seeds from a number of species. The equipment consists of an injector seed-collecting head (air amplified) powered by a trailer-mounted air compressor (fig. 1). The seed collection unit is attached to a lightweight backpack frame that is carried by an operator. Seeds are drawn into the machine through a rubber hose. Hoses varying from 4 to 8 inches in diameter have been tested. A 6-inch hose appears to be most satisfactory. Seeds are deposited in a burlap bag. Approximately 20 pounds of fourwing saltbush seed can be stored in a bag. Bags are replaced as they are filled.

Figure 1.--Backpack-carried 8-inch air amplified seed collector.

Sufficient air injection is not created to extract seeds of fourwing saltbush, big sagebrush, or rubber rabbitbrush from the bush. Field tests have demonstrated the unit is only 25 percent as efficient as hand collection for these three shrubs.

The machine is capable of collecting lightweight seeds and is useful in extracting seed from plants with spiny branches. The machine has operated satisfactorily in collecting seeds from shadscale and squirreltail. However, other seed harvesters operate more efficiently.

Because the unit is operated by a trailer-mounted air compressor, the machine can only be used in areas accessible to vehicles.

A commercial air blower built by Solo Kleinmotoren Co. of West Germany has been adapted to suck seeds into a collection bag. A small gasoline engine powers the unit, which can be strapped onto the collector's back. The machine weighs 24 pounds. Seeds are drawn from the plant through a nozzle or rubber tube that is about 1-1/8 inches in diameter (fig. 2).

Figure 2.--Solo backpack-mounted seed collector with 1-1/8-inch inlet.

The machine does not develop enough suction to remove heavy seeds from the shrub or draw them into the machine. Only small, lightweight seeds can be collected. Seeds drawn into the collection bags are not damaged. If additional suction could be generated, the unit would have promise as a backpack device.

A very promising machine was acquired and tested in heavy browse seeds. The machine is called an Elphant-Vac (fig. 3). It is marketed by Evans Sales and Marketing, Inc., Suite 4, 22371 Newman Rd., Dearborn, Mich., (313) 563-1413.

Figure 3.--Elphant-Vac being used as a seed collector.

The unit has been designed and sold as a vacuum collector to clean debris from walkways, parks, and recreation centers. The machine weighs 370 pounds, so must be transported by a vehicle. The unit is gasoline operated. A long rubber collection hose, 6 inches in diameter, has been mounted on the machine through which seeds are collected. The hose allows an individual to collect seeds from bushes 20 to 30 feet away from the machine.

The machine generates considerable suction and is capable of extracting heavy seeds from a plant. Dry seeds of fourwing saltbush can easily be detached from the shrub and collected with the equipment. During test runs in collecting fourwing saltbush seed, machine collection was not as efficient as hand collection. Hand collectors harvested approximately 25 percent more seed than was obtained with the machine. However, with some modifications and increased experience of the operator, machine collection rate would improve.

The machine can collect dry seeds from low growing bushes and plants that possess thorns much faster than by hand.

The unit's fiberglass collection tank holds about 4 bushels, a sufficient size to hold a large volume of seed. The collection tank can be opened quickly and emptied. The machine does not damage the seeds.

Because the machine must be transported in a small pickup, the unit can be operated only in areas accessible by vehicle. But it could be mounted on an all-terrain vehicle and transported into rough areas.

The collection hose must be moved from bush to bush and is tiring to manipulate. The present hose is rather heavy and should be replaced by a lighter one. A boom mounted on the machine to help suspend and rotate the hose would also simplify and accelerate seed collection.

Steep-Slope Stabilization
Bob Hamner, ***Chairman***

The Workgroup is in a period of adjustment with new chairman and membership. The group has written a charter and is searching for new tasks. The individuals who have agreed to serve on the committee as reconstituted are:

Bob Hamner, Chairman, Forest Service, Portland, Oreg.
Ray Adolphson, Forest Service, Denver, Colo.
Hal Legard, Forest Service, Eugene, Oreg.
Steve Monsen, Forest Service, Boise, Idaho
John Rinard, Idaho Division of Highways, Boise, Idaho
Bob Strombom, Forest Service, Portland, Oreg.
Louis Vaughn, ESI, Inc., Tacoma, Wash.

The group's original charter is almost entirely realized. Both the steep slope seeder and the tree/shrub planter have been developed, tested, and reported on. The seeder was described in an Equip Tips in February 1979; while the tree/shrub planter was reported in a Project Record issued in October 1980. Although both pieces of equipment have been shown to be effective, some design changes or adaption is needed to make them even more utilitarian.

A report on the effectivenss of the steep slope seeder is on the way. Steve Monsen indicates that the Intermountain Forest and Range Experiment Station will publish a report on seeding success using the seeder during the summer of 1981. We would like to have this information for the workshop next year.

The committee is now searching for new ideas in equipment that may be needed to revegetate the steep slopes resulting from energy development, mineral exploration, or logging. Committee members have several ideas in the formative stages that we hope to have considered for FY 1984 funding. We are also open for thoughts that any of you might have or needs that you have encountered. The need for revegetation is expanding and as our keynote speaker in 1980, Bill Leavell, stated, we must provide the information and equipment necessary.

The rest of the committee report will be based on a presentation on the use of the seeder in Idaho by Steve Monsen, as it was originally intended, followed by John Graves, who will show and discuss his modification for strip mine reclamation work.

Steep Slope Seeder Use Report
By Stephen B. Monsen, Forest Service, Boise, Idaho

The steep slope seeder was used to seed road cuts and fills on the Boise National Forest in the fall of 1980. The machine was tested with other items of equipment and methods of planting. Previous studies have demonstrated the machine to be well adapted to planting steep surfaces.

The machine performed adequately and effectively seeded and fertilized both cut and fill disturbances. Compared to broadcast seeding, hydro-mulching, and straw-mulching with broadcast seeding, the steep slope seeder performs the best. The machine distributes seed uniformly across rough surfaces. In addition, seeds are planted or placed into the soil. These features are major improvements over other seeding practices. Seeds planted by the machine remain in place and are not washed or moved downslope. Seeds placed in the soil germinate and establish without serious losses. The uniform placement and establishment of seedlings provides protection to the exposed roadways.

Operating costs are comparable with other methods of planting. The machine is highly versatile and can be used on other wildlands.

Adaption of the Steep Slope Seeder for Mine Land Reclamation Work
By John Graves, Native Reseeders, Windsor, Colo.

The need for a reliable, durable seeder in my reclamation work is great. I have contracted to do reclamation of a number of harsh, rough, mined sites over the past several years, in both Colorado and Wyoming. The areas were very tough on the conventional seeders that I originally used and my seeding success was not good.

Discussion with Ray Adolphson of the Forest Service in Denver brought the steep slope seeder to my attention. After discussing it with Mr. Adolphson, I traveled to the Willamette National Forest in Oregon to observe it. I could see that its design and reliability would be a benefit to my operation. However, the method of using a Gradall was too expensive for my operation and the modification made for towing by the San Dimas Equipment Development Center did not meet with the needs of the equipment that I owned.

I had only an old D-2 Caterpillar tractor on which to mount the seeder, so I was forced to do some improvising to accommodate the seeder. In addition, I also believed that several changes in design were necessary to work on the tougher sites found in the mined land and reclamation areas of Colorado and Wyoming.

The changes I made are listed below:

1. I designed a two-point hydraulic over cable hitch to adapt the seeder to my D-2. This allowed me to use the equipment that I had.

2. I changed the rake assembly to use Danish S cultivator tines. The reason for this was two fold:

- These tines are readily available at most implement stores. If I broke one, I could easily replace it, which was not the case with the heat-treated tines of the original design.
- These tines open the crusted soils, which result when low organic matter topsoil is placed back into the spoil material, much better than the original design tines.

The only problem with this change is that these tines will not pass over tree or shrub seedlings without causing damage, as the original tines did.

3. I beefed up the packer wheel arms by building them with 3-inch channel iron instead of the called for strap steel. I also use spherical rod end bearings to attach the packer wheel axles to the arms.

4. Finger weeder tines were used to support the conveyor chain drags.

5. The wheel hubs of the original design were not readily available, so I relaced them with automotive hubs available at any auto parts store or junkyard. These were bolted on the front frame leg.

These changes seemed to fit the majority of my needs. The only real problem still encountered is having to pick the seeder up to turn corners. The installation of an articulation device for continuous towing use would benefit the seeder. This could be placed where the orbital hydraulic motor is normally mounted. I would be happy to discuss my modification of the seeder with anyone who has similar needs.

Thermal Plant Control

Bill Davis, *Chairman*

During 1980, the Thermal Plant Control Workgroup continued to monitor the use of the gelled-fuel helitorch. As reported by the Missoula Equipment Development Center (MEDC) at previous VREW workshops, the helitorch was developed by a Canadian firm and modified to Forest Service needs and specifications at MEDC.

The helitorch is a reliable aerial ignition system for setting prescribed burns and controlling wildfires. The helitorch uses gasoline thickened into a gel by a powder similar in texture to laundry detergent—either Alumagel or military fuel thickener. Unlike gasoline-diesel fuel mixtures, which tend to burn out or break up before reaching the ground, the gelled gasoline holds together and keeps burning as it falls through the air.

The helitorch consists of a 55-gallon barrel, igniter, and electric pump that pumps out the gelled gasoline.

The helicopter pilot controls the flow and ignition of the gel. The new gel enables pilots to drop fire with greater accuracy from higher altitudes and faster speeds, increasing safety and efficiency.

Fire on the ground can be obtained from a height of 200 feet at an airspeed of 40 mph. This produces burning gel/gasoline globules the size of golfballs that burn 8 to 10 minutes. Drop heights of 150 feet and airspeeds of 30 mph produce burning globules the size of baseballs with a burn time on the ground of 12 to 17 minutes.

Operations within prescribed burning windspeeds will not affect the drift of gelled gasoline during ignition.

Ignition costs compiled from four National Forests for FY 1978 ranged from $6 to $30 an acre. Both service and standard helicopter contracts were used.

For more information concerning the helitorch contact the Missoula Equipment Development Center, Building 1, Fort Missoula, Missoula, MT 59801.

Mechanical Plant Control

Loren Brazell, *Chairman*

(Reported by Collis Lovely, BLM)

Rangeland Use of the Mercedes Benz Unimog

By Loren Brazell, BLM, Reno, Nev.
(Presented by Collis Lovely, BLM)

The Unimog is an extremely versatile diesel-powered, all-terrain vehicle that the BLM has used year round in Nevada for fire suppression, and by force account work using a backhoe attachment and a dozer blade.

Nevada has eight Unimogs in operation. As a fire truck, the Unimog will outperform a standard 4 by 4 fire truck. It will traverse rougher terrain with less vehicle damage because of high ground clearance and low operating speeds. When equipped with a backhoe and dozer blade, the Unimog can be used for digging soil pits or performing range development work. It has the advantage of traversing rougher terrain than a farm-type tractor, and can travel at highway speeds up to 40 mph for rapid movement between work areas.

We have found the Unimog to be more economical than either the seasonal gasoline engine fire truck, or the farm-type tractor-backhoe unit. The fire truck use rate is calculated on a 5 months per year basis. The tractor use rate is calculated on a 10 months per year basis. But both are single-use vehicles, and the tractor must be transported by a truck.

The Unimog use rate can be calculated on a 12 months per year basis, and amortized out at 15 years, making the use rate much lower, even though the initial purchase price is higher.

In Nevada, the Unimog is used extensively for digging and recovering soil pits, developing springs, transporting water development materials, and fire suppression during high fire danger periods of the year. In FY 1980, we used a Unimog and a 12-foot drill for small fire rehabilitation projects.

Disadvantages with the Unimog are:

1. Case Tractor Co. no longer has the franchise for the Unimog, and Mercedes Benz dealers are the only suppliers of equipment and parts.
2. Parts are not readily available, and an inventory of parts must be kept on hand.
3. The two-person cab is too small to carry firefighting crews.
4. The highway speed of 40 mph is too slow for long distance movement, and a truck must be used for distances of more than 150 miles.

The attachments are easy to change, and it takes about 30 minutes. We are pleased with the performance of the Unimog to date, and report a capability of up to 35 soil pits per day, and up to 300 acres of land seeded per day on level to rolling terrain.

Mercedes Benz Unimog.

Methods of Mechanical Plant Control at the Energy Fuels Mine in Northwest Colorado

By Kent Crofts, Range Scientist, Energy Fuels Corp., Steamboat Springs, Colo.

Although the most commonly conceived types of mechanical plant control are associated with forestry and range management practices, there is a need for controlling woody plants in areas subjected to the surface mining of coal. Reclamation regulations have long required that topsoil be salvaged prior to mining-related disturbances. More recently, regulations issued by the Office of Surface Mining under 30 CFR 816.22 require that all vegetative material that might interfere with the use of topsoil shall be removed prior to topsoil removal.

At previous VREW meetings this problem has been the focus of much discussion. In San Antonio, Rice (1978) outlined the types of equipment available for mechanical brush cutting and slash treatment. The final report on this project was later published by the San Dimas Equipment Development Center (McKenzie and Miller 1978). In Casper, Vogel (1979) and Estes (1979) discussed the problems of disposal of the woody vegetation cleared ahead of the surface mining operation. Vogel described how in the eastern coal fields the trees are cut and dragged to a protable chipper wherein the chipped wood is utilized for mulching purposes. Estes (1979) explained how specialized equipment is being developed that allows for these wood chips to be used in the revegetation of surface mines in Kentucky.

Because the Energy Fuels Mine has been in continuous operation since 1962, various methods have been used to segregate trees and shrubs from topsoil. Berg and Barrau (1973) described how spoils were leveled and topsoiled in the late 1960's and early 1970's using a dragline at the Energy Fuels Mine. This operation, although primitive by today's standards, consisted of stripping the dense stands of trees away with the dragline bucket and dumping them in the pit after which the topsoil from the next pit was dumped on top of the partially leveled previous spoil ridge.

With the advent of spoil recontouring and topsoil salvaging programs in 1974, this practice was abandoned and dozers were used to walk the trees and brush down after which they were pushed into the pit. Topsoil was then salvaged using scrapers. This technique was limited in its effectiveness due to the breakage of hydraulic lines and windows, which averaged about three hydraulic lines and four windows per week for dozers and approximately one scraper tire and three hydraulic lines on scrapers per week. On a weekly basis it was costing us about 24 hours of downtime per week on our equipment and $6,000 per week in lost tires.

The mixing of a relatively small amount of topsoil with the trees and brush and the loss of that topsoil as the trees were pushed into the pit was also the topic of concern. Attempts to locate a timber company interested in harvesting the aspen were unsuccessful.

A conventional bush rake was subsequently employed with mixed results. In soils 3 to 4 feet deep the brush rake worked reasonably well, but in areas where topsoils were less than a foot thick the brush rake caused more damage than it did good. Since it was necessary for the teeth of the brush rake to extend 6 to 10 inches in the soil to get under the roots of the aspen and oakbrush to pull them up, a considerable amount of bedrock was pulled to the surface. This bedrock made it difficult to adequately salvage topsoil in some areas and resulted in such a high degree of pitting and contamination of the topsoil that the brush rake had to be abandoned.

In the summer of 1979 we spoke to Dan McKenzie about the possibility of using one of the machines described in his report to dispose of the woody plant material on sites scheduled for topsoil removal. With his assistance we spoke to several people from National Hydro-Ax, Inc., to inquire about the availability of a Hydro-Ax for the disposal of our woody vegetation. A Hydro-Ax 500 was located in Washington and was subsequently leased.

Over the next 2 months approximately 30 acres of aspen and oakbrush were treated with varying degrees of success. We soon discovered that the machine we had acquired was underpowered, poorly balanced, too slow, and, above all, posed an extreme safety hazard to men and equipment. Trees 8 to 10 inches in diameter often required as long as 10 minutes to chop. On slopes above 5 percent the cutter head was so heavy that the back wheels of the machine were frequently bounced off the ground. Above all, the most serious problem with the machine was the fact that sticks often 1 to 2 feet in length were thrown upwards of 300 feet from the machine. Due to limitations imposed by the regulatory agencies concerning the width of topsoil removal, it was not uncommon for flying debris to fall around men and equipment working nearby.

From a safety standpoint this machine proved to have serious disadvantages; however, the potential benefits of such a system became obvious. No hydraulic lines were lost and the ease with which the topsoil loaded into the scrapers was found to be extremely improved due to the absence of large pieces of wood; however, since the incidence of scraper tires lost to stumps was doubled, this system was also considered unacceptable.

In February 1980 at the San Diego VREW meeting we heard the presentation of Ed Dick concerning the land clearing capabilities of the Madge Rotoclear machine. We discussed our problem with Ed and arranged for him to visit our mine and determine if his machine had utility on our mine. After his visit we flew to Calgary for a demonstration of the Rotoclear machine. Convinced that the Rotoclear machine would alleviate some of our previous problems involving woody plant control, we placed an order for one.

Madge Rotoclear machine at the Energy Fuels mine, Steamboat Springs, Colo.

Since July of 1980 we have treated over 300 acres of aspen and mountain shrub. To date we have put 634 hours on the machine and have averaged 92 percent mechanical availability on the machine. Production rates and treatment costs of the Rotoclear along with the Hydro-Ax 500 and dozer are presented in table 1.

Vegetal characteristics of our sites were characterized as having DBH's ranging from 0.8 to 21.7 inches with an average of 7.5 inches. Densities ranged from 204 to 770 stems per acre, with an average of 345 and an air-dry above ground biomass of 77.3 tons per acre.

Operating under these conditions our production rates averaged 0.63 acre per hour with a maximum of 1.00 acre per hour. Dick (1980) stated that production rates with the Rotoclear averaged 1¼ to 1¾ acres per hour. A possible explanation of the lower production rates we obtained might be that we mulched our trees to an average depth of 7 inches and the trees we were mulching were larger in diameter than those reported by Dick (1980).

Analysis of the data in table 1 reveals that the immediate cost savings of operating the Rotoclear over using a production dozer average $444 per acre. Because the Rotoclear we purchased cost approximately $110,000, we effectively paid for the machine after only treating 248 acres, or after only 50 days of operation.

Table 1.—*Estimated production rates and costs per acre of treatments tested for mechanical plant control at the Energy Fuels Mine*

Treatment	Production rate acres/hour	Direct equipment cost/acre[1]	Indirect cost/acre[2]	Total cost/acre
D-9 Dozer w/U Blade	0.36	$236	$390	$626
D-9 Dozer w/Brush Rake	0.40	213	83	296
Hydro-Ax 500	0.38	292	416	708
D-8 Dozer w/Rotoclear	0.63	182	0	182

[1] Equipment and operator cost times production rate.
[2] Includes cost for broken windows, hydraulic lines, and scraper tires.

Mechanically and operationally we have been extremely pleased with the performance of this machine. Operational limits as to the slopes this machine will effectively treat are limited only by the slope a dozer can traverse. Mechanically this machine has performed exceptionally well. The mechanical components of the machine are proven and dependable.

We feel some minor modifications are necessary to improve the machine. The electrical cord from the control panel of the Rotoclear to the pulling tractor is too exposed and needs to be enclosed along the tongue. The battery box is located too low on the machine and needs to be moved to a less vulnerable position on top of the fender to eliminate damage to the batteries. The spacing between the bearing casings and the mower drum are too far apart and should be modified by welding a quarter-inch rod on the drum and in contact with the bearing casings. The rod ends will wear down to the point that barbed wire will not become entangled in the spacing and availability will be greatly increased. Lastly, we have found that the air cleaner intake tube is unacceptable. Under dry, dusty conditions the filter is quickly plugged, and is too vulnerable to breakage in its present configuration. The tube needs to be extended upward at least 5 additional feet and adequately braced. Also, we have found that the present dust cap is ineffective. We have replaced the original dust cap with a conventional dust turbo-precleaner and have tripled the life of the dust filters.

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Rice, C.M., 1978, Mechanical Equipment for Brush Cutting and Slash Treatment, pp. 26-27. *In*: 32nd Annual Report, Vegetative Rehabilitation and Equipment Workshop, 60 pp.

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Chemical Plant Control

Ray Dalen, *Chairman*

Work continued on the proposed Aerial Herbicide Application Handbook this past year. Several members of the workgroup working together made some revisions and updated the material in the draft copy. These revisions included spray calibration and characteristic field methods, meteorological factors of drift control, with more specific information on effects of relative humidity. These revisions were sent to Dr. Norman B. Akesson, University of California at Davis, to review and add several graphs and tables on some recent work involving spray deposit assessment. Following his review, the draft will be further reviewed by all members of the workgroup to determine acceptability for field use. Publication is planned for FY 1982.

Structural Range Improvements

Ron Haag, *Chairman*
(Reported by Bill Hardman, Forest Service)

During 1980, the Structural Range Improvements Workgroup began work on alternative energy sources for rangeland water systems. The primary thrust of this project is (1) to develop technology to prevent livestock water from freezing and (2) to develop solar and wind energy as alternative power sources for livestock water pumping systems.

Dan McKenzie, San Dimas Equipment Development Center, is the project leader and will give us a progress report on each phase of this project.

Our plans for 1981 will be to continue the work started on alternative energy sources for livestock watering systems. Also, we hope to initiate a project for a structural improvements handbook. Our objective will be to publish a document similar to the catalog on revegetation equipment. Also, our workgroup has been working closely with the Information and Publications Workgroup to produce a video tape on range improvement. Video tapes offer an excellent vehicle for disseminating workgroup information.

Most of you knew Walt Rumsey, who was killed in a commercial plane crash last year. Walt was an active member of our workgroup. His contribution to the profession and close friendship will be missed.

The Monday morning session was devoted to alternative energy sources. There were two presentations on solar energy and two on wind energy. All four were of special interest, but I think Mr. Valentine's talk on "Wind Energy—An Industrial Perspective" was extremely intriguing.

Because of a reassignment in administrative responsibilities and additional workload I am no longer able to chair the Structural Range Improvements Workgroup. Bill Hardman, who has Forest Service Northern Region range improvement leadership will be the new chairman.

Range Water Systems Improvements, Project ED&T 0314

By Dan W. McKenzie, Forest Service,
Equipment Development Center,
San Dimas, Calif.

The project goal is to improve range water supplies and systems for pumping and handling range water. The objectives, as determined by the Structural Range Improvements Workgroup, are to (1) investigate and develop systems for preventing stock watering tanks from freezing; and (2) investigating and develop solar water pumping systems as alternatives to the standard windmills.

Preventing Stock Water Tanks From Freezing
The San Dimas Equipment Development Center is investigating methods of preventing stock water tanks from icing over and preventing stock from watering. The investigation includes contacting stockmen, producers, and U.S. and foreign patent offices, and computer searching the Department of Energy publication files, as well as livstock journals, equipment publications, and catalogs.

Systems, so far, seem to fall into three main categories:

- Circulation systems
- Mass insulation systems
- Solar systems

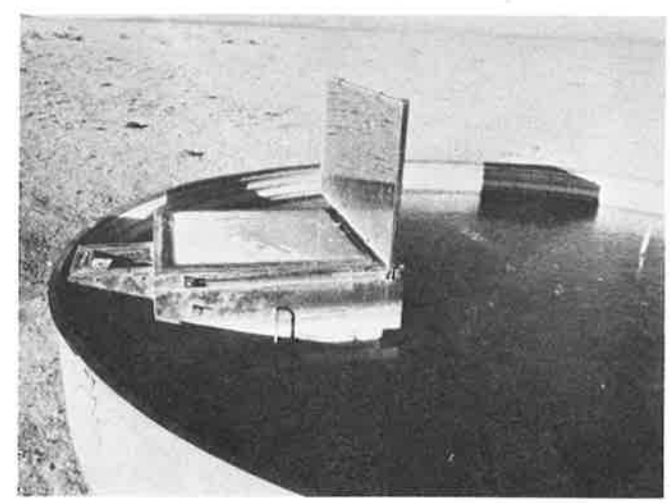
Circulation Systems
Circulation systems utilizing the internal energy of the unfrozen water to maintain ice-free areas in the stock water tank. Systems falling into this category are:

Propane bubbler. Rising gas bubbles released from a special propane bubble-forming device, supplied by a propane tank, circulate water creating an ice-free area at the surface. This system usually uses a 5-gallon propane bottle. This propane will generally last up to 90 days. The propane to fill the bottle costs $7 to $8 and the whole system costs less than $100 and is reported to be very effective and dependable.

Walden Pondmaster. The Walden Pondmaster floats on the surface of the water in the tank and has a propeller below the surface. The propeller, driven by a Savonius rotary windmill, agitates the water within the tank, preventing ice from forming. The Savonius windmill rotor is an inefficient wind machine but it is well suited for this application because of the simplicity of construction and the ability of the Savonius to take wind in any direction.

Mass Insulation Systems
Mass insulation systems use large water masses, usually in a buried tank, with the earth as insulation. A number of these are in operation, and the Development Center is gathering information on them. In general, the reports indicate these systems operate well in very cold and overcast areas.

Solar Systems
Solar systems use the energy from the sun, usually in a greenhouse effect, to prevent freezing. Several patented systems are in operation and at least one can be purchased. Photovoltaic or "solar cells" possibly may be used also.



Solar system using greenhouse effect to prevent freezing of stock water, near Datil, N. Mex.

In summary, our investigations indicate a number of ways to prevent stock water tanks from freezing, but most are not well known or widely used. It is the plan of the Equipment Development Center to prepare a Project Record detailing stock water tank freezing prevention systems along with proposed systems for development.

Solar Water Pumping Systems
Three categories of equipment offer potential for improving range water pumping systems: (1) photovoltaic-powered systems; (2) solar-thermal powered systems, and (3) improved or new windmills.

Photovoltaic Pumping Systems. Photovoltaic systems use what are called "solar cells" to generate electricity directly from sunlight. This electricity then powers conventional pumping equipment.

Normally, a dc motor is used, and the system contains batteries and a controller device. One problem with solar cells is cost, $7 to $13 per watt at present; but the Department of Energy projects this cost to drop to around $2.70 per watt by 1986. What this cost reduction will mean can best be illustrated by the Roswell, N.Mex., installation where the cost of the solar cells was 65 percent of the installed cost; at $2.70 per watt, the solar cells would be only 33 percent of the total system cost.

The University of Arizona at Tucson is working on a sun concentrating system (five suns) using solar cells where the costs of solar cell electricity will be reduced by 70 to 75 percent. This system looks very promising for range installations.

Other developments in photovoltaic water pumping systems include:

- Conventional rod and well cylinder pumps operating without batteries or a controller. Centrifugal pumps (and jet pumps) also have been connected without batteries and a controller.

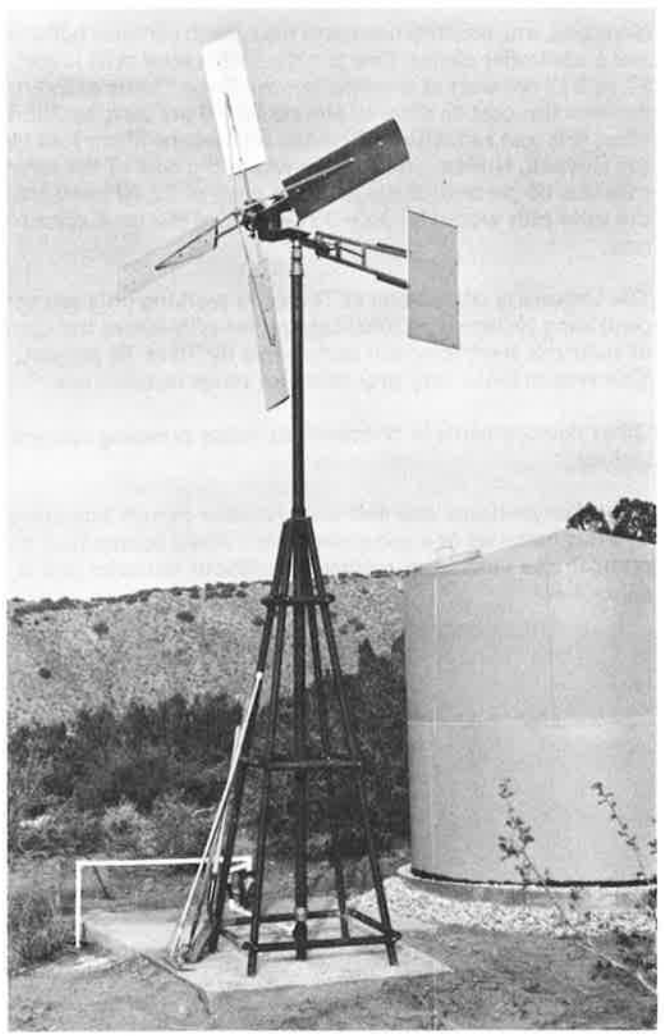
Photovoltaic solar powered conventional rod and well cylinder pump using no batteries and no controller. The unit pumps 2 to 3 gallons a minute from 230 feet, 5 to 7 hours a day, operating near Redlands, Calif.

• Photovoltaic cells powering submergible ac centrifugal pumps, using an inverter to convert the dc power to ac.

• Submergible dc pumps.

Solar-thermal Pumping Systems. Both small (.17 hp), about equal to an 8-foot windmill, and large (200 hp) solar-thermal pumping systems have been built and operated. These have been demonstration systems and the costs have been high.

Improved or New Windmill Systems. Work is under way to improve conventional windmills, but it does not appear that improvements will be of a large order of magnitude. One new design produces compressed air, which is used to lift water. The windmill is available from the Bowjon Resource Co., 2829 Burton Ave., Burbank, CA 91504, (213) 846-2620.



New design windmill in which compressed air is used directly to lift water.

Summary
The World Bank has a project, "Testing and Demonstration of Small-scale Solar Powered Pumping Systems." To date it has produced a good engineering report on the state-of-the-art of solar water pumping systems. A report on actual field demonstration units is scheduled for publication in June 1981.

The conventional windmill is a functional, reliable, long-lasting, economical range water pumping system. As such economical alternatives are not easy to find. However, in some circumstances, even with the high cost of photovoltaic solar cells, the photovoltaic water pumping system can offer better performance and lower cost.

Range Water Improvement Systems is a very timely project because systems are just now being developed that certainly have the potential for replacing the windmill under some circumstances. The long-range plan for this project is to produce a handbook on rangeland water pumping systems.

Special Reports

Liaison Report on the American Council for Reclamation Research

Willis G. Vogel, *Forest Service, Berea, KY*

The American Council for Reclamation Research (ACRR) was formed in 1978 as an outgrowth of an organization that previously confined its activities to the Appalachian Region. The ACRR is now striving to exert a voice for needed reclamation research on a national level through expanded membership and possibly through its own publication. Current membership includes persons from 19 States, the District of Columbia, Canada, and Great Britain.

The objectives of ACRR are mainly to promote, assist, and support research and educational programs related to reclamation of land disturbed by mineral extraction. Membership is open to persons who contribute to land reclamation research through their work in scientific, practical, and administrative fields. The Council is formally organized under a set of bylaws and is seeking incorporation in the State of West Virginia. Routine administrative services and business management duties are conducted through an appointed executive director.

ACRR is an affiliate with the Canadian Land Reclamation Association for the sponsorship of *Reclamation Review*, an international journal published quarterly by arrangement with Pergamon Press. Annual membership dues are $10 for regular members and $5 for students. An additional $20 provides members with a subscription to *Reclamation Review*.

ACRR meetings, held twice yearly, include presentation of technical papers and field trips to reclaimed mine areas. Some recent actions by the Council included: (1) deleting from its bylaws and objectives the development and sponsorship of accreditation standards for certification of educational institutions engaged in Reclamation Technology programs; (2) sending letters to regulatory agencies in 18 Eastern States encouraging them to provide procedures in their regulations for designating experimental areas as part of the permitting process, and to consider bonding procedures that treat such areas independently of the permitted area; also that appropriate statutes or regulations recognize and promote conduct of experimental practices; (3) informing members of recent publications in reclamation and providing a calendar of events on upcoming activities, meetings, symposia, etc., pertaining to reclamation; (4) making available to members selected publications on reclamation—some of these sponsored or prepared by VREW and the Equipment Development Centers.

ACRR continues to be interested in the possibility of cooperative equipment testing with VREW.

The spring 1981 meeting of ACRR will be May 20-21 at the new Forest Service Forestry Sciences Laboratory in Berea, Ky.

Correspondence with the American Council for Reclamation Research should be directed to William T. Plass, Executive Director, 21 Grandview Dr., Princeton, WV 24740.

Canadian Land Reclamation Association Report

Farnum M. Burbank, *Forest Service, Washington, D.C.*

In August 1980 I again had the privilege of attending the annual meeting of the Canadian Land Reclamation Association (CLRA). It was held in Timmins, Ontario, a small mining town in northern Ontario. Titles of the papers presented are included.

The emphasis this year was on reclamation of smelter tailings. This area is reputed to be one of the largest copper producers in the world. The operations have been in process for many years, but intensive reclamation efforts have been underway for only the past 5 to 10 years; the last 2 to 3 years have been the most successful. There are probably thousands of acres of these tailing "dams" throughout that area of northern Ontario and Quebec. Each dam could be 100 to 150 acres in size, and rise from 50 to 150 feet above the surrounding terrain. As one can tell from the agenda, most of the papers dealt with biological, geological, or hydrological topics. In this type of work, equipment has not really presented great problems.

The meeting included two field trips to these tailing areas, the first in the immediate vicinity of Timmins, and the second to Noranda, Quebec, a company-owned copper smelting town. Demonstrated were many test plots of attempts over the years to revegetate the tailings, initially mostly failures, but with practice, intensive soil studies, and patience many fine successes. The impressive fact in all this was the amount of success now being achieved by a good soil analysis and evaluation of each site prior to any extensive on-the-ground work. Soil amendments must be applied to each acreage selectively because of the variations in the residue composition. There are no more mass trial and errors on the ground before good laboratory testing of the soils and alternative treatments.

The proceedings from this meeting will be in the hands of VREW Chairman Ted Russell. Anyone wanting to see them please contact Ted. I, of course, would be glad to discuss in more detail this or previous meetings I have attended. I also have literature regarding CLRA. For those involved in reclamation work, I highly recommended participation in their annual meeting if at all possible.

Papers

Bailie, T., Brampton, ON, Coated Seed—Its Potential Use in Land Reclamation Areas.
Berdusco, Roger J., Elkford, BC, The Use of Vertical Rock Drains Through Coal Mine Spoils at Fording Coal Limited.
Blunden, John, Milton Keynes, UK, Reducing Land Dereliction Through the Economic Utilization of Waste Materials from Mines and Quarries.
Byington, R.C., Nashville, TN, Tennessee Tombigbee Waterway—The Project with a Challenge.
Coates, W.E., Guelph, ON, State Hospital Site, Elgin, Illinois—A Case Study in Rehabilitation Preplanning.
Comer, Robert D., New Haven, CT, The Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87): Some Forgotten Principles of Ecology.
Felker, R.B. & S.L. Warner, Kitchener, ON, The Impact of Aggregate Mining on Agricultural Production and the Preservation of Prime Farmland.
Heagy, Muriel I., London, ON, The Natural Vegetation of Abandoned Gravel Pit Slopes.
Luke, A.G.R., Cambridge, UK, Establishment of Wooded Landscapes From Seed on Disturbed Land: the Effects of Aspect and Mulching on Seedling Recruitment.
Mitchell, Elizabeth C., Syracuse, NY, Encouraging Indigenous Woody Plant Colonization on Iron Mine Tailings in New York.
Mortimer, A. Chandler, Boulder, CO, The Use of Metal-Tolerant Grass Cultivars for Reclamation of Severely Disturbed Lands in Pennsylvania.
Murray, David R., Elliot Lake, ON, Water Movement and Contamination in and From Sulphide Uranium Tailings Related to Surface Treatment and Abandonment.
Pepperman, Robert E., Pittsburgh, PA, Experimental Direct Vegetation of A Deep Coal Mine Spoil Bank in Greene County, Pennsylvania.
Rowell, Michael & P.D. Lulman, Edmonton/Calgary, AB, The Potential Use of Plants with Nitrogen-Fixing Root Rhizosheath Bacterial Associations in the Revegetation of Nutrient Poor Areas.
Rutherford, G.K., Kingston, ON, "Pedological" Properties of Tailings in the Sudbury Area and Chemical Composition of Associated Plants.
Shaneman, R.M. & R.J. Logan, Calgary, AB, Coal Mine Reclamation Experiments Based on Various Soil Replacement and/or Amendment Procedures in East Central Alberta.
Watkin, E.M., Guelph, ON, Assessing the Vegetative Potential of Mining Wastes.
Ziemkiewicz, P.F., Alberta's Reclamation Research Program.

BLM's Equipment Development Program for Revegetating Disturbed Lands

Richard Hallman, *Forest Service, Equipment Development Center, Missoula, Mont.*

When surface mining for coal in the West began in earnest, about 10 years ago, it became apparent that many techniques developed over the years for improving range habitat were unsuited to revegetating mined land. Surface mining mixes soil profiles, alters surface and ground hydrology, and removes all vegetation. Clearly, new equipment and techniques were needed to restore this land.

The Bureau of Land Management (BLM) of the Department of the Interior (USDI) was the logical Government agency to tackle the problem. About 80 percent of the strippable coal in the West is Federally owned, and the BLM manages most of the land where the coal is found. The BLM, along with the Office of Surface Mining, another USDI agency, is responsible for determining the revegetation potential of these lands.

Federal and State mining laws require that restored vegetation equal what existed before mining. Fortunately, coal seams in the West often are thick; seams of 20 feet and more are not unusual. So revenue from mining deposits of that magnitude make it economically feasible for operators to do the revegetation job that is required.

As part of its effort to develop new revegetation techniques, the BLM turned to the USDA Forest Service Missoula Equipment Development Center (MEDC). MEDC and its sister center at San Dimas, Calif., were the only equipment development organizations involved in rangeland improvement activities.

In 1975 MEDC personnel began working with the BLM to develop equipment and techniques to revegetate lands under arid and semiarid conditions where establishing vegetation is difficult and expensive. Six pieces of equipment were eventually built to accomplish six specific revegetation tasks. Each piece of equipment is described in the following pages. The six equipment systems currently are being evaluated in various locations in the West to perfect the techniques and to establish cost data. For additional information, write USDA Forest Service, Missoula Equipment Development Center, Fort Missoula, Missoula, MT 59801.

Dryland Plug Planter

Function
The Dryland Plug Planter is designed to automatically plant containerized trees and shrub stock on surface-mined reclamation sites. To insure survival on semiarid sites, the root systems must stay in contact with soil moisture. To help accomplish this, the planter is able to plant containerized stock seedlings that are up to 61 cm long.

Description
The dryland planter is a trailer unit towed behind a tractor. It features automatic leveling devices, hydraulic auger with a scarifier, rotating carousel mounted on a movable carriage, and two packing spades.

The machine plants containerized shrubs or trees quickly and effectively. The leveling devices and high clearance enable operation on rough ground or moderate slopes, while insuring adequate placement. The containerized root system and auger holes allow sufficient moisture uptake and unrestricted root growth for better survival.

The planting is automatic and controlled from the tractor. When the trailer is positioned, the platform is leveled with hydraulic cylinders. The auger digs a hole; the scarifier auger then removes any competing vegetation from around the hole. The carousel containing the seedlings rotates and the carriage moves forward on the platform, dropping a seedling into the hole. The packing spades firm the soil around the seedling. Planting rate is estimated at more than one per minute.

Specifications

Carousel capacity: 24 seedlings
Auger diameter: 7.6 to 12.7 cm
46 cm scarifier
Depth: 61 to 76 cm
Power requirements (drawbar): 52 to 75 kW

Dryland plug planter.

Tree Transplanter

Function
The tree transplanter system was designed to transplant small trees and large shrubs that grow naturally around the mining site to the revegetation area. The trailer is an important part of the system because it greatly reduces overall transplanting costs by reducing the transport time required for each tree. Up to 24 trees per day can be transplanted with the tree transport trailer system. The front-end loader-mounted tree spade is very maneuverable and can negotiate slopes up to 20 percent.

Description
The system consists of a Vermeer Model TS-44A Tree Spade mounted on an Owatonna 880 articulated front-end loader and a specially built trailer consisting of two rows of four cone-shaped pods. The pods are 112 cm in diamter and 108 cm deep.

Eight soil plugs are removed from the transplant site, loaded into the trailer, and transported to the transplant supply area. They are then replaced in the trailer with selected trees and shrubs that are transported back to the transplant site and planted. The front-end loader-mounted tree spade digs the trees or plugs, places them in the trailer pods, and tows the trailer between the transplant site and transplant supply area.

Specifications—Trailer
Overall width: 2.4 cm with walkway removed
Height: 2.1 m
Weight: 2,722 kg
Capacity: 8 trees or plugs or 3,992 kg
Cone size: 112 cm diameter, 108 cm deep
Power requirements: 60 kW recommended

Specifications—Tree Spade
Ball (cone) diameter: 51 to 198 cm
Ball (cone) depth: 46 to 152 cm
Tree size:[1] to 25 cm diameter
Mounting: tractors, trailers, truck, or front-end loaders

Tree transplanter.

[1] Maximum tree size may vary with the type of root structure.

Dryland Sodder

Function
The dryland sodder transfers native topsoil from the mine area to the reclamation area with its structure, profile, and vegetation intact. Reclamation is greatly enhanced because the soil horizons are not mixed, so soil development does not have to be repeated.

The dryland sodder strips the top layer of soil and vegetation (sod, forbs, shrubs, and small trees) from areas to be surface mined and places it intact over reshaped areas. The soil layer is scooped into the sodder and transported to the reclamation area. It is removed by tilting and shaking the bucket while slowly moving the loader backward. The conveyor system will feature hydraulic control of the conveyor rollers, allowing the sod to be removed without tilting the bucket.

Dryland sodder.

Description
The dryland sodder is a modified front-end loader bucket. The side walls and back wall are vertical to minimize damage to shrubs and tree seedlings that are stripped along with the soil and sod. The wide, flat bottom of this bucket is sprayed with plastic to reduce friction. A conveyor system is being developed for the bottom of the dryland sodder to aid loading and unloading of the sod strips and to prevent excess soil separation during the transfer.

Specifications
Width: 4.3 m
Length: 2.4 m
Depth: to 30 cm
Power requirements (flywheel): 80 to 391 kW

Sprigger

Function
The sprigger undercuts and gathers sprigs, or portions of rhizomatous stems, that can produce roots and shoots. The harvested sprigs are then spread out on the area to be revegetated and covered with soil.

Description
The sprigger is a modified potato harvester. It consists of an undercutting blade and a pair of wide, inclined conveyors. The conveyors are long rods attached between two chains and spaced 3.8 cm apart. A third conveyor across the top of the machine moves the harvested material to the side where it is dumped into a truck or piled in windrows. The sprigger is towed and powered by a tractor.

After the shrubs are mowed, the sprigger is pulled through the stand, cutting the roots well below the ground surface. The cutting action lifts the soil and shrubs onto the conveyors. The soil is shaken loose and falls through the spaces in the conveyors to the ground. The bareroot, rhizomatous shrubs, or sprigs, are gathered and carefully planted on the reclamation area.

Specifications
Width: 1.5 m
Depth: 30 cm
Power requirements (drawbar): 60 to 75 kW

Sprigger.

Basin Blade

Function
The basin blade scoops out large basins or depressions along slopes. Moisture accumulates in these basins to provide a favorable microsite for plant growth. The large basins reduce wind erosion. They also provide the advantages of terracing with fewer hazards and less expense. They collect runoff and trap snow and blowing topsoil. The furrows formed by the scarifying teeth help retain broadcast seed and fertilizer and promote increased infiltration.

Description
The basin blade is a large, crescent-shaped, heavy steel blade mounted on the rear of a crawler tractor. The blade is mounted on a parallelogram multiple-ripper shank. It is raised, lowered, and tilted hydraulically. Several replaceable scarifying teeth are located along the bottom edge of the blade.

Basin Blade.

The tractor is driven along the contour of a slope and the blade is periodically raised and lowered to form large depressions. Seed is then broadcast along the slope.

Specifications
Width: 3 m
Depth: to 91 cm
Power requirements (flywheel): 216 to 276 kW

Modified Hodder Gouger

Function
The gouger creates numerous depressions in the soil surface. These depressions provide a suitable microclimate for plant establishment by increasing moisture availability, preventing wind and water erosion, and providing shade.

Description
The gouger consists of three to five semicircular heavy steel blades attached to solid arms. Each blade has three scarifying teeth along the bottom edge. The arms are attached to a heavy-duty frame with spring-loading mechanisms. They may be mounted in either one- or two-row configurations. The frame is supported with side wheels that are periodically raised and lowered to allow the blades to scoop out depressions. The unit is operated hydraulically and features positive depth control and automatic up and down cycling. A seedbox spreader is mounted on the rear of the machine to broadcast seed into the depressions.

The gouger is towed behind a tractor. The hydraulically powered automatic cycling system moves the frame up and down in relation to the wheels to create depressions. The depth of the depressions, cycle rate, and blade configuration can be varied to suit the site conditions. Average production rates have varied from 1 to 1.1 ha per hour.

The gouger creates more and larger depressions than similar equipment. The automatic cycling and hydraulic depth control make it easier to operate and the adjustable cycle rate and variable blade configurations contribute to its versatility. The spring-loaded blade arms enable it to operate in fairly rocky ground.

Specifications
Implement width: 3.4 m
Depression width: 38 to 56 cm
Depression length: 10.9 to 1.2 m
Depth: 15 to 25 cm recommended
Power requirements (drawbar): 37 kW minimum

Modified Hodder gouger.

Forest Service Equipment Development Center Activities

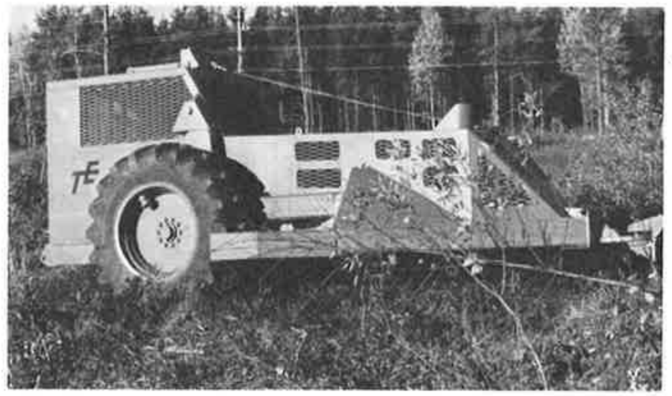
Representatives from the Forest Service Equipment Development Centers at San Dimas, Calif., and Missoula, Mont., presented film and slide programs on their current activities of interest not reported elsewhere during the workshop. Ken Dykeman presented the San Dimas program, and Dick Hallman presented the Missoula program.

San Dimas Equipment Development Center

The San Dimas Equipment Development Center (SDEDC) is located in San Dimas, Calif., which is east of the greater Los Angeles area. About 55 people are employed at the Center, including 15 engineers and about the same number of other professionals. Center personnel are working on about 60 projects. A few of interest to workshop participants are covered here.

Intermittent Containerized and Bareroot Tree Planter
Developing a reliable and affordable tree planter capable of planting both containerized and bareroot stock on sites without extensive site preparation has been the effort of the Center and private companies and agencies for several years. Two commercially available planters in the United States, the Marden Planter and the Timberland Planter, are being evaluated by the Center engineers and technical reports will be published soon.

Marden Manufacturing Co.'s intermittent planter.



Timberland Equipment Ltd.'s intermittent planter.

Hill Climbing Machine
The machine is a hill climbing backhoe/grapple that walks on steep slopes. Other attachments are a feller-buncher, auger, hydraulic hammer, and several sizes and shapes of backhoe buckets. The unit also can be used as a portable power pack for operating remote power equipment. The machine has been tested by the Center on three National Forests and has been found to be a versatile and productive piece of equipment for working in mountainous terrain where no other equipment can get to the work sites. Work done during the tests included: digging test holes to find subsurface materials to aid in cost analysis and design of forest road structures; placing large boulders to improve fish habitat in a remote canyon bottom; excavating a wildlife watering hole in a remote area; bunching, piling, and loading slash into a chipper in steep clearcuts; and preparing sites for tree planting. The Center plans to purchase a machine in 1981 and continue developing and evaluating attachments.

Hill climbing machine.

Forestland Residues Machine
The machine was developed to thin thicket and pole-size timber stands on the large backlog of thinning acreage on the National Forests. The horizontally rotating cutterhead with 100-pound flails was conceived, designed, and developed by SDEDC engineers. Recently a 10-acre stand of Coulter pine was thinned on the San Bernardino National Forest. Production was about 1 acre per hour. Residues were minimal; water runoff was nearly eliminated because of mulching; fire hazard was reduced; and the stand was opened up for forage growth. The Pettibone Corp. has manufactured two units and sold one.

SDEDC forestland residues machine.

Missoula Equipment Development Center

MEDC serves the nine Forest Service Regions and cooperating Federal and State agencies. The Missoula Center makes available to these groups information, concepts, equipment, and ideas to better manage the millions of acres of public land.

This mission of wide ranging problem solving in resource management demands varied skills. Foresters and engineers, draftsmen and illustrators, writers and photographers, equipment specialists and technicians all work as project team members to accomplish goals. MEDC occupies buildings at Fort Missoula, a military reservation a few miles southwest of Missoula, Mont. Located there are the offices housing most of the 55-member staff.

Tree Shaker
For years tree shakers have been used in the South to harvest cones in tree seed orchards. To see if the concept would work on western conifers, we mounted a shaker assembly on a crawler tractor, and tested it on the Winema National Forest last fall.

We found that the equipment could be used on trees up to about 30 inches dbh and up to about 150 feet tall. The early results indicate that when the technique is perfected, tree shakers may be the tool we have long needed in wildland cone collection in the West.

Cone and Seed Collecting
In the South, cone collection methods are also changing for species like loblolly pine, that cannot be shaken without tree damage. The Georgia Forestry Commission uses netting to collect the seed as it falls naturally.

We became involved when assigned the task of building a seed collection system that retrieves the netting and separates the seed from the pine straw and other material that falls on the netting. Construction was finished last summer and shakedown testing was conducted close to our Center.

As the netting is retracted, the seed and debris are dropped into a conveyor. The conveyor dumps the material into a separator. The needles and other debris are moved away while the seed drops into trays located under the shaking table where it is ready to be sent to the extractory for final processing and storage.

The netting system was sent to Georgia for field testing last fall. Some minor modifications will be made before construction drawings are prepared to complete the project.


Seed collection system retrieves netting and separates seed from pine straw.

Parachuting Cargo
In the past, cargo drops were made at about 200 feet to obtain good placement. Now, safety regulations require that cargo planes maintain a minimum of 500 feet. The problem is that the cargo can drift far off target from that height.

To correct the problem, a reefing system was designed at the Center to restrict the full deployment of the chute. The constricted chute falls rapidly for the first 6 seconds. Then at about 150 feet the lines constricting the parachute are automatically cut with a mechanical cutter and the chute fully deploy.

With this system cargo drops can be made within a 300-foot-radius drop zone, at more than twice the height previously used.

Lightweight Cable Yarder
Several years ago the Center designed a lightweight yarding system for the Clearwater National Forest in Idaho. The machine was used to yard slash to prepare sites for planting. In the past few years several other versions have been made of the Clearwater Yarder, and it has been tested from Alaska to North Carolina.

In North Carolina it is being tested to demonstrate the advantages of using lightweight cable systems in small timber. Production is high, up to 300 trees a day, and impact on the ground is slight.


Clearwater Yarder can economically remove small logs and residue from steep rugged terrain.

The yarder is now commercially available, and we have just purchased one for a site preparation project currently assigned to the Center. We plan to develop a method of doing spot site preparation on steep land with cables. We are now building several implements that will be used with the cable system.

Mini Cable Yarder
For smaller jobs we have just designed a mini-yarder that can be mounted in a ¾-ton truck. This yarder will be field tested this summer in western Montana in thinning slash and perhaps on some small project sales.

Rock Rake
Raking of roads has long been an effective and economical way to keep the running surface smooth. The problem has been there was no good way to truck-mount the rake, and trailer mounted rakes are hard to control.

To improve the performance of the rock rake, a mounting frame was designed by Center engineers to fit 1-ton Forest Service trucks. The blade can be angled 22° in either direction and hydraulic downpressure can be applied as needed. Tests to date indicate that from 30 to 40 miles of road can be worked per day with this equipment.

Another feature of the system is the control box that can be positioned in the truck cab to make this a one-person operation.


Mini Yarder is capable of pulling 2,000-pound loads at 160 feet per minute.

Handtool Study
In our fire program, we are studying the human energy cost of working with handtools. We use a gas analyzer to measure expired air, which in turn gives a measure of the amount of oxygen used to perform a given task. For stationary work, the analyzer can be used directly. For a moving operation, a CO_2 collector is used. Initial testing shows that some tools are more efficient than others. For example, the pulaski is about 30 percent more efficient than a mattock for constructing fireline. Testing of handtools will continue again this summer.

Mechanical Nurserybed Thinner
Nurserybeds are usually oversown to compensate for uncertain germination rates and early mortality. Too often, however, overcrowding results. Hand thinning is done, but at $6 to $7 per hour for each worker. The cost is more than some nurseries can afford.

We were asked to develop a mechanical nurserybed thinner to solve the problem. A commercial croprow thinner was purchased and modified. The machine works four rows at a time. We quickly learned that to do precision thinning, the equipment had to be belly mounted. The cutting blades are geared to the forward movement of the tractor, and each swing of the blade thins 12 inches of row length.

The spacing can be adjusted to remove from one-third to three-quarters of the seedlings. Additional modifications will be made as testing continues. We hope to finish the project this year.

Four-row thinner being tested at Forest Service nursery.

Hand Thinner
While working on the thinner project we found that nurserymen also want equipment for thinning small lots of seedlings. A hand-operated thinner was designed that works like a scissors. Initial testing with this 3-foot-long hand thinner was very promising. We have since made a 5-foot-long aluminum thinner that will be tested this summer.

Aerial Spraying
Aerial application of pesticides in tree seed orchards is being evaluated by the Center to determine its effectiveness. Compared to ground application, aircraft can do the job much faster and with far less material. Smoke was used to determine the effect of aircraft wake turbulance on the spray pattern. Both fixed-wing and rotary aircraft were tested. The results will be used to build a computer model for planning aerial spray projects in tree seed orchards.

Spawning Gravel Cleaner
In the Pacific Northwest, spawning gravels are being lost because silt is filling in the voids and the gravel becomes unusable for hatching fish.

Washington State University designed and built a gravel cleaner that has been mounted on an FMC log skidder. The machine has three suction heads that can remove silt down to 12 inches in the gravel. In operation, the silt-laden water is pumped out of the stream onto the bank.

Hand-held gravel cleaner uses standard fire pump.

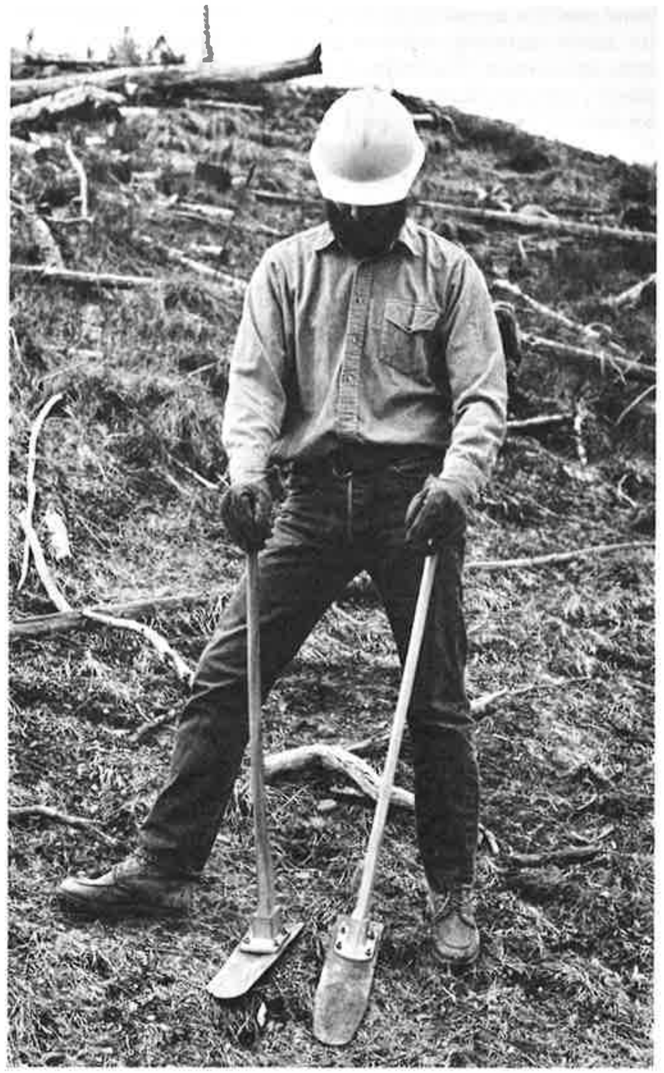
We are monitoring the evaluation of the WSU machine and may become involved in the development of a machine similar to it. In the meantime we are developing a hand-held gravel cleaner for smaller jobs. This system uses a standard Forest Service fire pump to pump the silt onto the bank.

Tree Planting Slide-Tape
The last project I'll cover is a slide-tape we just finished that deals with tree planting. More specifically, it is a training aid for contracting officers's representatives (COR's). They are the people who administer Forest Service planting contracts on the ground.

The slide-tape covers the basic principles of keeping a seedling healthy, how to handle it, and proper planting techniques. Seedling protection is explained, as is proper shipping, storage, field handling, and proper planting. Diagrams showing comparisons of the right and wrong way are used.

Tool selection is lightly covered with a reference to the *Reforestation Equipment Handbook* that was recently completed by the Center and has been distributed to Forest Service units. The handbook covers a wide variety of planting tools as well as other reforestation equipment.

Some of the projects that were discussed here have reports that are available at MEDC. An Equip Tips listing those reports is available here for your use.



Center's tree planting slide-tape shows proper use of tools like these.

Papers

Sun-Powered Water Pumping

Kenneth A. Ude, *ARCO Solar, Inc., Chatsworth, Calif.*

Solar electric pumping systems have significant applications for cattle watering, drinking water production, and small-scale agriculture. The following is a summary on solar electric power, specifically water pumping, now under development by ARCO Solar, Inc.

The structure of a single crystal silicon solar cell is such that the front of the cell is negative and the back is positive. When sunlight hits the solar cell, electricity is generated. Each cell is nominally a ½ volt, 2 amp device; 33 are wired in series to form a module.

The first application for solar cells was in space. In 1973 the first terrestial module was introduced. The price was approximately $50 per watt, compared to $2,000 a watt for space cells.

In 1978 the cost of solar cells was in the $20 a watt price range; today the price ranges between $7 to $13 a watt. With each price reduction, new cost-effective markets open up to solar electricity. The low power remote market is cost effective at about $20 a watt. A typical application of this type is for telecommunications repeater stations atop remote mountains.

At today's prices we are starting to compete with gasoline engine generators. In this area we think a cost of $5 a watt is necessary to become cost effective on a broad scale. But even at today's $10 a watt there are selective applications where solar cells are the most cost-effective power source when compared to a gasoline engine generator. Rural medical installations in developing countries, small-scale water pumping worldwide, and refrigeration are the applications that are going to be "big" in this area.

Water Pumping

I want to focus on water pumping. The major components of a solar water pumping system are the solar array, the electric motor, and the pump. Centrifugal water pumps can be directly connected to the solar array with no battery or electronics. When batteries and controller are added to the system, the motor is allowed to operate at a relatively constant rpm. This means that when the system operates, you are guaranteed of getting water, or if you have a positive displacement pump, you can overcome the initial high starting torque.

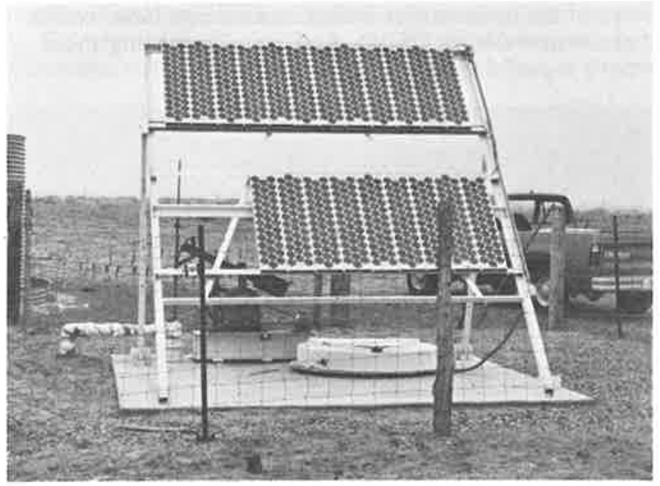
ARCO Solar believes the most cost-effective approach is to use a small amount of battery storage and a controller that allows the system to operate about the same number of hours per day as peak sunlight hours.

About 6 o'clock in the morning, the sun will come up, reach peak about noon, and drop off in the evening. If you have a directly connected pumping system, your available power is going to track right along with the sun curve. A battery will integrate the power into blocks. In a typical day in the United States, that integrated value (or block) is about 5 peak sunlight hours. In making a system selection, the requirements of the system will determine whether a direct connected system or a battery and controller system will be best.

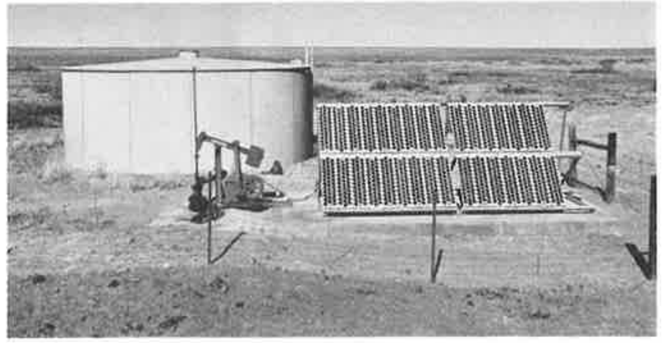
Applications

In looking at a small-scale solar water pumping system, the primary application areas are livestock watering, small-scale irrigation, and domestic water. It is more economical to store water than it is to store electricity, so in the system design, ARCO tries to pump all the water that is needed for a 24-hour period during peak daylight hours and store it in an elevated tank; then allow gravity to supply pressure to the application.

The first solar-powered water pumping system installed by ARCO Solar was in 1976 on the Isleta Indian Reservation, south of Albuquerque, N.Mex. This system is pumping about 4 to 5 gallons a minute from a 213-foot well. We found that livestock water is a very appropriate application to look at because of the modest water requirements of a cattle herd. A ½ horsepower system will satisfy the needs of a small herd. For people who are not familiar with some of the consumptive requirements of different livestock, see table 1. The ARCO Solar system designed for the Bureau of Land Management at Roswell, N.Mex., has been operating close to a year, pumping about 10 hours a day, made possible by the design balance between the solar cells and the batteries. The pumps used at Isleta and BLM Roswell are positive displacement rod and cylinder type pumps.



Solar cell water pumping system on Isleta Indian Reservation south of Albuquerque, N. Mex. System pumps 4 to 5 gallons a minute from 213-foot well.



BLM solar cell pumping system near Roswell, N. Mex., pumps 2 to 3 gallons a minute from 380 feet.

We have been working with Robbins & Myers on solar powering their progressing cavity positive displacement pumps. We believe we now have the efficiency to pump about 1,000 gallons of water a day from 20 feet with one solar panel. With the same pumping unit, we can go from 4 gallons per minute up to 15 gallons per minute, depending what speed we run the motor. One of the fortunate things with a dc motor is that if a motor is rated for 48 volts and 400 rpm's, you can power it with 24 volts and it will run at 200 rpm. So, with one motor, and one pump voltage, we can get 4, 7, 11, or 15 gallons per minute by changing voltage.

We are doing some work with Rain Bird on solar-powered irrigation systems, particularly using some of its low-pressured sprinklers and some of its drip methods. I would expect that within the next year Rain Bird will be coming out with solar-powered drip irrigation packages.

Because the solar cells are still expensive, today we have to pick applicaton areas very carefully. The major components that affect the cost effectiveness of the system are sunlight and the availability of fuel and maintenance.

Table 1.—*Typical water requirements for animals*

Animals	Gallons/day
Horse	12
Cow (dry)	15
Cow (milking) By hand:	35
Dairy operation:	45
Beef cattle	12
Hog	4
Sheep	2.5
Turkeys (per 100)	13
Chickens (per 100)	4
Hens:	8
Rule of thumb: 10 gallons per 1,000 pounds weight.	

Source: U.S. Dept. of Agriculture and Jacuzzi Pump Co.

Solar Photovoltaic Irrigation Pumping Plant [1]

Neil Sullivan, Thomas L. Thompson, P.E. Fischbach,
Agricultural Engineering Department, University of Nebraska, Lincoln, Nebr.
Ray F. Hopkinson, *Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.*
(Presented by P.E. Fischbach)

Abstract

The direct current output of a 25 kW peak output 520 m^2 photovoltaic array was used to run an irrigation pump for a 32 ha cornfield. The battery storage requirements for different methods of pump operation were compared. When 30 kW·h of power storage depending on whether the day was clear or cloudy. However, when the power storage was reduced, the step load operation could use only 60 percent of the power produced by the array. Of the remaining 40 percent, 33 percent was dissipated in the power dump and 7 percent was lost in reduced system operating efficiencies.

Introduction

In spring of 1977, the University of Nebraska began work in cooperation with Massachusetts Institute of Technology, Lincoln Laboratory on a project funded by the U.S. Department of Energy. The project was to design and build a 24 kW peak output photovoltaic (PV) energy system along with the appropriate electrical and mechanical equipment to operate an automated gated pipe irrigation system and a grain drying system for a 32 ha corn field near Mead, Nebr.

This report will limit itself to describing the irrigation system operation (fig. 1). The solar cell system was made up of two arrays, each 107 m long and 2.4 m wide. Approximately 100,000 silicon solar cells were used. The direct current output from the collector varied from 110 to 150 v and 0 to 200 A. The collector output was coupled with 40, 6 v, 113 kg lead-acid batteries that were used for power storage and load leveling. The dc output from the array and batteries was inverted to 3-phase alternating current by three, 7.5 kW inverters. The inverters supplied power to the irrigation motor which was used to pump water from a 3,000 m^3 reuse pit and reservoir to the automated gated pipe system. The motor speed was varied by adjusting the inverter output frequency and voltage.

Objective

The experiments, completed in 1977 and 1978, compared how different method of pump operation could best match the output of the PV collector to the irrigation power demands of the 32 ha corn field. The experiment defined the changes from normal practices required to use the PV power when it was available. Constraints included meeting the water demands of the crops and applying the water uniformly throughout the fields. Evaluation included measurement and comparison of electrical efficiencies while determining ways to reduce the power storage requirements of the different methods of pump operation.

[1] This article is reprinted with permission from "Transactions of the ASAE" (vol. 23, No. 4, 1980).

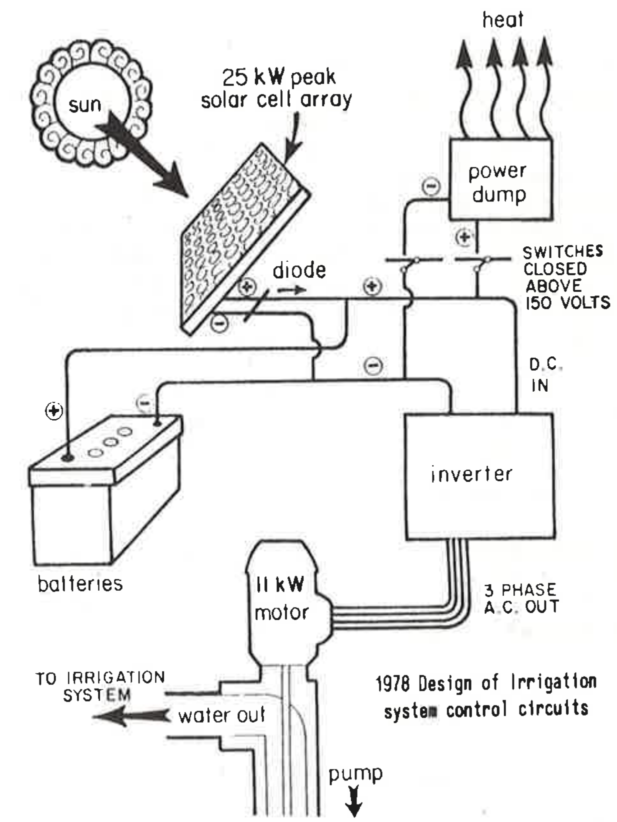


Figure 1.--Power flow for solar cell system used for irrigation.

Description

Irrigation System
An automated gated pipe irrigation system was used to provide water to 32 ha or corn. The 32 ha were divided into six separate fields (A-F) as shown in figure 2. A total of 44 pneumatic valves were located as illustrated in the same figure. Each of these valves could be turned on or off individually, from a central irrigation control panel.

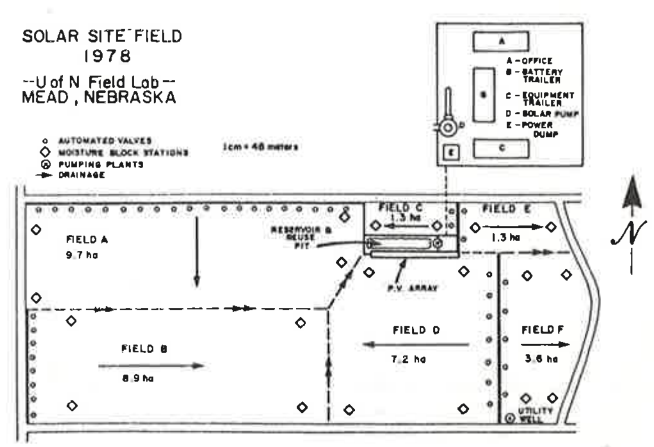


Figure 2.--Automated gated pipe irrigation system provides water for 32 ha of corn.

Uniform water application was obtained by maintaining the maximum allowable furrow stream size and by running the sets for approximately the same amount of time within each field. In a given field, each irrigation valve covered the same number of furrows, and the rows were approximately the same length. The openings in the gated pipe could be adjusted such that the flow rate down each furrow was constant for the length of time that an irrigation set was operated. In order to match the array output, different flow rates were required at different times in the day. Each irrigation valve required about 28 L/s flow rate for maximum allowable stream size. Therefore, to maintain uniform flow in each valve in the field, the pumping rates used were multiples of 28 (i.e. 56 and 84 L/s). The valves that were operated at the same time had to be at the same elevation or the lower valve would receive more water than the other valves. For this reason, consecutive groups of three valves were installed at the same elevation. Due to field irregularities, there were some valves that could be operated singularly and others in pairs, but the irrigation controller could handle these irregularities without difficulty.

The irrigation controller was developed to meet three requirements: (a) Record and digitally display flow rate, water pressure, pump speed and 3-phase ac inverter output frequency. (b) Control and display automated valve conditions throughout the six fields. (c) Manually adjust inverter output frequency and voltage to achieve desired flow conditions.

The flow rate, water pressure and pump speed were measured with transducers, and displayed on the controller. The ac frequency input to the pump was also displayed and could be adjusted between 30 and 60 Hz by the rotation of the potentiometer on the control panel. This adjustment permitted variations of flow rate between 25 and 95 L/s. The automated valves were manually controlled by toggle switches on the planel to correspond to the flow rate. The switches were positioned on the control panel to represent the field layout of the valves. Indicator lights on the panel provided immediate information as to which valves were open and their location.

The peak crop water use rate during the irrigation season was about 0.76 cm/day. A procedure was developed to irrigate the entire area in ten days or less. This irrigation frequency insured that excessive moisture deficiencies that would reduce yields did not occur. The soil was a Sharpsburg (silty, clay loam) with a 15 cm/m available water holding capacity. At no time was the soil permitted to have depletions in excess of 50 percent of available moisture. Electrical resistance soil moisture blocks were placed at three depths (15, 50, and 80 cm) in several locations in each field (fig. 2). This gave a representative sample of the moisture condition in the plant root zone to a depth of one meter. The condition of the blocks were measured twice/week and, from the readings, soil moisture depletions were calculated. The depletions indicated how much water to apply to refill the soil profile and evapotranspiration estimates were used to determine approximately how much time was available before the next irrigation was required. Water was not applied when depletions less than 2.5 cm were existing within the field.

The factors which determined the operation time for an irrigation set as well as the flow rate/furrow are: soil type, slope, and the length of the furrows. The irrigation controller was able to maintain uniform flow rates for each valve; consequently, the times to complete the sets within a field were constant. The times required to complete each irrigation set for each field were 1.5 h for field A, C, E, and F, and 3.0 h for fields B and D. Runoff from the fields averaged 14 percent with these application times. The runoff from the fields returned to the reservoir and was repumped through the solar powered irrigation system.

The vertical turbine pump used to supply water to the irrigation valves was a Western Land Roller single stage 10D bowl with an H impellor. This pump was chosen because it operated in a reasonably efficient manner between 28 and 85 L/s flow rates used in the test (fig. 3). Pump efficiencies varied between 60 and 79 percent as the flow rate was changed. An 11 kW electric motor was selected to operate the pump. The motor was slightly oversized to protect against overheating at the slower operating speeds.

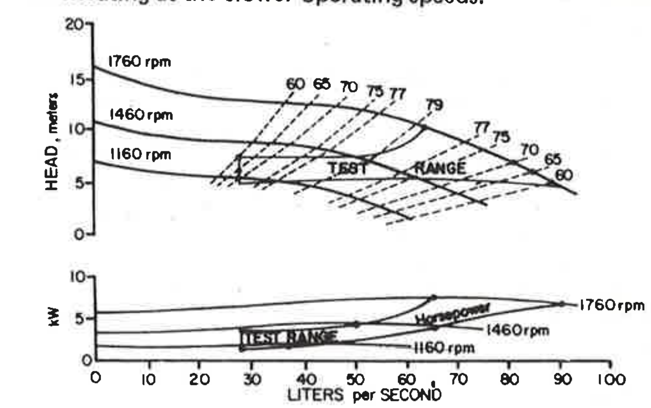


Figure 3.--Pump curve for solar powered irrigation system.

The final portion of the irrigation system was a utility powered 30 kW pumping plant. This unit was used to fill the 3000 m^3 reservoir during the night at off-peak utility power demand periods. The pump supplied water to the reservoir at a flow rate of 70 L/s and pumped the water from about 25 m below the surface. The pumping plant ran for an average of 10 h during the night to refill the reservoir.

The Array
The photovoltaic array contains approximately 100,000 silicon solar cells. The individual 5 to 7.6 cm dia cells are about 11 percent efficient in converting sunlight to electricity and each cell is capable of producing one-fourth W of power at noon on a clear day.

The array is made up of many modules or groups of cells. About 60 percent of the module surface is solar cells. The modules are therefore, only 7 percent efficient in producing electricity from the sunlight. The modules are connected in parallel and in series to produce higher currents and voltages, respectively. The peak power output of the array is about 25 kW at solar noon on a clear day.

The Batteries

Batteries were used to store energy when the array produced more power than the irrigation pump required; the excess power was normally used to charge the batteries. Conversely, if the array produced less power than the load required, the batteries were used to provide the additional power. The 40 batteries used for the Mead experiment were 113 kg, 6 v, lead-acid batteries, a type of battery conventionally used by the railroad industry. The batteries were divided into two groups, each group of 20 batteries forms a series string to produce approximately 120 v. These two groups were then wired in parallel to increase the amperage and storage available for the electrical loads.

The batteries store a maximum of 90 kWh of energy. A minimum of 18 kWh was held in reserve at all times to prevent deep discharging and improve battery life expectancy. The batteries were kept at temperatures above 10°C and were checked monthly for cell voltages, specific gravity, and water level. The batteries were equalized (fully charged) about once a month when specific gravity readings indicated inequalities among the battery cells.

Diodes were used to prevent the batteries from discharging backward through the array. The batteries were protected from overcharging and deep discharging by voltage controller equipment. If the voltage across the array-battery connection exceeded 150 v, an electrical resistance load was automatically cycled in to reduce the voltage. If a part of the system failed and the BUS voltage exceeded 150 v for over 15 s, the batteries and array were automatically turned off. If the voltage went below 110 v, the electric loads were automatically switched off and utility power could then be used if desired.

The Inverters

Inverters were used to change the array-battery output from direct current to 3-phase alternating current. The inverters could be controlled to produce any frequency—voltage output desired between 30 and 60 Hz and 120 and 240 v, respectively. The variable frequency feature of the inverters permitted variable speed operation of the pump motor.

The electric motor was operated below full speed for a maximum of six h/day. This operation did not appear to have any effect on motor life or performance except for a slight reduction in motor efficiency.

Operation Procedures

Operation of the irrigation system compared constant and step (variable) load methods of pump operation. The pump was always operated at full speed in constant load tests. The speeds chosen for step-load testing were dependent on the array output and the time of day.

The step-loading operation of the pump was accomplished by varying the output frequency and voltage from the inverters. This variation of frequency and voltage correspondingly changed the pump motor speed between 1,000-1,760 rpm. At the same time, the flow rate ranged between 25 and 88 L/s. The step-loading operation required more manual labor than did the constant speed operation because many more changes were made in the system condition during the day and the changes involved more parameters.

The factors considered when operating the constant load were what time to start the pump, when to change irrigation sets, and when to stop the pump. Additional factors considered during the step-loading operation included frequency of inverter operation for a given flow rate, when to change the flow rate based on array output, and what should be done if cloud cover occurs. Other factors were how long the pump can be operated at full speed, and where to begin decreasing pump speed.

During all of the tests, the electrical conditions of the array-battery and inverter-pump systems were measured every six minutes by a data acquisition system. This data was recorded on magnetic tape for analysis.

Results

The photovoltaic powered irrigation system provided all the power necessary to pump from the storage reservoir and meet the crop water use requirement for the 32 ha corn field in 1978. Figures 4 and 5 summarize the overall system performance during the irrigation season. In figure 4, the photo-

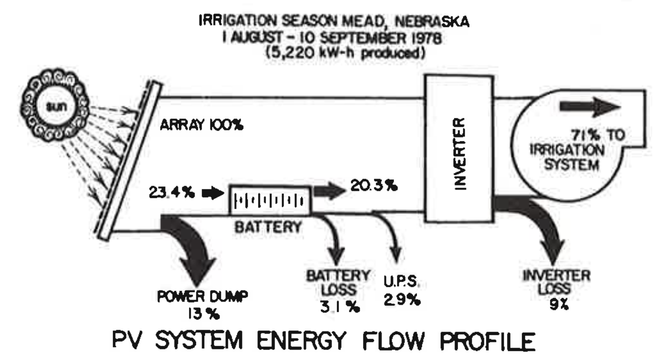


Figure 4.--(Note, percentages shown are based on the total array output.)

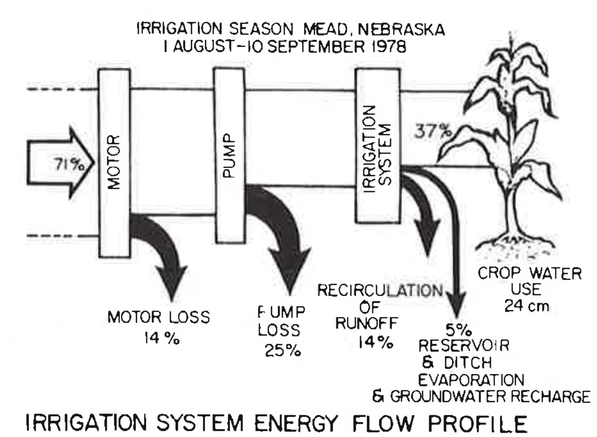


Figure 5.--(Note, percentages shown are based on the input to the individual unit.)

voltaic system losses are expressed as a percent of the total array output. In figure 5, the irrigation system losses are expressed in terms of the efficiency of the individual unit concerned. Eighty-one percent of the energy produced by the PV array was used to pump 114,000 m^3 of water during the irrigation season (August 1 through September 10, 1978).

An average of 24.2 cm of water was applied over the entire 32 ha. According to the depletions measured by the soil moisture blocks, irrigation water application never exceeded the water holding capacity of the root zone. The block readings also confirmed that the pumping schedule prevented soil moisture depletions in excess of 50 percent of the available water holding capacity of the soil. This was true for both constant and variable speed operation of the pump throughout the season. Both methods of pump operation consistently met or exceeded the crop water use for the 32 ha during the irrigation season. The following comparison of constant speed versus step-loading of the pump will therefore be limited to power storage, management, and overall system efficiencies of the two operating methods.

Figure 6 illustrates the constant speed operation of the pump on a clear day with excess battery storage available. On September 1, 1978, table 1 shows that over 140 kW·h of the 155 kW·h produced by the array was used for the constant load operation of the irrigation motor, and 30 kW·h of battery storage was required to meet the operating requirements of the irrigation system.

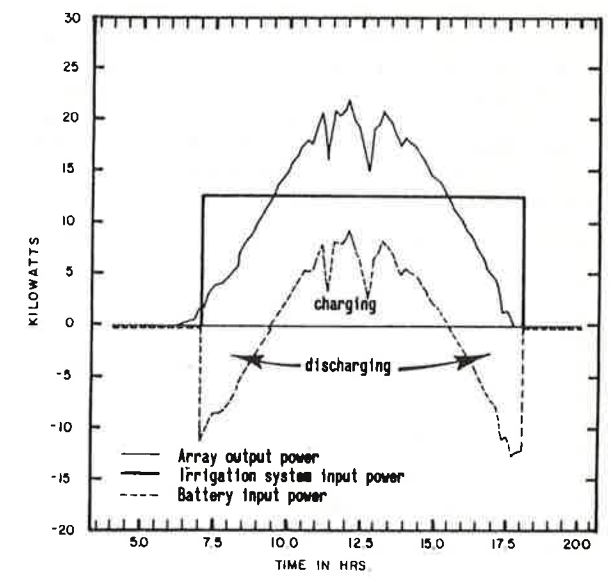


Figure 6.--System energy diagram for September 1, 1978 (clear skies, constant pump speed).

Table 1.—*Comparison of three days of irrigation data, 1978*

Date	*September 1*	*September 4*	*August 29*
Description of day	*Clear*	*Clear*	*Cloudy afternoon*
Method of operation	*Constant load*	*Step-load*	*Step-load*
Array output, KW·h/day	155.0	153.0	126.0
Inverter input (")	140.0	97.0	94.0
Battery storage requirement (")	30.0	1.5	15.0
Power dump requirement (")	0.0	50.0	8.1
Average inverter efficiency	90.0	82.0	82.0
Average pump and motor efficiency	60.0	55.0	55.0
Average lift, m	2.4	2.4	2.4
Average pressure, kPa	73.0	39.4	39.0
Average flow, L/s	70.0	70.0	70.0
Total water pumped, m^3	2,750.0	2,750.0	2,750.0

On September 4, 1978, table 1 and figure 7 show that only 97 kW·h of the 153 kW· produced by the array was used for step-load operation of the irrigation motor, but only 1.5 kW·h of battery storage was required. The battery storage requirement was reduced over 28 kW·h with the step-load operation of the irrigation motor. However, the irrigation motor was only able to utilize 60 percent of the power produced by the array with the step-load operation as compared to 90 percent with constant load operation. The step-load operation, (fig. 7) with reduced battery storage, required one-third (50 kW·h) of the power produced by the array to be dissipated by the power dump as heat.

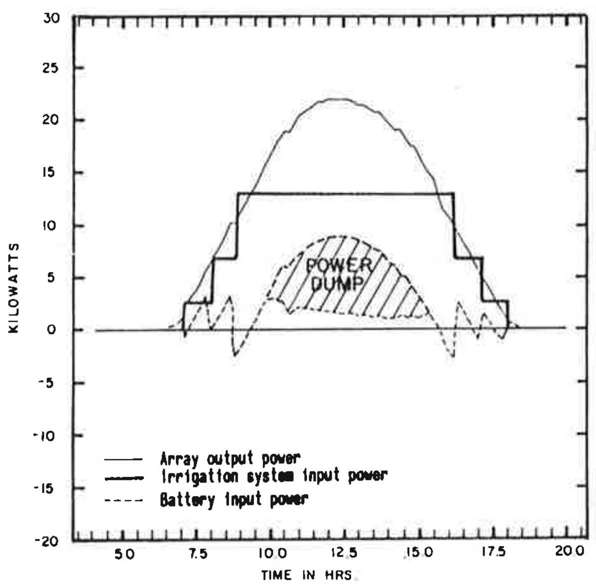


Figure 7.–System energy diagram for September 4, 1978 (clear skies, variable pump speed).

This illustrates a major problem with step-load operation. If battery storage is eliminated, then either: (a) the step function requires a larger pumping plant to consume more power directly from the array and reduce power dump operation, or (b) an alternate use for the power produced in the middle of the day must be found.

A larger pumping plant would involve larger inverters, motors and a larger irrigation system cost (pipelines, valves, etc). The larger range of system operating conditions would also bring on less efficient overall system operation (fig. 8). The overall efficiencies are reduced by a factor of two in the operating range considered for the data in figure 7. If the steps were increased to cover the whole range of array output, the average system efficiencies would drop even further.

The alternate power use is therefore, a more reasonable alternative. Some of the possibilities for alternate power uses are: (a) a manufacturing device for farm chemicals, (b) selling the power to a utility company, (c) storing the power for other home or farm use, etc. The cost or benefit associated with the alternate use of this power will correspondingly reduce or improve the economics of the system.

Battery storage also affects the flexibility of the irrigation system. Figure 9 shows the effect of cloud cover on the array output and therefore, the battery storage requirements of the system. If battery storage was not available on August 29th, irrigation system output would vary tremendously making it nearly impossible to apply water uniformly. However, only 15 kW·h with the constant load system on September 1. This means that although it may be impractical to eliminate all the battery storage, a significant reduction in the storage requirements for the irrigation system can be accomplished with step load operation.

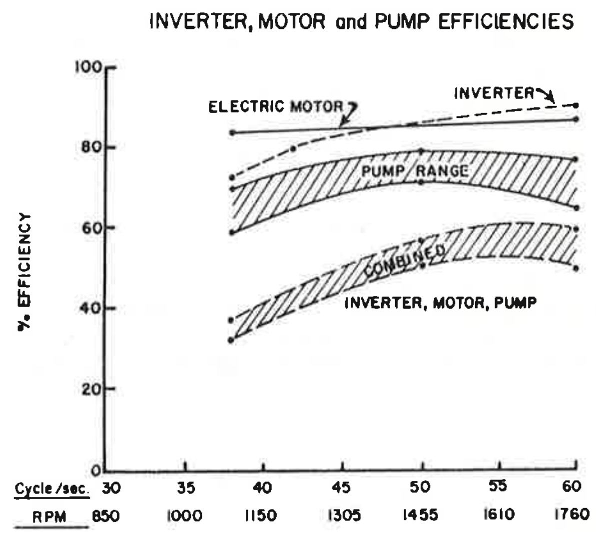


Figure 8.–System component efficiencies during operation of the irrigation pump under variable loads.

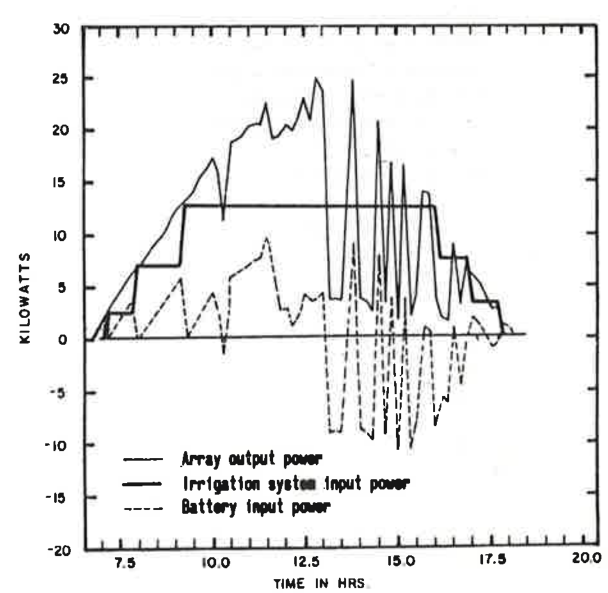


Figure 9.–System energy diagram for August 29, 1978 (afternoon clouds, variable pump speed).

A final point to consider when comparing the two methods of operation is the extra management involved for the step-load operation. The step-load operation required almost constant monitoring and a minimum of 2 h/day was required for adjusting the flow rate, valve conditions and frequency of the system. Much of this time could be saved by controlling the changes with a microprocessor. This would, of course, increase the system cost but it would make the system far easier to operate.

Conclusions

The 25 kW photovoltaic array provided 100 percent of the power necessary to pump from the storage reservoir and meet the crop water use requirements of the 32 ha of corn throughout the irrigation season with both constant and step-loading operation.

With 30 kW·h of battery storage, constant load operation of the pump was able to utilize over 90 percent of the power produced by the array for irrigation. On clear days the step-load operation of the pump could reduce the battery storage requirements of the system to less than 2 kW·h but up to 20 kW·h of storage was required to operate the pump with step-loading on cloudy days. When the battery storage capacity was reduced the step-load operation could only utilize 60 percent of the power produced by the array for irrigation. Of the remaining 40 percent, 33 percent was dissipated in the power dump and 7 percent was lost in reduced system efficiencies at the slower operating speeds.

The management requirements for the constant load operation of the pump were much less than the requirements of the step-load operation. The step-load required almost constant monitoring to obtain maximum reduction in battery storage. In the future, many of the adjustments required for the step-load operation could be handled automatically with the use of a microprocessor.

The costs associated with alternate approaches are the main areas to consider when designing an agricultural photovoltaic system.

Some of the major factors to consider when contemplating a reduction in battery storage are:

1. The cost of battery storage in dollars/kW·h year. This factor includes the storage capacity of the batteries as well as their expected useful life.

2. The drawbacks of reducing the battery storage capacity include: (a) reduction of operating time, (b) reduction in management flexibility, (c) reduction in overall system efficiency (wasting power), (d) increase in management and/or equipment cost associated with battery storage reduction.

Variable loads require either constant manual adjustment based on the array output or automatic equipment which will increase the investment cost of the system. If a motor is operated on a variable load, there are hidden costs to be considered. For instance, the irrigation system would require a larger inverter, motor, pump, and pipeline to meet the operating conditions produced by the array in the middle of the day. The operation of smaller loads, to take care of the peak produced by the array in the middle of the day, must consider the effectiveness of utilizing the array power for these loads. The array power has a specific cost/kW·h produced and the efficiency of the array system will be determined by the relative benefit associated with any loads operated from the array power. For example, the power produced by the array would be more cost effective operating a motor than it would be producing electrical resistance heat.

The trade-offs between the above considerations must be examined in detail before an optimum agricultural photovoltaic system can be designed. The design must take into consideration all of the types and sizes of loads to be operated by the system. The design must also include a method to manage operation of the various loads under different situations.

Reclamation Techniques

Allan M. Hale, *Dames & Moore, Cincinnati, Ohio*

The subject of reclamation techiques is one which covers a vast array of different areas of development. In any discussion of reclamation technology, a thorough understanding of the specific nature of the individual site problems is the key to successful rehabilitation efforts. Distinctly different reclamation techniques are used when reclaiming active or abandoned mined lands. The following discussion will detail some of the major problem areas, limiting factors and reclamation techniques that have been found to be successful.

Identification of the problem forms a focal point in the use of appropriate reclamation technology. The following problems are common to active and abandoned sites:

- Steep Highwalls—Exposing toxic seams or presenting a physical danger.
- Acid Mine Drainage—Degrades watersheds from runoff of surface mines or seepage from underground mines.
- Erosion and Sedimentation—Create significant problems when runoff from outslopes builds up in stream channels.
- Physical Site Conditions—Including steep unstable outslopes, gob piles, slurry ponds, and surface subsidence.

These problems are commonly found in both the Eastern and Western United States and deal with both environmental and technical engineering aspects of the mining process. In most instances the problems are highly interrelated and a thorough investigation or preevaluation planning program must be included in the overall end-use for the site.

Many of the problems associated with coal mining relate specifically to various physical components inherent to any mining site. These limiting factors have been described by the Soil Conservation Service as part of the SCS Land Capability Classification System. The limiting soil properties that control the type of reclamation techniques used on an individual site include the following elements:

1. Minimum soil rooting depth
2. Textural class—sand, silt, loam
3. Coarse fragments permitted
4. Maximum slope percentage
5. Minimum permiability within the top 20, 40, and 60 inches of depth
6. Minimum drainage class and growing season watertable depth
7. Maximum flood hazard
8. Maximum salinity and exchangeable sodium within the top 20 and 40 inches
9. Maximum acidity
10. Maximum wind and water erosion hazards

In addition to this listing, other factors such as the agronomic (fertility) properties of the mine soil and the toxicity of the overburden must be considered. One often overlooked factor in any reclamation program is the available economic resources with which to accomplish the desired reclamation goals. In many instances the amount of reclamation that can be attained is a delicate balance between permit requirements, site limiting factors, and available funding to accomplish the individual projects.

Many of the current reclamation techniques involve conventional earthmoving. Whether by bulldozer or pans, reshaping and recontouring the overburden is a necessary first step in the reclamation effort. Resoiling of the overburden with stockpiled topsoil or alternate resoiling materials such as paper pulp sludge, municipal compost, flyash, or other suitable materials must be performed to establish a fertile growing medium for the revegetation of a site.

An important aspect of the reclamation program is proper runoff and erosion control of the mined area. Construction of surface diversions, rock collars, terraces, drainage ditches, underground drains, silt dams, and settling ponds is important in assuring fully controlled drainage from the mine site.

Revegetation design and stabilization relates to many aspects of reclamation activities. Revegetation design is keyed to providing a quickly establishing ground cover vegetation, specifically selected for the individual surface mine characteristics. This approach combines specific plants for specific needs, whether those needs be surface stabilization, visual screening, dust suppression, or development of habitat/cover crops. In the Eastern U.S. area, stabilization of spoil against surface sheet and rill erosion is an important reclamation design criterion. Stockpiling and respreading of "topsoil" material is an expensive process. The needless loss of this organic soil material is costly in terms of reestablishment should the material become eroded due to poor or ineffective revegetation design. As a result, proper topsoil stockpiling and protection includes revegetating the stockpile storage area and revegetation of the mined area should be part of the post-mining process.

Harnessing the Wind for Irrigation Pumping

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Wind Power has been used for centuries to provide power for farms. Some of the first windmills were used to grind grain and later used to pump water. The Dutch are remembered for their use of windmills to reclaim land from the sea for crop production. In the United States, a wooden-wheeled windmill called an "Eclipse" was patented in 1871. This windmill and similar ones are credited with providing a stable water supply that enabled settlers to live year-around in the Southern Great Plains. Much of this area was not settled until after the development of these windmills.

Wind-electric systems were introduced in the 1920's and soon were installed in many rural areas. Jacobs, Windcharger, Sears-Roebuck, and Montgomery Ward were a few of the companies that sold the small wind-electric systems (Simmons, 1975). A few systems are still in use today producing up to 2,500 watts of electricity, although most were removed when the rural electric cooperatives provided electric service to the farmers.

Modern crop production requires many energy inputs, some of which can be easily adapted to wind systems and others which cannot. Tractors, combines, and trucks require an easily transported fuel. However, irrigation pumping, grain drying, and fertilizer production utilize fuels in stationary systems. These latter uses can be adapted to wind energy or other type power sources.

Irrigation was a major energy user in crop production and in 1978 required an estimated 87 billion kilowatt-hours (kWh) of energy. In that year irrigation was practiced on about 12 percent of the cropland in the United States, and those lands produced 27 percent of the agricultural products. Only energy used for manufacturing fertilizer and for tractor and truck fuel exceeds that used in irrigation, thus making irrigation the largest on-farm, nonvehicular user of energy in agriculture.

In the Southern Great Plains, irrigation pumping accounts for about two-thirds of the energy used on irrigated farms. In this area, over 100,000 pumps are used to lift water at least 150 feet and require between 20 and 150 horsepower, with an estimated average of 50 horsepower. Most irrigation pumping is done with electricity or natural gas. These sources are rapidly increasing in price and are becoming limited in supply. This has created interest in new or alternate power sources, especially wind, because most irrigated areas are located in, or near windy regions.

A wind energy project for irrigation pumping was started at USDA—SEA—AR, Conservation and Production Laboratory, Bushland, Tex., in 1977 (Clark and Schneider 1978). The pumping system uses both a wind turbine and an electric motor to power a conventional vertical-turbine irrigation pump. The electric motor is sized to operate the pump on a stand-alone basis and runs continuously. The wind turbine is coupled to the pumping system through an overrunning clutch and combination gear drive, and furnishes power to the pump only when the windspeed exceeds 13 mph. When the wind turbine operates, it reduces the load on the electric motor, rather than replacing the motor.

Wind Turbine

The vertical-axis, or Darrieus, wind turbine was designed to produce 54 horsepower in a 32-mph wind and was manufactured by DAF-Indal, Mississagua, Canada (fig. 1). The rotor height is 55 feet, and the maximum rotor diameter is 37 feet. The rotor is on a 30-foot steel tower and is supported at the top by four 7/8-inch steel cables. When the turbine is producing power, the rotor turns at a nearly constant speed of 90 rpm. A speed increaser and right-angle gear drive increase the shaft speed from 90 to 1,780 rpm (fig. 2). An overrunning clutch in the wind turbine drive shaft transmits power to the pump without power being transferred from the electric motor back to the wind turbine at low windspeeds.

A 5-horsepower electric starter motor is required because Darrieus wind turbines are not reliably self-starting. The motor is used to accelerate the rotor to its minimum operating speed. A 30-inch-diameter disk brake with three double-action calipers is used to stop the rotor in normal or emergency shutdowns.

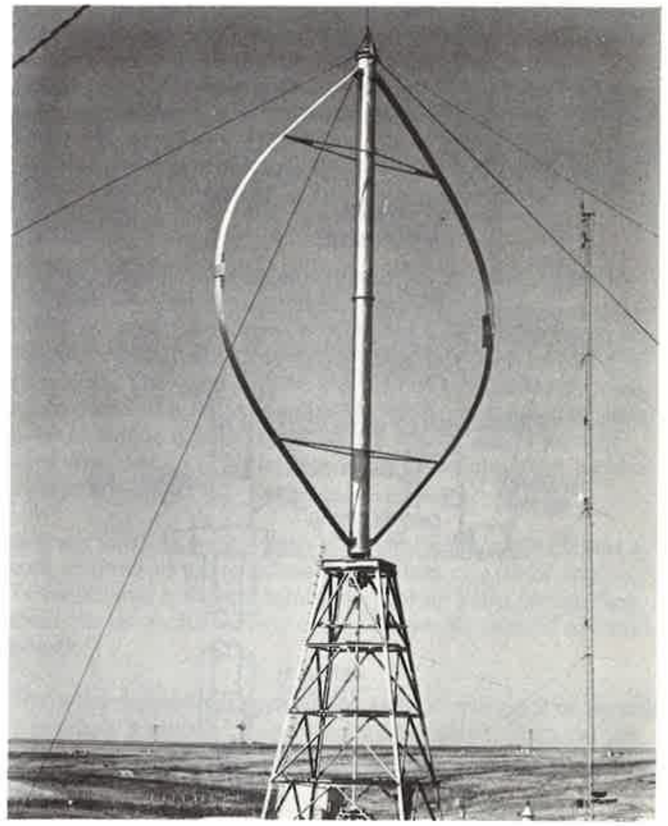

Figure 1.--Forty-kW vertical-axis wind turbine with a rotor height of 55 feet and maximum diameter of 37 feet.

Pumping System

The entire pumping system was assembled from commercially available equipment, and much of it was already installed in an existing irrigation well. The 8-inch, vertical-turbine pump installed in the well in 1964 is a type commonly used in irrigation pumping. The well produces 400 gallons per minute, and the total dynamic head is 300 feet. The pump and well were used without modification in the wind-assisted pumping system.

The electric motor used to power the pump is a 3-phase, induction, vertical hollow-shaft type normally used with turbine pumps. The 75-horsepower motor has a design operating speed of 1,780 rpm, the same as the pump.

A combination gear drive (fig. 2) between the electric motor and the pump discharge head permits power to be supplied to the pump from two independent power sources. In the wind-assisted pumping system, the wind turbine connects to the combination gear drive where a standby engine normally would be connected.

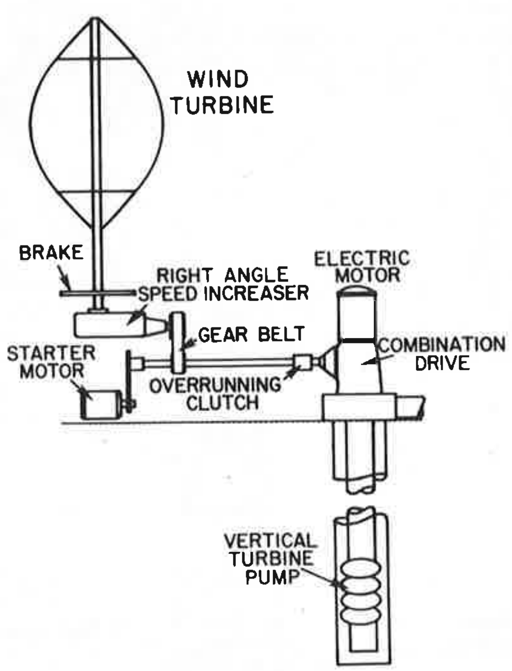

Figure 2.--Schematic of the wind-assisted irrigation pumping system.

Results

System operating performance with a rotor speed of 90 rpm is summarized in figure 3. The curves show the operating characteristics of the wind-assisted pumping system with windspeed ranging from 12 to 45 mph. The difference between the rotor output and turbine system curves represents the losses in the speed increaser and averages about 9 percent. The power used by the electric pump motor was reduced from the 67 horsepower for full-load operation below 13 mph, to 5 horsepower when the windspeed was 44 mph.

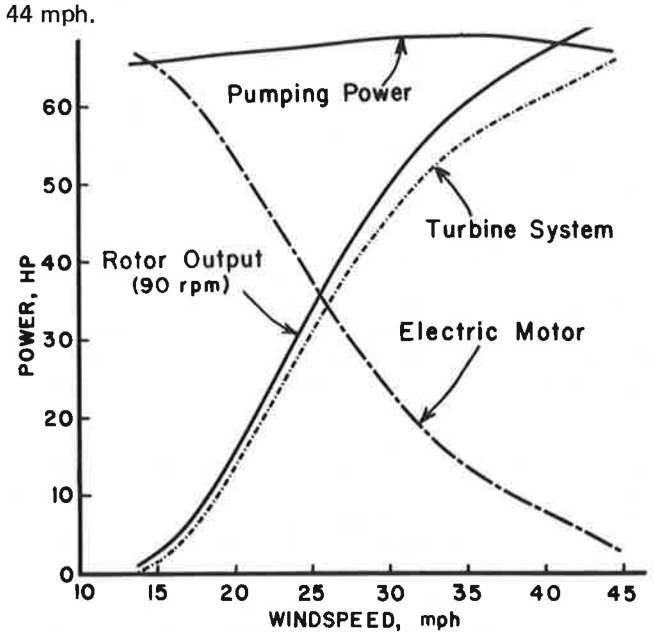

Figure 3.--Rotor output, turbine system power, electric motor power, and pumping system power vs. windspeed for 90 rpm operation.

The wind turbine has been tested at three rotational speeds to determine performance characteristics of the turbine. The power produced at each speed is shown in figure 4. The peak power level is greatly influenced by turbine rpm, increasing from 28 horsepower at 68 rpm to 73 horsepower at 90 rpm. The windspeed at which power production begins is also influenced by turbine rpm; the slower turbine speeds begin producing power at lower windspeeds.

Eleven years of windspeed data from the Amarillo National Weather Service office have been analyzed to determine the monthly power that could be produced with this wind turbine. Figure 5 shows monthly energy production for each of three turbine speeds, 90, 81, and 68 rpm. During the spring months of highest wind, the 90-rpm speed produced the most power; however, the 68 rpm produced the most power during the summer months. The largest annual energy production occurs at 81 rpm, although the differences are only about 3 percent. Energy produced by this machine would cost $0.75/kWh assuming a 20-year life, initial cost of $30,000, annual fixed charge rate of 13 percent, and an annual operating cost of $1,000 per year.

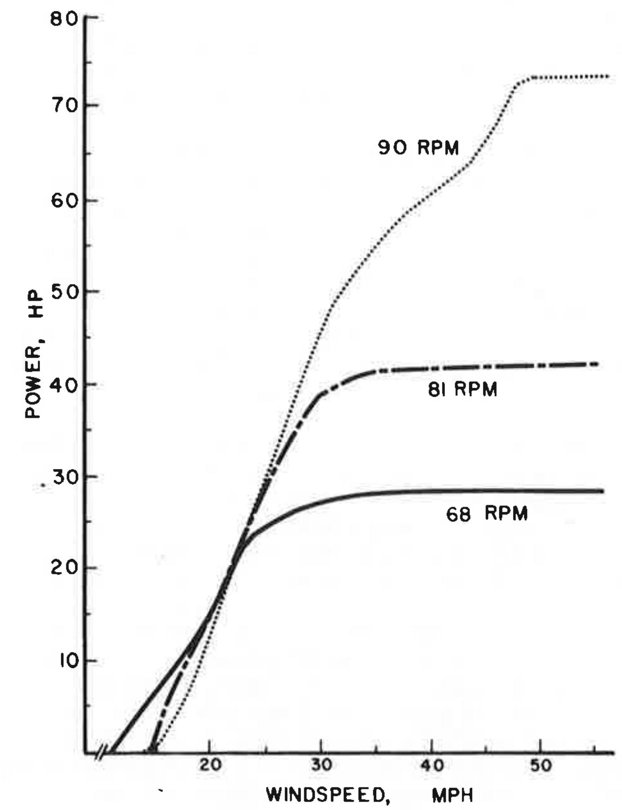

Figure 4.--Rotot output vs. windspeed for 68, 81, and 90 rpm rotor speeds.

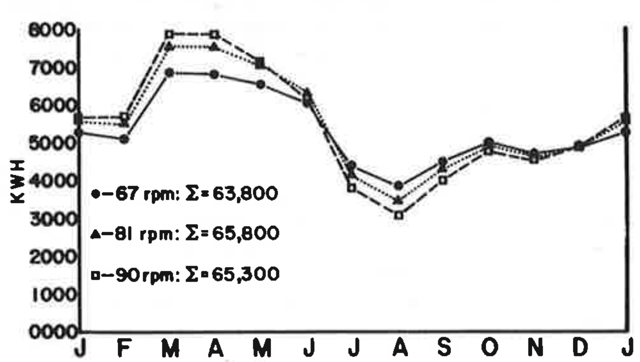

Figure 5.--Monthly power available for the three turbine speeds tested.

In relation to irrigation pumping, figure 5 clearly indicates that wind energy is lowest during the peak of the irrigation season. Adequate amounts of wind energy appear to be available during March, April, and May for irrigating winter wheat and pre-irrigation of summer crops. Enough wind energy should be available for some irrigation during July and August. Wind energy systems for irrigation appear best suited for limited irrigation of summer crops like cotton and sorghum rather than full irrigation of crops like corn and alfalfa.

Discussion

The wind-assisted pumping system effectively utilized the unsteady power output of the wind turbine. The system has operated satisfactorily, and the concept has proven to be sound. All components are readily available and proven, and the mechanical drive is simple. The overrunning clutch has proven to be a simple and reliable method of synchronizing the two power sources.

The wind-assist pumping concept has several advantages over a stand-alone system: (1) Water can be pumped and distributed to the crops during critical water-use periods regardless of windspeed. (2) A constant pump rpm is maintained for good pump efficiency and optimum well yields. (3) The wind-assisted system is easily adapted to existing irrigation pumping installations without exchanging pumps or other existing equipment. (4) A constant water flow permits good irrigation application efficiencies and good water management.

The shortcoming of the wind-assist concept is that it requires two power sources and, in this case, required a connection to the electric utility with associated demand changes. Any correctly sized wind turbine could be mechanically connected to the system and operated at constant speed. If wind turbine power exceeds the total load on the system, the induction motor will be driven above synchronous speed and become an induction generator. Pump output will increase according to the pump speed laws, and electricity at the correct voltage and frequency will flow back into the power grid. With this design, the wind turbine can be sized twice as large as the electric motor.

A diesel engine could be substituted for the electric motor in the wind-assisted pumping system. Diesel engines operating at constant speed can be throttled from 100 percent to 25 percent load with a corresponding reduction in fuel consumption. The wind turbine should not be sized to provide more power than that required by the pumping system when a diesel engine is used. Wear on the engine would then be very rapid because the engine would brake the wind turbine at high windspeeds.

A spark ignition engine such as a natural gas engine is not as well adapted to the wind-assisted system as a diesel engine. These engines require a minimum fuel:air ratio for ignition, and little or no fuel saving occurs below 50 percent of rated power.

The wind-assisted concept can be used in any rural or remote area where a second power source is available. Practical use will depend on whether wind energy is more economical than existing energy sources.

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Wind Energy—An Industrial Perspective

Gene C. Valentine, *Windfarms, Ltd., San Francisco, Calif.*

Windfarms, Ltd., was formed in 1974 by an entrepreneur, Wayne Van Dyck. Wayne got the idea for Windfarms when he was stuck in a farmhouse in Calistoga, Calif., when the electricity went out in a freak snowstorm with temperatures well below 30^{o} F. Because the house was all electric, he had no light, heat, or any other electrical service that most of us have come to take for granted. The fact that this occurred shortly after the Arab oil embargo added to the profound effect this had on his thinking in terms of electrical power.

From 1974 through 1977, he studied the oil crisis, searching for a place for him to make a contribution in an area he believed to be the most critical facing the United States. In 1970 through 1978, the oil imported to the United States has gone from 35 to 55 percent. The price for that imported fuel went from $7 to $80 billion. Since 1978, there has only been a 3 percent decrease in our oil imports.

Over the last 100 years, man has found and extracted about 50 percent of the oil that took nature about 100 million years to produce. Another important consideration is that the United States comprises only 5 percent of the world's population, yet the U.S. consumes 40 percent of the aggregate energy production.

When evaluating the alternatives, Mr. Van Dyck decided that wind power had the best near-term potential for the following reasons: it was a large, renewable resource; it was a soft path technology; and it was a simple technology that had a long history. He went on to examine how wind energy industry might be developed in the United States.

Examining the utility sector, he saw several problems. First of all, utilities are very conservative by nature. They're heavily regulated, which acts as a further inhibitor to their risk-taking. Finally, they're experiencing a financial crisis, as a function of the rapid oil price escalation that has taken place, and the reluctance of public utility commissions to allow the rate increases commensurate with the rising cost of producing the energy. Their stocks are selling below book value, and their bond ratings are down. These capital restraints are further taxed by the need to replace aging and obsolete equipment. A second-order effect of this particular situation was that there was no market, no manufacturer, so here one sees a classic "chicken and egg" dicotomy.

Over the past decade or so, the Department of Energy has pumped some $200 million into programs, resulting in some experimental prototype wind generators produced by companies such as Boeing, Hamilton Standard (a division of United Technologies), Westinghouse, and Alcoa. These prototypes seem to have a high probability of being useful equipment. Putting all these facts together, Mr. Van Dyck, in 1978, formed the Windfarms concept, which included: packaging and development; sale of power to utilities; and distribution of uncertainties in such a way that investors and utilities all had a comfortable level of risk.

The first project that Windfarms embarked upon was in Hawaii with the Hawaiian Electric Co. Hawaii was the perfect target for this grand experiment if it was to work. The reason being that it is 100 percent dependent on imported oil, and that 80 percent of the time it has very strong trade winds.

When Mr. Van Dyck first visited Hawaiian Electric Co. in 1978, the corporation was not interested in the concept, having a nice long-term, fixed-price oil contract with Standard Oil of California. However, when he went back again in 1979, and the price of oil had gone up 60 percent, the Hawaiian Electric Co. had a change of mind. By the end of 1979, a letter of intent was signed between Windfarms, Ltd., and Hawaiian Electric Co. for an 80-megawatt windfarm, which would ultimately supply 8.5 percent of Oahu's electric power, saving about 700,000 barrels of oil per year.

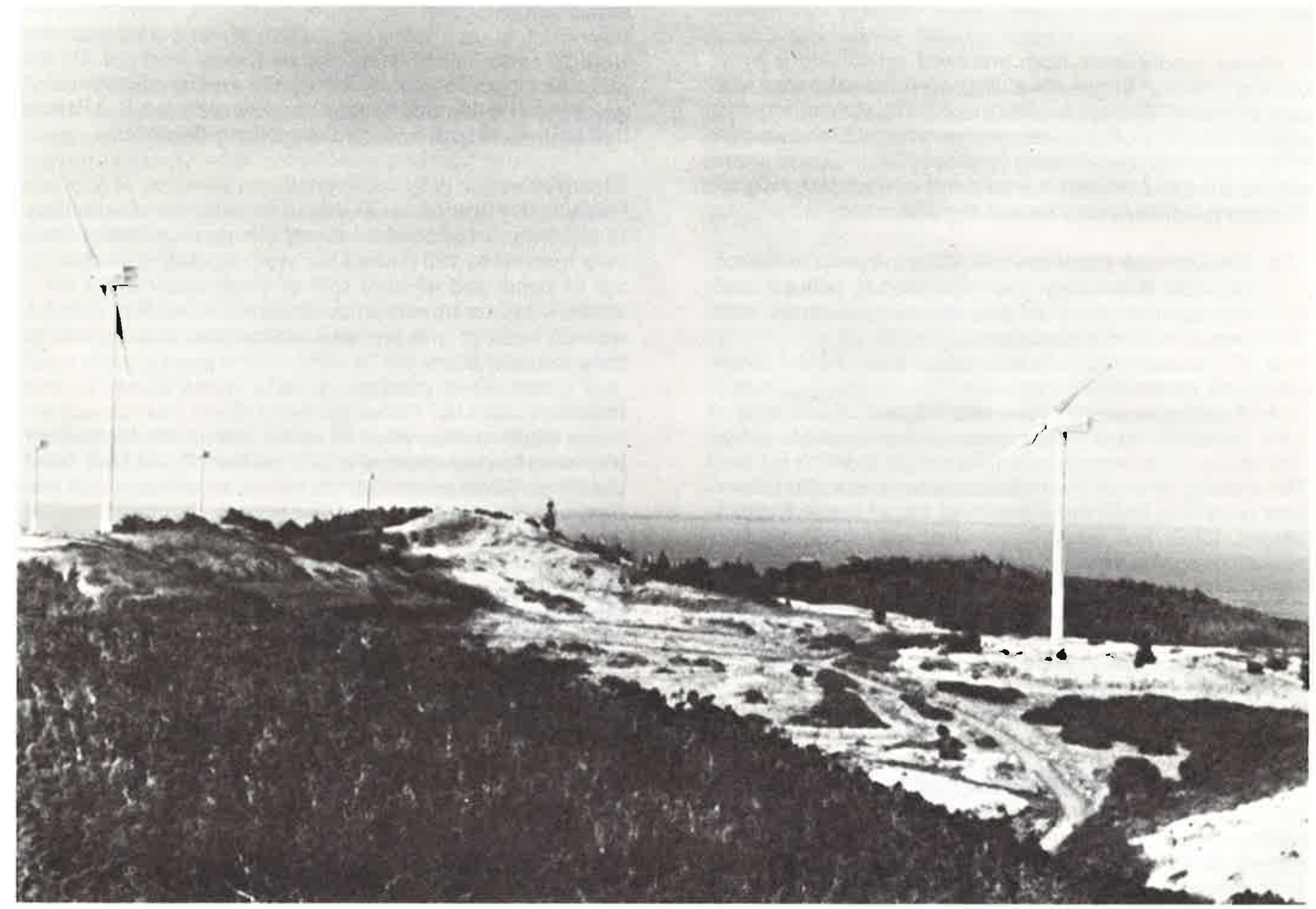
After signing the letter of intent, it became apparent that stringent engineering requirements had to be met for utility power production by wind energy, such as acute needs for frequency regulation, and stability of the power supply and voltage requirements. So, in 1980, Mr. Van Dyck, through Windfarms, retained Bechtel Corp. as the project engineer.

The next item that needed to be put in place was the capital. Projects of this kind, even an 80 megawatt one, are very expensive. It seems that the financing required for this project would be between $250 and $300 million. It was determined that the First Boston Corp., investment bankers in New York, whose projects included the $7.5 billion Alaska pipeline, would be an excellent candidate to assist in this complex and ambitious program.

Another factor was the Public Utilities Regulatory Policies Act, which became law in 1978. It requires utilities to buy energy produced by alternative means that were not consumed by the producer itself. That act, along with the favorable tax credit situation, created a favorable climate for a project of this type.

With someone to buy the power, someone to help raise the funds, and someone to build the project, the only thing missing was site acquisition. A lease was negotiated between the Campbell Estate and Windfarms, Ltd., to use land in the Kahuku Point area of Oahu. Negotiations began with the U.S. Army also because it was a sublessor of the Campbell Estate.

The next step was the collection of the necessary meteorological data. This is a very expensive and tedious process, but extremely important, because siting is one of the most critical factors in putting together a successful Windfarm. Movement of a distance of as little as 1,000 feet from a known high wind resource area could result in a substantial loss of power production. So a detailed meteorological survey had to be done.



Artist's rendering of wind-powered generators in the Kahuku Point area, Oahu, Hawaii. When completed, this project will have a capacity of 80,000 kW and save the importation of about 700,000 barrels of oil a year.

Finally, in 1981, Windfarms signed an agreement with Hamilton Standard to supply the machinery.

This project is now firmly underway. The meteorological work is progressing as are the other aspects of preliminary planning, including interconnects, powerlines, and other related items.

The completed project will help to demonstrate to both energy planners and politicians that alternative energy should be considered as a viable part of the U.S. energy mix. Secondly, it will help off-set this country's heavy dependence on imported oil.

As a company, Windfarm's goal is to demonstrate the feasibility, through application, of wind technology. Our objective is to have 1,000 megawatts of wind generated power installed by the year 1995. If that goal is reached, the savings in imported oil would exceed 6 or 7 million barrels per year.

Since Mr. Valentine's talk in Tulsa, Windfarms, Ltd., has sold 40 percent of its company to Standard Oil of California. This seems to indicate the interest on the part of the major oil companies in the emergence of alternative energy technologies.

Seed Production Techniques

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Introduction

If greater productivity from grassland agriculture is to become a reality, better use of improved forage species will be mandatory. The nationwide success of grassland improvement programs, however, depends on available seed supplies. Present seed supplies of many improved warm-season grasses are not adequate to meet the demands of reseeding programs. This can be attributed to several important factors:

- Grower seed yields are low. This is due to a lack of available technology and expertise on cultural and management practices and harvesting methods that would maximize seed yields.
- Growers are reluctant to produce seed of plant species that are unfamiliar to them.
- Inability to establish and stabilize production areas of improved warm-season grasses grown for seed.

The scarcity of seed and high consumer demand result in seed costs that limit the widespread use of many forage species. Often less desirable varieties are substituted in reseeding programs.

Seed Production Systems

There are two types of grass seed production, and each has merit in certain situations.

The dual purpose system is practiced when stands of improved varieties are planted primarily for grazing and haying purposes but are fertilized and managed for seed when prices are favorable. The advantage to such a system is that it allows light grazing of livestock to within 3 to 4 weeks of seed harvest. After harvest livestock are returned at heavier stocking rates or fields are mowed for hay. The disadvantages are in seed quantity and quality. Generally, seed yields are irregular and unpredictable. Seed quality is usually poor, and stands are eventually contaminated by other perennial grasses. Weed seed content is often excessive.

The single purpose system is practiced by specialized seed growers on irrigated or dryland farms in areas of adequate rainfall. Seed production fields are usually established in rows, irrigated if needed, fertilized, and managed for maximum seed yields. The advantages of this system are that limited breeder and foundation seed supplies can be multiplied rapidly, seed yields are usually high, and seed quality is excellent.

Maximizing Seed Production

A cultural or management practice is beneficial when it effects changes in the quantitative expression of one or more components of seed yield, e.g., the density of inflorescences (seedheads), number of florets per seedhead, seed size or fill, and the percentage of seed-set per head. These components are influenced by different factors in different ways, depending on the kind of grass being grown. Production methods that result in excellent yields with one group of grasses may not work well with another group.

Stand Density

Row spacings used in the production of some grass seed vary from 22 to 40 inches, depending on species involved. On the other hand, sod stands are better for seed production of grasses such as bermudagrass, *Cynodon dactylon* (L.) Pers. or buffalograss, *Buchloe dactyloides* (Nutt.) Engelm.

Fertilization

Preplant fertilization needs should be determined according to soil tests. On established stands nitrogen applications may vary from 40 to 100 pounds per acre, depending on species, age of stand, and whether split or single applications are made. There are no soils in the Southern Great Plains that will not improve with nitrogen applications, thus increasing grass seed yields.

Irrigation

Water requirements—when to water, how much, how often, and when to stop—depend largely on the kind of grass being produced. Some grasses require rather large amounts of moisture, e.g., tall warm-season native grasses, to maximize seed yields. Others require comparatively small amounts, e.g., weeping lovegrass, *Eragrostis curvula* (Schrad.) Nees, blue grama, *Bouteloua gracilis* (H.B.K.) Lag. ex Steud., etc. Still others, such as bermudagrass, require two to three alternate wet and dry cycles to first promote and then to slightly stress plant growth, to stimulate seed-stalk production and flowering, and to produce a good seed crop.

Weed Control

Controlling weeds and weedy grasses during and after establishing seed production fields is very important. Chemical and cultural control methods vary with area and kind of grass grown. Weed problems are usually minimal in well-established row stands but can be serious in sod and broadcast stands.

Insect Control

Thrips, midges, and other minute insects do considerable damage to seed-set in warm-season grasses and reduce seed yields unless controlled. Most growers use a shotgun approach to control both forage- and seed-feeding insect problems. Few pesticides are registered for use on grasses other than turf.

Diseases

Usually foliar diseases are not a problem in seed production of improved warm-season grasses. Ergot and seed smut problems vary with species. Methods of field sanitation, such as spring burning and the use of pre- and postemergence herbicides, in some instances aid the control of these diseases.

Harvesting Methods

The method used to harvest a particular grass seed crop can mean the difference between profit and loss. It is not unusual to leave as much seed remaining in the fields as is actually harvested. Grasses differ in growing habits, maturity patterns, and seed characteristics. Thus, the method of harvesting, the timing of harvesting, and the equipment used in harvesting will vary according to kind of grass being grown. Harvest timing and method often represent critical decisions that determine yield and seed quality of the crop.

Some species, such as the Old World bluestem complex, which includes "Plains" bluestem, *Bothriochloa ischaemum* Keng., and "Caucasian" bluestem, *B. caucasica* A. Camus, mature unevenly with continuous seedstalk production, resulting in seedhead populations changing numerically and qualitatively with time. At harvest, early, mature, or ripe heads have shattered, and late heads are immature and do not contribute to yield.

Judgment and a certain degree of guesswork are involved in selecting the optimum time to harvest seed of these grasses. Since there is never a time when all the seed is ripe, the best time to harvest occurs when the majority of the seed is in a medium to hard dough stage but before full maturity when the seed shatters easily. When 30 to 40 percent of the seedheads can be easily stripped by grasping them with the hand and gently pulling between the fingers, the seed crop should be harvested.

To maximize seed yield with these grasses, seed harvesting should be done with a stripper harvester. The prototype model of a flail stripper we developed to harvest light fluffy grass seed crops is now being manufactured commercially. The harvester should solve the problems associated with many difficult to harvest chaffy seeded grasses. However, the stripper harvesting method harvests immature seeds as well as ripe. The harvested crop must be thoroughly dried before storage since storing seed at high moisture contents can result in rapid deterioration of seed quality.

Some species shatter readily soon after the seed reaches the physiologically mature stage, e.g., kleingrass, *Panicum coloratum* L. In these grasses the best time to harvest is when the seed crop is from medium-firm dough to first shatter, which is usually only 3 to 4 days and may be less if the temperature is high.

The trick to obtaining high seed yields with grasses in this group is with the use of irrigation water. The transition between vegetative and reproductive growth usually requires 1 to 3 weeks. By repressing irrigation after the early boot stage of crop development, seed-stalk production and maturity is more uniform and harvesting can be more easily timed to maximize yield. Direct combining is the usual method of harvesting. Swathing or windrowing the crop will buy the grower time to complete harvesting without excessive seed losses provided the cured swath is not excessively stirred during the pickup process of combining. This will also eliminate the need for postharvest drying.

Some grasses mature and retain seed well, but shatter losses can be high if harvesting is not timed properly. Among these are a number of native warm-season tall grasses such as big bluestem, *Andropogon gerardii* Vitmar; indiangrass, *Sorghastrum nutans* (L.) Nash; little bluestem, *Schizachyrium scoparium* (Michx) Nash; and switchgrass, *Panicum virgatum* L. as well as certain cool-season grasses: tall fescue, *Festuca arundinacea* Schreb.; orchardgrass, *Dactylis glomerata* L.; smooth bromegrass, *Bromus inermis* Leyss.

Most native grasses in this group are combine harvested just before or after frost. This harvest time is not conducive to high seed yield but is practiced because moisture content is lowest then. This eliminates problems associated with artificially drying the harvested seed. Grass seed crops that are combined direct must be thoroughly dried before storage.

In cool-season grasses, the straw color of the seed field and the yellowing of the seedstalk 3 to 4 inches below the inflorescence indicate ripeness. While these seed crops can be harvested by direct combining, the best method is swathing or windrowing the seed crop before shatter begins. The swath or stubble height should be no less than 12 inches. This allows air circulation through the swath, keeps the crop from contacting the soil, reduces the curing time, eliminates the need for artificial drying after seed harvest, and reduces the amount of straw that goes through the combine when the seed is threshed.

Other species, such as bermudagrass, have a more or less continuous seed-stalk production but do not shatter readily and retain seed on the inflorescence for long periods after maturity. The inflorescence or seedheads of bermudagrass are mixed among the vegetative canopy, and one must handle the forage growth in the seed harvesting operation. Seed fields are normally swathed and allowed to cure for several days before combining. After the initial combining or threshing, the tailings are rethreshed three to four times in order to obtain as much of the seed as possible. This technique is costly as well as time and energy consuming. It can be shortened by chemical desiccation of the standing crop and direct combining. However, desiccants, such as paraquat,[1] oversprayed on the seed affect seed quality (germination), and this is an obstacle to its recommended use. Research is needed to determine the effect of other desiccants on seed quality of bermudagrass and other grass seed crops.

Conclusions

Seed of our better forage grasses is very difficult to produce, and those that produce and set seed well, when managed properly, often present unique and difficult harvesting problems. High seed yields can be achieved with many grasses with the proper combination of variety (strain or species) with environmental and agronomic practices (cultural, management, and harvesting). Much more is known of growth and crop development of the cool-season grasses than of warm-season grasses. The influence of the physiological processes associated with the complex relationships of environmental and genetic factors and cultural conditions on crop seed yields need to be determined. Optimum combinations of these factors are fundamental to establishing grower-efficient seed production techniques.

[1]This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.

Kincaid Grass Harvester

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Continuous testing has been done on the grass harvester designed by Oklahoma State University. Dr. Robert Ahring and Dr. Richard Whitney were both very helpful in the advancement of the harvester, since they were both involved in the initial construction of the machine.

Improvements to the harvester include a mechanical bagging system with a "Y" discharge, so bags can be changed while harvesting. An extended hood has also been added to decrease seed loss.

Purity of seed can be affected by header height, reel speed, and forward travel. By achieving the correct ground speed and reel, very little unripened seed is removed from the grass stalk, and unwanted debris is left on the field. Ground speeds of 4½ mph were used, and the results were acceptable. Seed purity and seed removal were well within the expected range.

Grasses that have been harvested with successful results are as follows: little bluestem, big bluestem, side oats Grama, indiangrass, Old World bluestem, caucasian bluestem, buffelgrass.

The grass harvester has other advantages. It is less expensive than the conventional means of harvesting. It is easy to transport, easy to set, and easy to clean out. It can normally cover more acres and harvest at higher moisture levels than a regular combine.

Continued evaluation will be done during the 1981 season. There are many different types of grasses raised, but we feel that the harvester will harvest most grasses with similar characteristics of the ones we have tested. We will monitor the machine and look for ways to improve it.

Kincaid grass harvester represents the application of seed harvesting research and development work by the Agricultural Engineering Department, Oklahoma State University. This harvester can be operated up to 4 ½ mph.

Equipment Development & Test Funding

Planning and Budgeting Procedure

For many years the "Range Reseeding Committee" was an informal group, meeting each year to exchange information on work of mutual interest and to develop project proposals for work to be done by Equipment Development Centers or field units. The proposals were written, estimated for cost, and finalized "on the spot." Informal but it seemed to work!

Today there are demands being placed on us to plan in detail 2 years in advance, and in general 5 to 10 years ahead. This does take away some of the informality of the operation and dictates the need for a more organized approach to the preparation and submittal of project proposals. Figure 1 shows a plan by which we can meet our budgeting dates. It provides a mechanism whereby the Equipment Development Centers can stay with the budget process of the Forest Service.

The other aspect of our planning procedure is a more uniform format for project proposals. Figure 2 is a suggested guideline for proposals. Following this guide will help all concerned in preparing and reviewing proposals. It should make the flow of information more efficient and provide a much better story for those who must analyze needs, prepare programs, and assign priorities.

We hope that everyone associated with the Vegetative Rehabilitation and Equipment Workshop will cooperate in this more formal approach. It should be an aid to everyone. If any questions arise or there is a need for help in this process, call the Centers or the Washington Office.

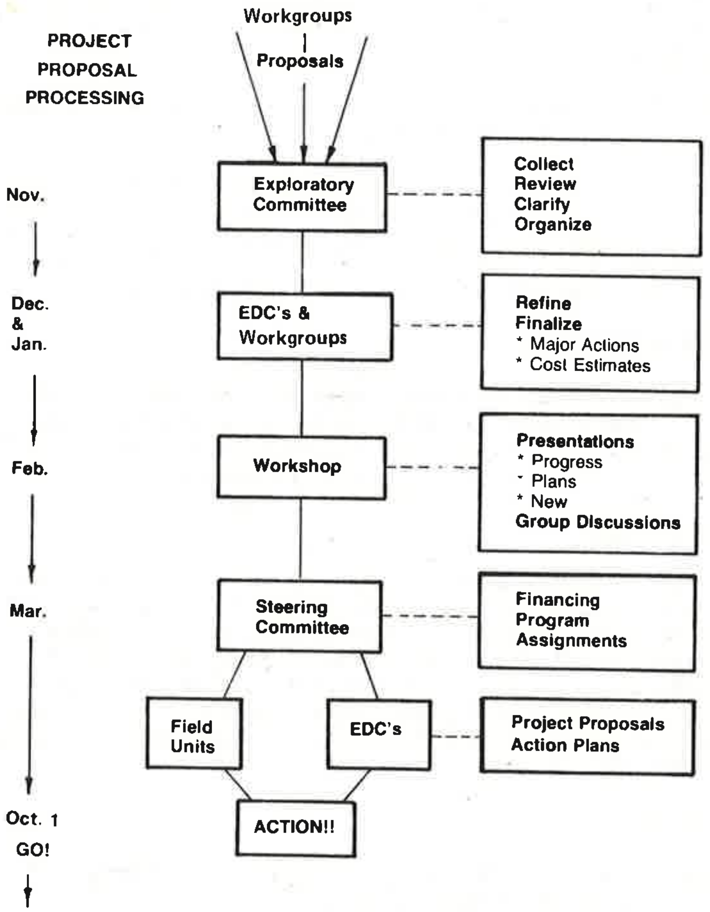

Figure 1.--Project proposal processing.