United States
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Forest Service

Equipment
Development
Center

Missoula, Mont.

History of the Vegetative Rehabilitation and Equipment Workshop (VREW) 1946-1981

2200—Range
8222 2805

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This history is the product of the Missoula Equipment Development Center Publications staff. The information was compiled by John Larson, a Biological Technician.

December 1982

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Foreword

From its beginning in 1946, the Vegetative Rehabilitation and Equipment Workshop (VREW) has worked to make equipment and information for range rehabilitation available to land managers. Starting with a few individuals concerned with range seeding, VREW has expanded its organization and interests and now includes diverse participants and a wide variety of activities.

This booklet traces the organization and history of VREW and describes VREW equipment development and test projects accomplished by the USDA Forest Service Equipment Development Centers at Missoula, Mont. (MEDC) and San Dimas, Calif. (SDEDC). Several people have been involved in this effort. A.B. (Tony) Evanko deserves special credit for his efforts to complete the original *History—Range Seeding Equipment Committee 1946-1973,* which this publication updates and expands. Dan McKenzie from SDEDC and Dick Hallman from MEDC have provided material and encouragement for this and other projects of the VREW Information Workshop, during recent years. Finally, the editors, Bob Hensler and Brenda Holland, and the rest of the MEDC publications staff deserve recognition for their fine work on recent VREW publications. Ultimately, however, congratulations are due to all participants, workgroups, and funding agencies throughout the years who have helped to make VREW a success. With this excellent support, VREW should continue to make important contributions to land rehabilitation. We look forward to another 35 years of progress.

Sincerely,

W L Evans

W. L. Evans
Director, Range Management
USDA Forest Service

Introduction

The Vegetative Rehabilitation and Equipment Workshop (VREW) is an informal organization interested in developing and testing revegetation equipment and providing information about suitable equipment to land managers. Formerly known as the Reseeding Equipment Development Committee (1946-1958) and, later, as the Range Seeding Equipment Committee (1958-1974), VREW is mainly concerned with equipment for rangeland improvement and disturbed land reclamation.

VREW is an informal, ad hoc group without by-laws, membership requirements, or dues. Meetings are held each winter, usually in conjunction with, and just prior to, the annual meetings of the Society for Range Management. Most of the workshops have been held in the Western United States. Workshop participants review accomplishments, discuss development activities, and present new information concerning revegetation equipment or techniques.

VREW includes representatives from Federal and State agencies, universities, industries, and other organizations. Foreign countries such as Canada, Mexico, Kuwait, Niger, Morrocco, Kenya, Argentina, and Australia. Several Federal agencies are actively involved in VREW. Major funding agencies have been the Forest Service (FS), the Agricultural Research Service (ARS), the Extension Service-Natural Resources (EXT-NR), and the Soil Conservation Service (SCS) from the Department of Agriculture (USDA); and the Fish and Wildlife Service (WS), the Office of Surface Mining (OSM), the Bureau of Indian Affairs (BIA), and the Bureau of Land Management (BLM) from the Department of Interior (USDI). State agencies such as Fish and Game departments, Highway departments, and extension services have contributed personnel and facilities for field tests and evaluation. In recent years, industries, including equipment manufacturers, seed suppliers, mining companies, ranches, and consulting firms, have become increasingly involved in VREW.

The chairman of VREW has traditionally been the Assistant Director of the Forest Service Range Management Staff in charge of Cooperative Programs (Fig. 1). This allows administration and coordination of range and resource programs with the Equipment Development Centers at San Dimas, Calif. (SDEDC), and Missoula, Mont. (MEDC). The VREW Chairman handles many of the administration details of the workshop, acts as a liaison among various agencies, and heads both the Steering and Exploratory Committees of the workshop.

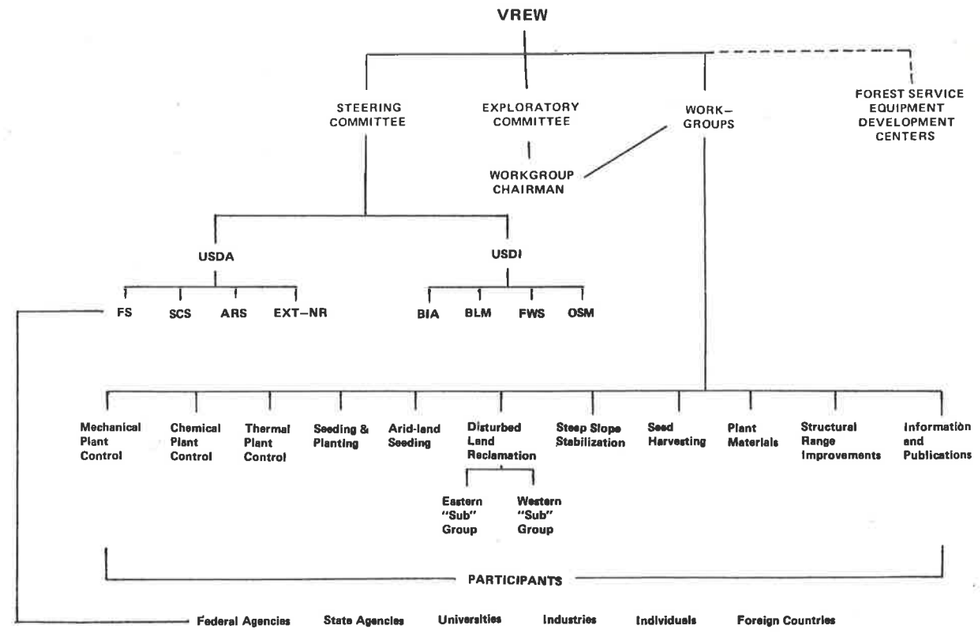


Figure 1.--Organization of the Vegetative Rehabilitation and Equipment Workshop (VREW).

The Steering Committee comprises representatives from each major funding agency (Appendix A). They examine the projects and set priorities according to field needs. They then assign the approved projects to existing workgroups (Appendix B) or, if necessary, create new workgroups to accomplish special projects. Workgroups that have accomplished their purpose are phased out or incorporated into other workgroups.

The Exploratory Committee is composed of the chairmen of the VREW workgroups, members of the Steering Committee, and selected personnel from the Equipment Development Centers. It meets annually to examine project proposals for VREW (Fig. 2). Project proposals originate from a variety of sources including surveys of field personnel, spin-offs from previous development work, and suggestions from researchers, ranchers, or other interested individuals.

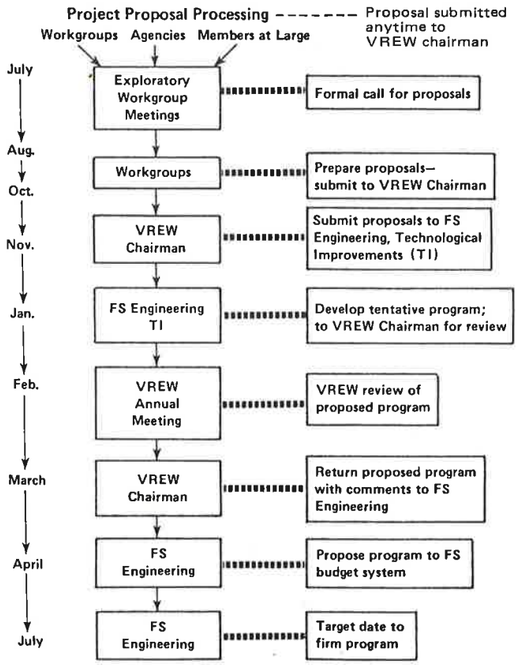


Figure 2.--Project proposal processing.

The workgroups are responsible for developing project proposals, monitoring progress, directing field testing, evaluating results, and discussing new developments in their areas of interest. Each workgroup also reports its activities to the entire VREW organization during the annual meetings. These reports, along with papers presented during the meetings, are published every year. All VREW reports are distributed on an extensive mailing list compiled for VREW.

Workgroup meetings are held several times during the year at the discretion of the workgroup chairmen or at the convenience of the members. The cohesion and structure of VREW are largely maintained by the various workgroups. Members generally have varied backgrounds and are drawn together by common interests. The workgroup structure fosters cooperation and promotes good working relationships among individuals from various agencies, industries, and organizations.

VREW works very closely with the Forest Service Equipment Development Centers where most of the actual project work takes place. SDEDC and MEDC planners, project leaders, and support staff identify equipment needs, evaluate commercially available equipment, design, construct, and test equipment, and publish reports, films, and slide tapes. In addition, they provide technical services that involve answering routine requests, maintaining and updating drawings and specifications, attending seminars and special courses, and determining the benefits and costs of equipment development projects.

Many successful development projects and other accomplishments have resulted from the unselfish cooperation that has been characteristic of VREW. These efforts serve as an example of what can be done through cooperative efforts. The workshop will undoubtedly have an important future role in revegetation of disturbed lands, especially in light of increasing environmental concern. Membership is open to anyone interested and rewards are abundant to those who enjoy seeing results.

History

VREW's roots go back to World War II, when more wool and beef were needed to sustain the war effort. With increased demand for sheep and cattle, officials sought to increase productivity from National Forest rangelands. However, many of these lands, already suffering from a long history of abuse, could not support additional livestock without substantial improvement. Range seeding had been demonstrated by small-scale tests in the 1930's, but additional research was necessary to implement large-scale seeding efforts. The research was approved and seeding tests were initiated throughout the West.

The range seeding test program proved successful, but several problems needed to be solved before it could be effectively expanded. A major problem was that the equipment commercially available at that time was designed for crop production on farmland and was poorly adapted to the rough terrain, rocky ground, steep slopes, and dense brush encountered on rangeland.

A conference of Forest Service researchers and administrators was held in 1945 to discuss the state-of-the-art in range seeding and what needed to be done. Participants at the conference recognized that a major effort was needed to test, adapt, or develop suitable equipment for range seeding and other improvements. An interregional administrative research committee was established to work with the staff at the Forest Service Equipment Development Center at Portland, Oreg. Center personnel joined the group to add their expertise to help solve rangeland equipment problems. The Center also provided the necessary facilities and equipment for the development efforts. Eventually this work was moved to the Center at Arcadia, Calif. In the late 60's some Range equipment development work was started at MEDC.

The conference group became known as the Reseeding Equipment Development Committee. In 1958, it changed its name to the Range Seeding Equipment Committee, and, later, became VREW. The first formal cimmittee meeting was held in Portland, Oreg., on Dec. 9-11, 1946 (Table 1).

Table 1—*Attendance at VREW Annual Meetings*

Meetings			Attendance						
Date	Location	Chairman	USDA Forest Service	Other Federal Agencies	State Agencies	Universities	Industries and Individuals	Foreign	Total
Dec. 1946	Portland, OR[1]	J.F. Pechanec	6						6
Dec. 1947	Ogden, UT[1]	J.F. Pechanec	9						9
Jan. 1949	Denver, CO	J.F. Pechanec	15	2[2]					17
Dec. 1949	Ogden, UT[1]	J.F. Pechanec	22						22
Jan. 1951	Billings, MT	J.F. Pechanec	15	19	3	2			39
Jan. 1952	Boise, ID	A.C. Hull	21	24	8	1			54
Jan. 1953	Albuquerque, NM	A.C. Hull	25	50	10	5	9	1	100
Jan. 1954	Omaha, NE	A.C. Hull	21	42	4	4	3	5	79
Jan. 1955	San Jose, CA	W.W. Dresskell	19	43	9	1	4	1	77
Jan. 1956	Denver, CO	W.D. Hurst	21	65	5	7	1	2	101
Jan. 1957	Great Falls, MT	W.D. Hurst	26	69	7	3	4		109
Jan. 1958	Phoenix, AZ	F.C. Curtis	27	60	4	5	3		99
Jan. 1959	Tulsa, OK	F.C. Curtis	23	61	2	3	2		91
Jan. 1960	Portland, OR	F.C. Curtis	30	68	3	7	3	3	114
Jan. 1961	Salt Lake City, UT	F.C. Curtis	39	84	8	3	14	2	150
Jan. 1962	Corpus Christi, TX	F.J. Smith	19	39	3	2	7	1	71
Jan. 1963	Rapid City, SD	F.J. Smith	17	35	1	5	1		59
Jan. 1964	Wichita, KS	J.S. Forsman	24	37	2	8	5		76
Jan. 1965	Las Vegas, NV	J.S. Forsman	29	48	3	5	6		91
Feb. 1966	New Orleans, LA	J.S. Forsman	19	28	3	5	5	1	61
Feb. 1967	Seattle, WA	A.B. Evanko	20	38	7	3	4		72
Feb. 1968	Albuquerque, NM	A.B. Evanko	40	44	9	7	13	1	114
Feb. 1969	Great Falls, MT[1]	A.B. Evanko	24	22	2	1	12		61
Feb. 1970	Denver, CO	A.B. Evanko	35	46	4	4	11		100
Feb. 1971	Reno, NV	A.B. Evanko	36	38	2	4	15	2	97
Feb. 1972	Washington, DC	A.B. Evanko	26	22	1	3	5		57
Feb. 1973	Boise, ID	A.B. Evanko	23	37	1	6	7	4	78
Feb. 1974	Tucson, AZ	B.F. Currier	28	33	3	9	10	14	97
Feb. 1975	El Paso, TX[1]	J.S. Tixier	29	20	2	7	11	1	70
Feb. 1976	Omaha, NE	J.S. Tixier	26	24	3	17	12		82
Feb. 1977	Portland, OR	V.L. Thompson	39	24	7	19	31	10	130
Feb. 1978	San Antonio, TX	V.L. Thompson	30	38	4	22	35	6	135
Feb. 1979	Casper, WY	T.V. Russell	41	33	7	28	72	12	193
Feb. 1980	San Diego, CA	T.V. Russell	33	64	5	39	88	21	250
Feb. 1981	Tulsa, OK	T.V. Russell	30	26	5	30	111	16	218

[1]Meetings not held in conjunction with Society for Range Management meetings.

[2]Representatives from BLM and SCS attended but exact number is unknown.

A. Denham, L.A. Dremolski, T.P. Flynn, A.C. Hull, F.H. Kennedy, and J.F. Pechanec attended and J.F. Pechanec was appointed chairman. Other chairmen throughout the years have been A.C. Hull, W.W. Dresskell, W.D. Hurst, F.C. Curtis, F.J. Smith, J.S. Forsman, A.B. Evanko, B.F. Currier, J.S. Tixier, V.L. Thompson, and T.V. Russell.

During the first meeting, the committee formed a charter to "Consider, evaluate, and assign priorities to equipment problems suggested by the several Forest Service Regions . . . prepare a program of work each year for the Forest Service Equipment Laboratory to follow . . . (and) perform an essential function by drawing up specifications for the most desirable makes and models of equipment for range seeding."

The committee worked closely with the Equipment Development Center. Ted P. Flynn, Tom Coldwell, and Gene Silva of the Centers kept up enthusiasm and contributed to the success of many early projects.

The first few annual committee meetings were attended exclusively by Forest Service personnel from various Regions and Stations. After the American Society for Range Management (later the Society for Range Management) was founded in 1948, the Range Seeding Equipment Committee met at the same time to encourage attendance at both meetings.

Other agencies soon became interested in the Range Seeding Equipment Committee. Representatives of the BLM and SCS attended the committee meeting at Denver, Colo., in January 1949. A great deal of controversy existed at that meeting concerning the name and purpose of the committee. The debate resulted in a better understanding of the committee charter. Later that year the committee objectives were expanded to: "1) Evaluate available equipment suitable for range seeding (and brush control) and if none is satisfactory, suitable equipment (shall) be designed, constructed, and tested under guidance of the committee; 2) Prescribe specifications and standards for purchase, maintenance, and use of equipment and materials; 3) Function as a clearinghouse for . . . information, and 4) Act in an advisory capacity . . . in range seeding and undesirable plant control policies and procedures."

At times, the survival of the Range Seeding Equipment Committee seemed doubtful. Attendance at most of the early meetings was low. However, the enthusiasm and dedication of committee members attracted other land managers facing similar equipment difficulties. As committee efforts expanded, several other agencies became involved in committee meetings and activities. In 1951, BLM first contributed funds for committee projects. The BIA and SCS added financial support in 1955 and 1956, respectively. Interagency participation and funding has helped insure the survival and success of the Range Seeding Equipment Committee and VREW.

During the 1955 meeting, the committee decided to function as an informal organization without restricting membership or participation by interested agencies or individuals. This structure has encouraged participation from groups with diverse interests and has promoted a free exchange of information. Over the years, many Federal agencies, State agencies, universities, and industries have cooperated with the committee, and VREW, by contributing funds for special projects, participating in field operations and evaluation, or supplying materials and equipment for testing.

The informal structure and extensive cooperation have helped VREW accomplish its stated goals.

The Vegetative Rehabilitation and Equipment Workshop, VREW, is a forum to provide exchange of ideas to enhance the development and dissemination of technology used in improving rangelands and surface-mined spoils. To better identify an equipment development project, VREW may:

1. Promote an understanding of the ecology of the land to be treated as a first step in modifying or designing new equipment.

2. Utilize cost efficiency in evaluating proposed projects for selection.

3. Improve equipment evaluation through consultation with interested or affected Federal, State, and private organizations, and individuals.

The scope of VREW activities has inevitably broadened since the committee began. Investigation and development efforts have moved from seeding and seedbed preparation equipment, to mechanical plant control, chemical application, prescribed burning, contour furrowing, water developments, structural improvement, seed gathering, and related functions.

The Range Seeding Equipment Committee formally changed its name to Vegetative Rehabilitation and Equipment Workshop (VREW) in 1974 to better reflect the diversity and broadened scope of its support and interest. Today, most Federal and several State land management agencies are represented in VREW. In addition, universities and industries are becoming increasingly involved. VREW activities range from evaluating improved seedboxes for rangeland drills to establishing a computerized inventory of suitable plant materials.

A growing emphasis is also being placed on collecting and distributing current information about equipment and techniques for rangeland improvement and disturbed land revegetation. The Range Seeding Equipment Committee has supplied several useful publications, including the *Range Seeding Equipment Handbook, Chemical Control of Range Weeds, Operating Hints for Equipment Used in Range Revegetation* and others.

Range publications.

VREW is increasing the effort to provide land managers with pertinent, up-to-date information (Appendix C). Much of this information is published in news letters, Equip Tips, Project Records, VREW annual reports, service and parts manuals, operations handbooks, and the *Catalog—Revegetation Equipment* (Fig. 3). These publications should help land managers make informed choices about available equipment and techniques for their specific needs.

VREW equipment development and test (ED&T) projects have encompassed a wide variety of needs. VREW achievements have resulted in effective and economic improvements of many rangelands, critical watersheds, and other areas that might not have been possible otherwise. The interest, dedication, and cooperation among VREW members has produced a unique combination of knowledge, talent, and experience necessary to meet the growing demand for range rehabilitation equipment and techniques. VREW will continue to supply new ideas, better equipment, and current information as long as this demand persists.

Equipment Development and Test Projects

Over the years, VREW has been responsible for developing many types of rangeland equipment. VREW projects generally involve either evaluation of commerical equipment adapted to wildland use or development of new equipment to satisfy special needs. The *Catalog—Revegetation Equipment* provides detailed information on the techniques, capabilities, limitations, specifications, and availability of commercially available or commonly used equipment.

The following sections give brief accounts of the equipment development and test projects. They are grouped into plant control, ground preparation, seeding and planting, and miscellaneous categories according to the primary function of the equipment.

Plant Control

Plant control equipment removes plant competition or controls shrub growth to allow desirable forage plants to be reestablished or enable browse species to be rejuvenated. This is accomplished by mechanical treatments, herbicide applications, or prescribed burns, used singly or in combination. The timing and intensity of the control techniques may be varied to achieve the desired effects.

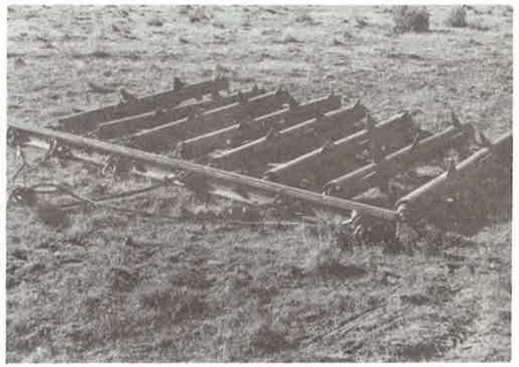
Equipment development and test efforts have concentrated mainly on mechanical control methods, but a few projects have involved spray equipment. Recent activities have been concerned with thermal brush control and aerial ignition systems.

Pipe Harrow, Project 33. This project was an early effort to develop equipment for controlling range brush.

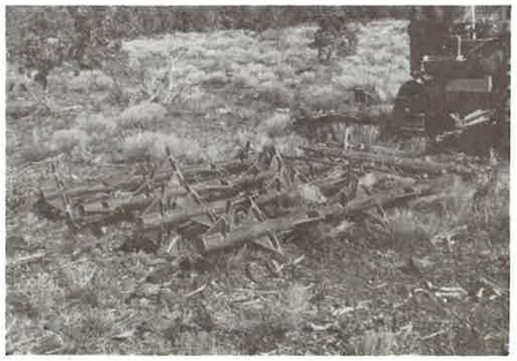
The unit consists of lengths of 4-inch pipe with a number of 3- to 4-inch spikes alternately welded to the pipe. Design and construction were by the Forest Service Pacific Northwest Region. The harrow is moderately effective in removing mature, big sagebrush plants, especially on rocky sites, but it is ineffective with young plants. It has also satisfactorily scarified rocky, compacted soils prior to broadcast seeding, and then covered the seed after broadcasting.

Modified units have recently been developed on the Coconino National Forest in the Southwestern Region. Several are now being used for preparing seedbeds on rough, rocky areas in the Southwest.

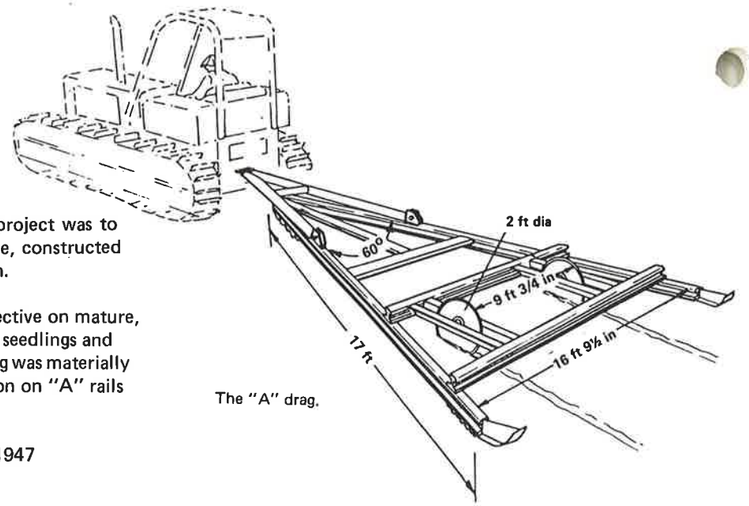
Project approved and initiated	1947
Project reviewed	1947, 1950, and 1952
Project terminated	1952
Project accomplished by Forest Service (Pacific Northwest, Intermountain, and Southwestern Regions)	



Original pipe harrow.



Modified pipe harrow.



The "A" drag.

"A" Drag, Project 33. The purpose of the project was to determine the effectiveness of an "A" frame, constructed from railroad rails, in removing big sagebrush.

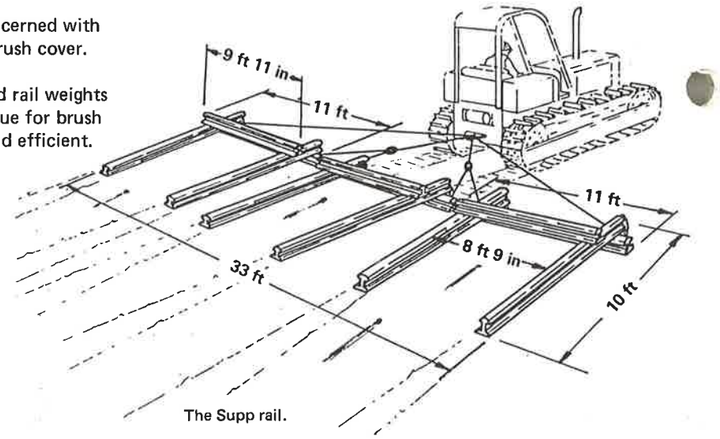
This means of control was only partially effective on mature, big sagebrush plants, and had little effect on seedlings and young plants. The uprooting action of the drag was materially reduced by debris accumulations. Information on "A" rails may be obtained from SDEDC.

Project approved, initiated reviewed, and terminated 1947
Project accomplished by Forest Service (Pacific Northwest Region and the San Dimas Equipment Development Center)

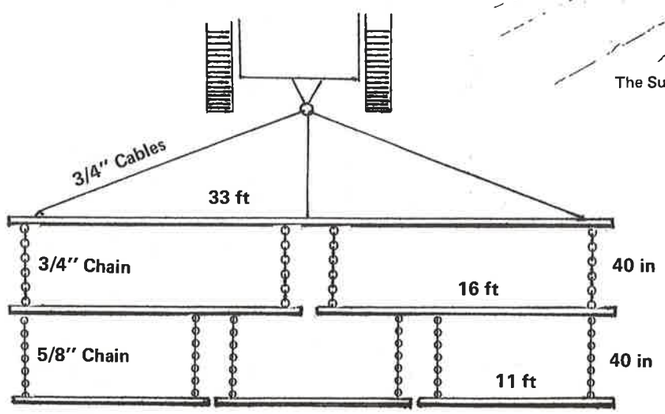
Sagebrush Rails, Project 33. The project was concerned with assessment of rails as a means of removing sagebrush cover.

Multiple rail drags and various configurations and rail weights were used in the tests. They had only limited value for brush control. Other equipment is more economical and efficient. Information may be obtained from SDEDC.

Project reviewed 1948-1949
Project accomplished by various agencies



The Supp rail.



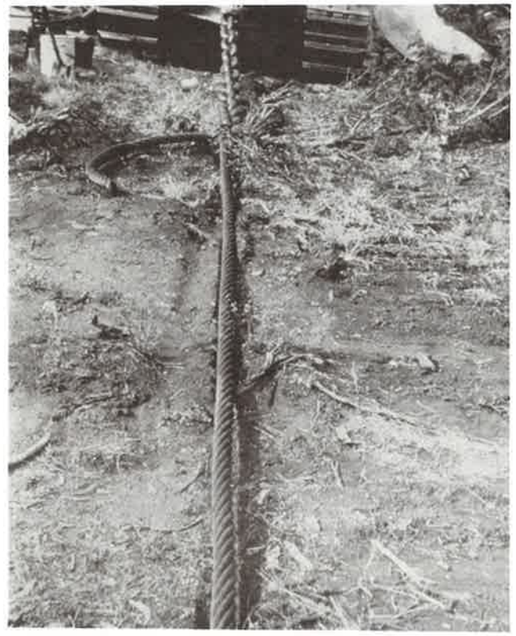
BLM rail drag.

Juniper Removal Equipment, Project 239. The objective was to survey techniques and equipment for removing pinyon-juniper, scrub oak, and mixed chaparral.

The survey included evaluating cabling and dozer pushing techniques. One and one-eighth inch to 1½-inch cables, 300 feet long, drawn by two tractors (D-7 class) did a reasonably satisfactory job with trees of medium size (8- to 10-inch diameter). Push bar and "cat claw" attachments materially increased dozer efficiency in uprooting and clearing juniper.

Grubbers may be obtained commercially or manufactured locally. They are also useful for controlling mesquite and other brush.

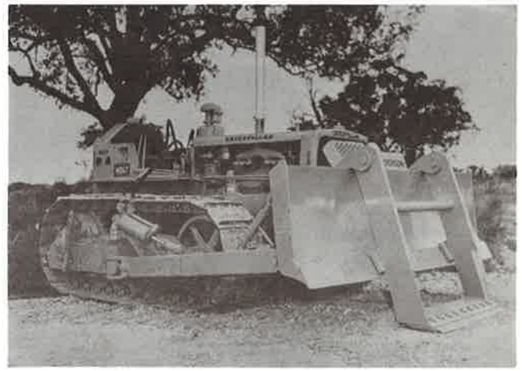
Project reviewed 1952-1953
Project accomplished by various agencies



Heavy cable used for brush control.

Push bar and dozer blade for clearing large trees.

Stumper attachment used to pry out trees.



Grubber mounted on a dozer blade.

Grubber attached to a "C" frame.

Low energy grubber for controlling mesquite.

The Ely chain.

Anchor Chains, Projects 602 and 1790. The objectives of these two projects were similar. The initial effort (Project 602) evaluated combinations of cables and light chains. Chaining in opposite directions with a single 40-pound link chain resulted in more satisfactory juniper control than did a single pass using two chains of different lengths. Renewed interest in brush chaining in 1966 followed a relatively inactive period.

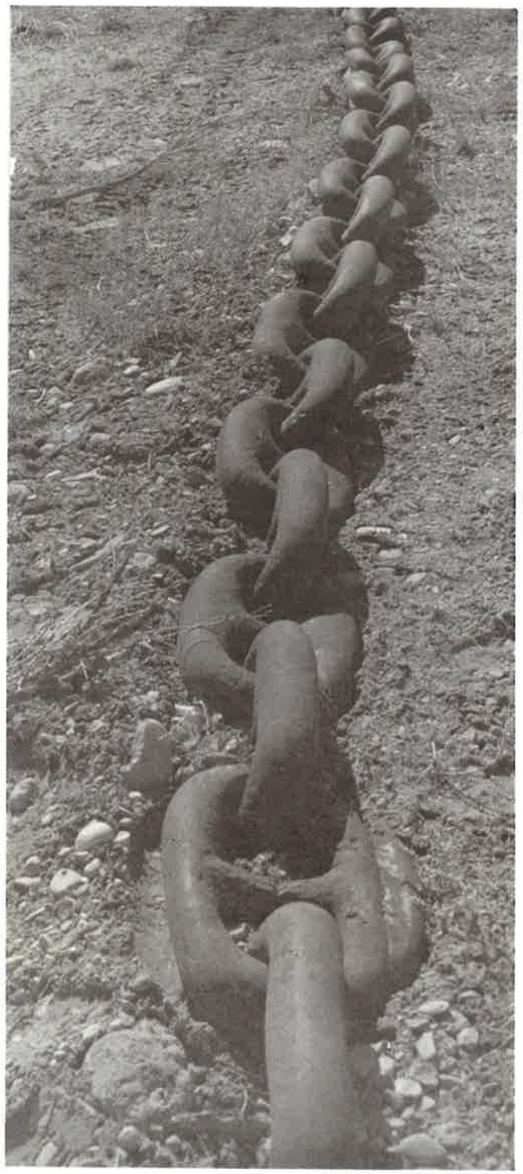
Project 1790 was a continuing effort to improve the effectiveness of chaining for controlling woody vegetation. Smooth chains were effective for seed covering and browse rejuvenation. Tests indicated that heavier chains were more effective for brush control than lighter chains, but required more power to pull. Chains weighing from 20 to 110 pounds per link are available from U.S. Navy surplus. Chains weighing over 70 pounds per link are.generally recommended.

The Ely chain developed by the BLM in Ely, Nev. and the Dixie Sager developed by the Forest Service, Dixie National Forest in Utah, are modified with steel bars or sections of railroad iron welded to the links. This increases the uprooting and scarifying action of chains as they roll over the ground. The Ely chain has an 18-inch bar or rail section welded across every link or every third link. The Dixie Sager has 8-inch sections of railroad iron welded to both sides of each link. The rails or bars are hard-surfaced to reduce wear.

Drawings of chains are available from MEDC. A handbook on chaining, *The Ely Chain*, was also prepared.

Project approved and initiated	1957
Project reviewed annually	1957-1971
Project terminated	1971
Project accomplished by Bureau of Indian Affairs, Bureau of Land Management, Soil Conservation Service, and Forest Service (Missoula and San Dimas Equipment Development Centers)	

The Dixie Sager.

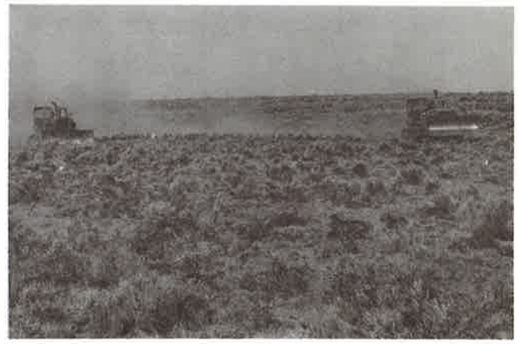


A smooth chain.

Chain Swivels, Project 1790. Chain swivels allow anchor chains to roll and chop as they are pulled along in a "U"- or "J"-shaped pattern behind two crawler tractors. Although suitable swivels are available commercially, they are expensive. More satisfactory and economical swivels have been fabricated from D-8 or D-9 Caterpillar tractor track rollers. Steel plates and supports are welded to the drum. A short length of lead chain is attached to one side of the swivel with a Navy master connecting link. The anchor chain is held in the swivel with a D-7 drawbar pin. The swivel is hardsurfaced to reduce wear and a grease fitting is inserted into the roller for lubrication.

The swivels have withstood extreme stress over large areas and under difficult conditions. Drawings are available from MEDC.

Project initiated	1966
Project terminated	1971
Project accomplished by Bureau of Land Management and the Forest Service	



Pulling the Ely chain.

Swivel made from a track roller.

Root Plow. This project consisted of testing a root plow as a means of controlling brush.

Generally, the root plow is effective in controlling most brush types except scrub oak. When properly done, root plowing will control nearly 100 percent of the brush. Fins are welded on top of the blade to force the plant roots to the soil surface where they are killed by dessication. It is difficult to keep blades sharp. Soil moisture and rocky terrain also adversely affect operation and results.

The root plow is a proven method for controlling mesquite and other sprouting shrubs. Attachments are available that pick the cut shrubs from the soil and dump them in windrows for burning or removal. This results in a finished seedbed with a single pass of the equipment.

Project approved and initiated	1960
Project reviewed	1961-1966
Project accomplished by various agencies	

Root plow.

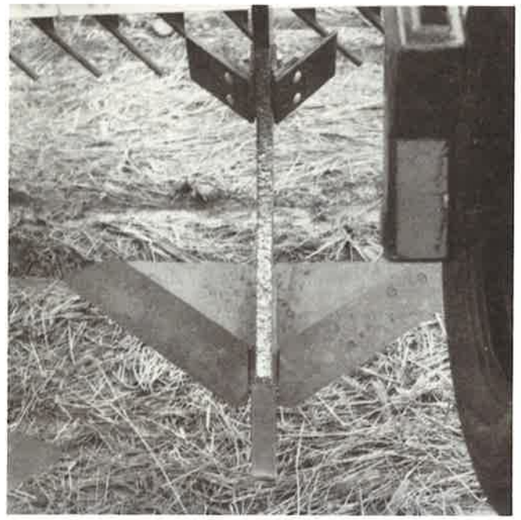
Stacko attachment for windrowing shrubs cut with a root plow.

Caterpillar Root Plane. The project was concerned with review of the Caterpillar root plane's effectiveness in controlling brushy plant cover.

The equipment consists of two V-shaped sweeps with an effective cutting width of 4 feet each. Big sagebrush and scrub oak were effectively controlled under favorable site conditions. Operation must be limited to relatively rock-free soils. Some clogging problems occurred in scrub oak stands. Less costly means are available for controlling big sagebrush.

Similar sweeps are available from some manufacturers of large subsoilers.

Project reviewed	1951
Project accomplished by the Forest Service	



Subsoiler shank with 32-inch wide sweeps.

Calkins Stubble Plow. The Calkins stubble plow was developed for treating stubble fields. Investigations were concerned with its possible use for brush control on rangelands.

The unit consists of three 25-inch, V-shaped sweeps mounted on a wheeled frame. The unit is easily towed by a small tractor. Performance is satisfactory in low density sagebrush stands of medium height. Clogging occurs with tall sagebrush and scrub oak. The unit is sturdy, but is considered primarily adapted to rock-free sites or agricultural land. Although no longer available from Calkins Manufacturing Co., stubble plows are commercially available elsewhere.

Project initiated, reviewed and terminated	1951
Project accomplished by Bureau of Land Management	

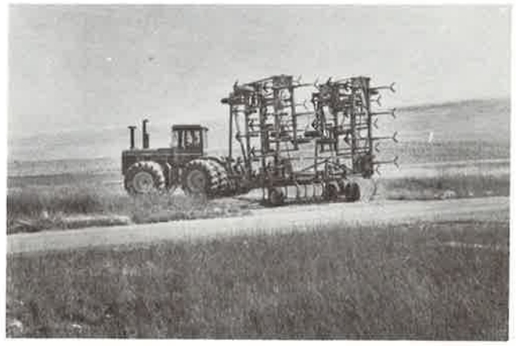
Stubble plow.

Noble Cultivator, Project 34. The project evaluated the adaptability of this unit for brush control.

The cultivator (blade) consists of a cutting sweep functioning as a root knife. The unit effectively eliminates big sagebrush and rabbitbrush on rock-free soils. The unit was manufactured by Noble Farms, Ltd., Nobleford, Canada, but it is no longer available. Chisel plows or field cultivators can be obtained with very wide sweeps or root planes.

Project approved	1950
Project initiated	1951
Project reviewed	1950-1952
Project terminated	1952
Project accomplished by the Forest Service (Intermountain Region)	

Noble cultivator.



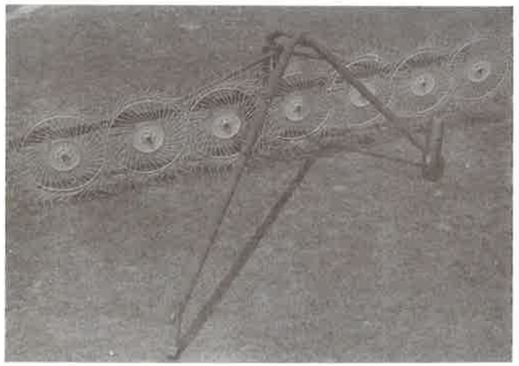
Large chisel plow with wide sweeps.

Brush Rake, Project 402. This project investigated the possible modification of commercial side delivery rakes for raking sagebrush from plowed areas.

Commercial equipment investigated was unsatisfactory. Breakage of the frame and rake teeth was the main deficiency.

Project approved and initiated	1954
Project reviewed	1954-1956
Project terminated	1956
Project accomplished by Bureau of Land Management	

Commercial side delivery rake used in the test.



Modern side delivery hay rake.

Brush Comb, Project 801. The project was concerned with investigating the performance of a brush comb for controlling sagebrush. The comb was developed before 1900, but its effectiveness was unknown.

About 80 percent of big sagebrush plants in a treated area were removed by the uprooting action of the comb. It is ineffective with small plants and seedlings. The disturbed soil resulting from combing provided a relatively good seedbed for either broadcast seeding or drilling. Residual native grasses were essentially retained. More effective methods of sagebrush control are available at lower costs.

Project approved and initiated	1959
Project reviewed	1955-1960
Project terminated	1960
Project accomplished by the Forest Service (Intermountain Region)	

Brush comb.

Flails and Rotary Cutters, Project 34. The project was an early effort to determine the suitability of commercial equipment for controlling brush. Several makes and models were tested and evaluated under rangeland conditions.

The Roto Beater, manufactured by Olsen Manufacturing Co., Boise, Idaho; a stalk shredder from the J.I. Case Co., Racine, Wis.; and a brush cutter manufactured by E.L. Caldwell and Sons, Corpus Christi, Tex. were among the flail cutters tested. Flails were developed for removing the foliage from potato or beet crops before harvesting and for mulching corn stalks. They proved only moderately effective in controlling brush. Excessive breakage and damage to the flails resulted on rocky or brushy sites. Flail mowers and stalk shredders are mainly light-duty farm implements that are not well suited for rangeland conditions. Larger, more efficient equipment has since been developed.

Rotary cutters tested under the project included a three blade model from the Budd Co., Detroit, Mich.; a cutter with four curved blades manufactured by Woods Brothers Manufacturing Co., Oregon, Ill.; and an Olsen Manufacturing Co., "Brute" Model 81 HT brush cutter. These units were well designed and had adjustable blade height. They operated satisfactorily on rock free sites. Sagebrush was removed, but quickly reseeded due to soil disturbance and lack of plant competition. Brush seedlings were unaffected. The blades were damaged on rocky or uneven sites. Several makes and models of heavy-duty rotary cutters are now available.

Project approved	1949-1950
Project initiated	1950-1951
Project reviewed	1949-1954
Project terminated	1954
Project accomplished by Bureau of Land Management, Soil Conservation Service, Agricultural Research Service (Ariz. and Calif.), and the Forest Service (Pacific Southwest Experiment Station, Southwestern, Intermountain and Pacific Southwest Regions; and the San Dimas Equipment Development Center)	

The Roto Beater.

Case stalk shredder.

Heavy duty rotary cutter.

Brush Cutter, Project 501. The project objectives were: (1) to investigate equipment capable of reducing chaparral brush cover (stem diameters approximating 4 inches) to a mulch-like condition, and (2) design and fabricate original equipment when unavailable from commercial sources. The project effort resulted in the design and fabrication of two units:

1. A unit mounted on the front of a D-7 tractor. The unit was self-powered with a Lycoming air-cooled gas engine and featured dual rotating cutting blades with cutting height adjustment using cable control. The unit was modified in 1963 for hydraulic height control.

2. A trailing unit, similar to the front-mounted unit, but equipped for towing so it could be removed from a tractor. Topography dictated tractor size. The cutters were towed with D-4, TD-9, and larger tractors.

Both units operated satisfactorily in chaparral stands with plant stem diameters less than 3 inches. Breakage and repair costs were excessive and unavoidable with this design.

Cutting the brush in front of the tractor was a desirable feature of the front-mounted unit. With the towed model, the tractor crushed brush in front of the cutter, which reduced its effectiveness. Neither unit can be used on sites with surface rock. Maximum treatment in the absence of breakdowns has not exceeded 1 acre per hour. Dust generated by these cutters may be objectionable.

Project approved	1956
Project initiated	1957
Project reviewed	1956-1967
Project incorporated with Brush Cutter Chopper Project 1222	1967
Project accomplished by Bureau of Indian Affairs and Forest Service (Pacific Southwest Region and the San Dimas Equipment Development Center)	

Towed brush cutter.

Brush Cutter-Chopper, Project 1222. The project effort involved investigating equipment for treating woody vegetation up to 6 inches in diameter.

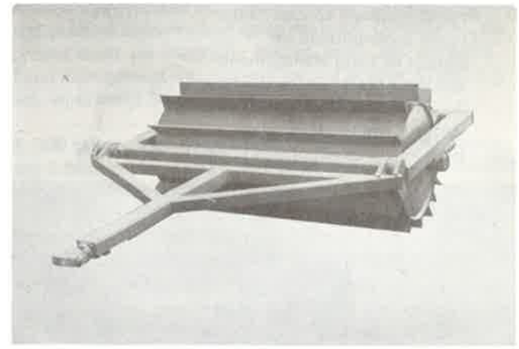
Evaluation and/or testing included: Atmore Brush Masticator, Bushwacker, hay swather, Le Tourneau Tree Crusher, Leydig Brush Shredder, Marden Brush Cutter, Northwest Motor Company's Roadside Brush Mower, and a Tree Eater manufactured by Tree Eater Corp. The equipment investigated was generally designed for specific purposes. Most equipment had limited application to the array of conditions prevailing on wildlands. The Le Tourneau Tree Crusher and Tree Eater were most efficient. Equipment improvements have increased the versatility of these and other machines, but brush cutting remains an expensive treatment. Current information may be obtained from SDEDC.

Project approved and initiated	1962
Project reviewed	1966-1968
Project completed (action phase)	1966
Project accomplished by the Forest Service (Southwestern Region and San Dimas Equipment Development Center)	

Front mounted brush cutter.

LeTourneau tree crusher.

Marden tandem brush cutter.



Towed rolling chopper.

The Tree Eater.

Large rotary shredder.

Ground Equipment for Herbicide Application, Project 232. The project was to investigate and determine the suitability of commercially available herbicide application ground equipment. Evaluation included the Bean and Buffalo Turbine sprayers, an E&E sprayer, and Broadjet and Kromer Widejet spray nozzles.

Other investigations were concerned with the possibility of using large, low pressure tires as reservoirs for the spray solution. However, tests indicated that there were many disadvantages with that method. The main disadvantage was the possibility of sudden and severe tire damage resulting in long delays and costly repairs. This phase of the project was terminated in 1965.

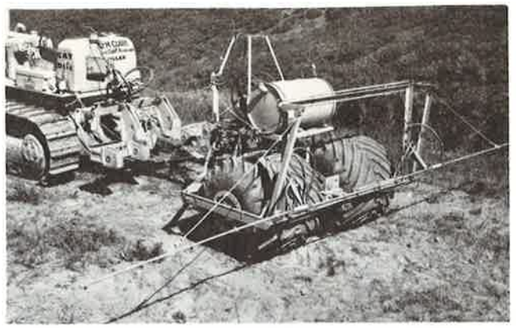
Documented results of the investigations are lacking. Other records, however, suggest that nozzle equipment was unsatisfactory under test conditions that prevailed. Similarly, application with turbine equipment resulted in poor plant coverage, especially on the leeward side. Distribution of spray material was adversely influenced by wind. Performance of the equipment could well be acceptable for situations differing from those investigated. Equipment improvements developed after the tests should be recognized. Mist sprayers and boomless spray nozzles have been used successfully for many years. However, government regulations or policy may restrict or prohibit the use of this equipment in certain locations.

Project approved and initiated	1970
Project reviewed annually since	1971
Project accomplished by	
Bureau of Land Management, and the Forest Service (Northern, Southwestern, and Intermountain Regions and the Missoula Equipment Development Center)	

Skid-mounted sprayer with a hose for spot treatments.

Buffalo Turbine mist sprayer.

Skid-mounted sprayer with a wide-jet nozzle.



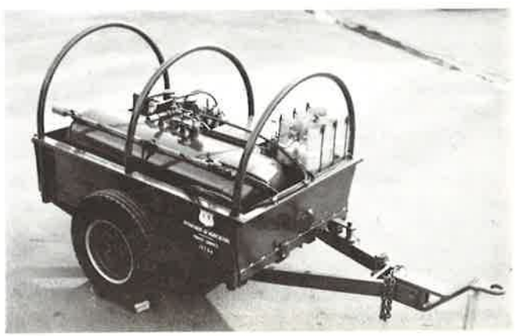
Large tires used as reservoirs for spray solution.

Flame Throwers, Project 34. In this project, portable flame throwers were investigated for backfiring and prescribed burning.

A backpack flame thrower, manufactured by the Fire Equipment Development Co., was satisfactory for fireline burning and ignition of fuels on prescribed burns. An operator can easily handle the unit. However, a faulty pressure pump and brittle asbestos wick caused problems during testing.

Performance of a trailer unit designed by SDEDC and fabricated by Western Fire Equipment was equally satisfactory. This unit consists of a 120-gallon compressed air tank and six small butane tanks. The flame can be projected about 30 feet. The unit can be pulled by a crawler tractor to most areas that a crawler tractor can reach.

Backpack flame thrower in operation.



Trailer unit for large flame thrower.

Flame throwers are commercially available from several manufacturers.

Project approved, initiated and terminated	1949
Project reviewed	1950
Project accomplished by the Forest Service (Intermountain Region and San Dimas Equipment Development Center)	

Thermal Brush Control, Project 2168. This project was established to develop a method of controlling rangeland invaders, such as sagebrush, with a minimum impact on the range ecosystem.

Tests indicated that hot air (500°F) blown at a velocity of 50 miles per hour killed sagebrush and other brush species, without combustion. A four-blower, self-propelled unit was built and tested in 1974. Since that time fuel costs have nearly quadrupled and the treatment is now impractical.

Thermal brush control equipment has ignited prescribed burns and burned out firebreaks. A two-blower trailer model has been used extensively for ignition of prescribed burns on the Uinta National Forest in Utah and to a limited extent by the Bureau of Land Management in Idaho. The equipment will be redesigned as an ignition device to reduce the safety hazard and ease transport between sites. A pump for transferring propane from one tank to another and a surge brake hitch have recently been developed.

Project approved	1971
Project reviewed	1972-1976
Project terminated	1976
Project accomplished by Bureau of Land Management and Forest Service Missoula Equipment Development Center	

Four-blower thermal brush control unit kills brush without combustion.

Ground Spray Equipment, Project 704. Chemical control of brush under wildland conditions requires sturdy equipment and positive placement of spray material. Commonly, the project areas are irregularly shaped, small, and scattered. Land management agencies and various programs need suitable equipment for brush control on such projects.

A 300 gallon, four compartment, "slip on" boom sprayer was fabricated for a cable-controlled D-7 tractor. A complete self-contained spray unit was designed. The large tractor and the spray unit performed very well on steep, rough terrain characteristic of fuel reduction and firebreak projects. However, the maneuverability and climbing capability of the tractor was limited.

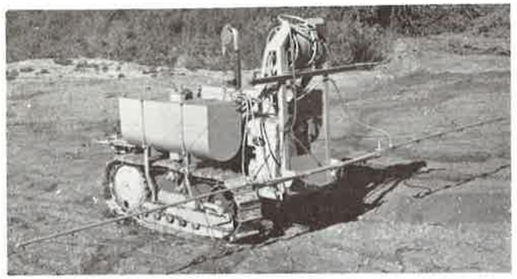
300-gallon sprayer on a D-7 tractor.

A smaller, less expensive spray unit was developed for a small T-2 crawler tractor. The unit was built for less demanding conditions than those encountered with the similar D-7 unit. Following initial field tests, the unit was redesigned and an improved unit was constructed.

The improved system features two 85-gallon tanks mounted alongside the tracks, a rear-mounted hose and reel for spot treatments, and a front-mounted boom. The units separate into four sections and can easily be installed or removed by two workers in 4 hours. The tanks are hinged to swing out for easy installation and access to the tracks.

A single-point-mounted spray boom was also developed for use on difficult terrain. The three-section boom assembly sprays a 27-foot swath. Each outer section is independently capable of moving up to 90 degrees when an obstruction, such as a tree or rock, is encountered, and is capable of returning to spraying position when the obstruction has been passed. The boom can be mounted directly on the front or rear of a tractor, on a bulldozer blade, or on the rear of a trailer sprayer. The spray boom is commercially available. Information and drawings are available from SDEDC.

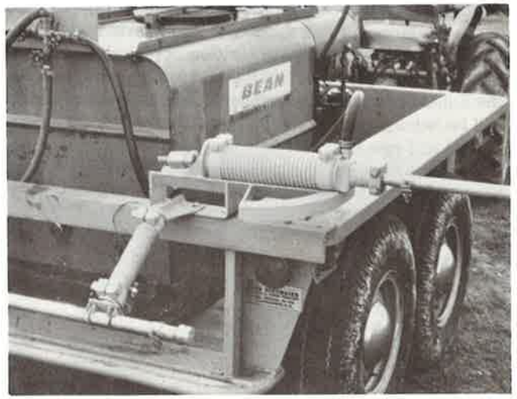
Project approved and initiated 1958
Project reviewed 1958-1973
Project terminated 1974
Project accomplished by the Forest Service (Pacific Southwest Experiment Station, Pacific Southwest Region and San Dimas Equipment Development Center)



Small spray unit on a T-2 tractor.

Single-point mounted boom sprayer on a crawler tractor.

Improved sprayer system for a small crawler tractor.



Single-point mount allows the spray boom to swing around obstacles.

Aerial Burning Equipment, Project 2627. Burning is reported to be the most economical method of brush control on rangelands. The goal of this project was to make available to rangeland managers equipment and improved techniques for safe and effective ignition of prescribed burns.

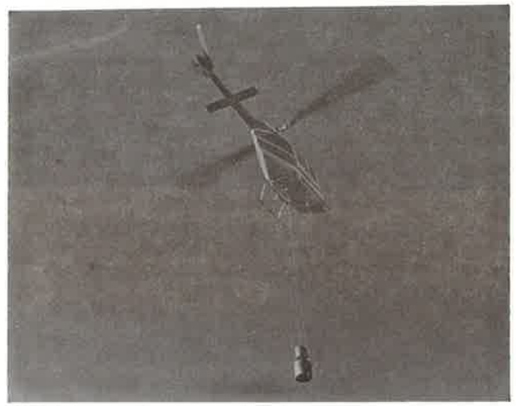
Thermite grenades used in fire management, were considered too expensive for the rangeland burning. They produce a very hot flame in a small area and are not suited to light fuel loads. A literature and market search revealed two other possibilities: ethylene glycol/potassium permanganate ($KMnO_4$) capsules and the flying drip torch. These devices were developed in Canada.

When capsules filled with $KMnO_4$ are injected with ethylene glycol (automobile antifreeze), the resulting chemical reaction produces a low-intensity flame of fairly long duration. MEDC fabricated a device to inject and distribute ping pong balls, loaded with $KMnO_4$. The device has a rotating disk and spring loaded injector needle. The capacity of the MEDC ping pong ball injector is 900 balls. When a helicopter carrying the device is flown at 45 miles per hour the incendiaries are placed about 13½ feet apart. This creates a satisfactory line of fire if the fuel loads and burning conditions are sufficient. An injector with a different design and prefabricated incendiary balls are available from Premo Plastics, Victoria, B.C., Canada.

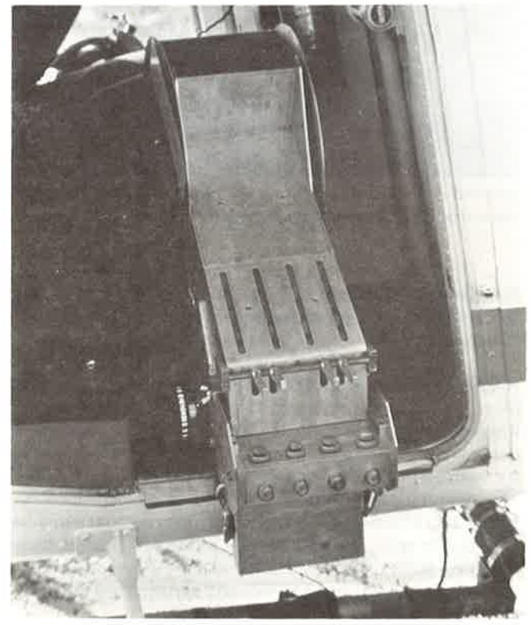
The original flying drip torch was considered too dangerous for aerial ignition because it required very low-altitude operation for the fuel to keep burning until it reached the ground. In 1979, MEDC tested an improved flying drip torch using gelled fuel. The gelled fuel carries the flame from higher altitude and sticks to the substrate while burning. Results appear very promising. The improved flying drip torch, or Helitorch, is distributed by Simplex Manufacturing Co., Portland, Oreg.

Placing thermite grenades in a dispenser.

Project approved and initiated 1975
Project reviewed annually since 1976
Project tests accomplished by the Forest Service (Northern, Pacific Southwest and Pacific Northwest Regions and the Missoula Equipment Development Center)



MEDC dispenser for ping pong balls loaded with $KMnO_4$ and injected with ethylene glycol.



Slipper block ping pong ball injector mounted in a helicopter door.

Helitorch crew preparing to exchange fuel drums.

Ground Preparation

Ground preparation equipment improves conditions for plant establishment by forming a suitable seedbed and providing more available moisture. Initial efforts were concerned with suitable tillage implements for rangeland. The development of the brushland plow during the early years of VREW represented a significant breakthrough.

VREW interests expanded over the years to include equipment for soil conservation, watershed rehabilitation, and slope stabilization. Rangeland pitters, contour furrowers, contour trenchers, and terrace building equipment have been evaluated or developed in connection with these interests.

In recent years ground preparation equipment has been adapted or designed for surface mine reclamation. Contributions from VREW members is evident in much of this work.

Brushland Plow, Project 328. The objective of this effort was to design a rugged plow, patterned after the Australian "Stump Jump Plow," for use on rangelands.

Results of this effort produced a most durable and effective plow for wildland situations. The lengthy project history involved a number of test periods of 2 or more years to determine the adequacy of the unit's components and need for improvement. The unit weighs approximately 6,000 pounds and plows a 10-foot swath. With reasonable care, it can be used effectively in extreme situations without excessive breakage or wear. Its conformation and weight present transportation difficulties. The brushland plow is available commercially. Drawings and a service and parts manual are available from SDEDC.

Brushland plow.

Project approved and initiated	1949
Project completed	1964
Project review (various modifications, updating of specifications and drawings, etc.)	Periodically during 1949-1968
Project accomplished by the Bureau of Land Management, and Forest Service (San Dimas Equipment Development Center)	

Baby Brushland Plow, Project 401. This project was concerned with the design and construction of a smaller version of the brushland plow for use on small, relatively inaccessible project areas.

A suitable model was developed for a tractor using a 3-point hitch. The unit weighs 1,200 pounds and plows a 30-inch swath. About ½ acre per hour can be plowed under moderately rocky conditions. Its use, if produced commercially, would have been limited to pilot plots, corner plowing, fireline construction, and similar projects.

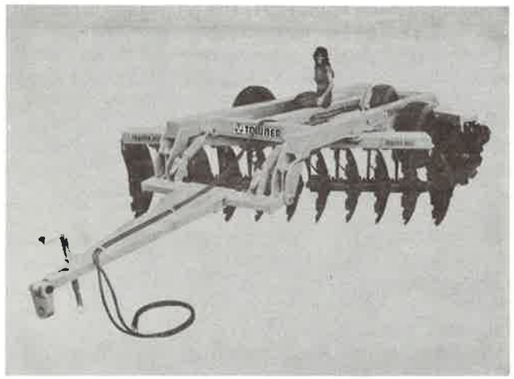
Baby brushland plow.

Project approved and initiated	1953
Project reviewed	1953-1956
Project terminated	1956
Project accomplished by the Forest Service (Southwestern Region and San Dimas Equipment Development Center)	

Towner Disc, Project 34. This project was part of a continuing effort to determine the suitability of commercially available equipment for treating rangeland brush types.

Satisfactory results were obtained in low stature medium-dense brush stands. Performance was improved with low soil-moisture conditions. The unit was relatively ineffective in dense brush stands because it tended to ride over the brush with little cutting or breaking action and was easily damaged on rocky sites. Improvements made in this equipment since these tests were completed are reported to have materially enhanced its capabilities for brush control. Information can be obtained from Towner Manufacturing Co., Santa Ana, Calif.

Project approved and initiated	1949
Project reviewed	1949, 1953, & 1955
Project terminated	1955
Project accomplished by the Forest Service (Southwestern, Intermountain, and Pacific Southwest Regions)	



Towner offset disk plow.

Amco Wheeled Offset Disk, Project 800. The objective of this project was to evaluate the performance of the Amco Disk in preparing rangeland areas for seeding.

The disk is a heavy-duty implement equipped with wheels that serve both depth control and transport. Performance on rock-free sites compared favorably with the brushland plow. Under such conditions, the harrow has further advantages of lower purchase price, easy transport between sites, and commercially available parts. The unit is produced by AMCO Products, Yazoo City, Miss. AMCO cooperated in the tests.

Project approved and initiated	1959
Project reviewed	1959-1960
Project terminated	1960
Project accomplished by Bureau of Land Management (Nevada) and Forest Service (San Dimas Equipment Development Center)	

AMCO wheeled offset disk.

Rockland Tiller, Project 34. The project was concerned with determining the implement's capability for preparing seedbed in rocky situations.

Test results indicated that the tiller, even though modified, was generally unsuitable for seedbed preparation under wildland conditions. Excessive cloggings, inadequate penetration, failure to break up grass sod, and ineffectiveness on slopes were among the problems encountered. Modern chisel plows have overcome some of these limitations, but others remain. These implements are better suited for agricultural conditions.

Project approved	1950
Project initiated	1951
Project reviewed	1950-1954
Project terminated	1954
Project accomplished by the Forest Service (Intermountain Experiment Station and Intermountain, Pacific Southwest and Pacific Northwest Regions)	

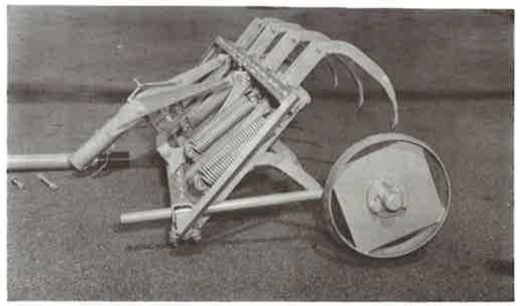
Rockland Tiller operating in scab land.

Modern chisel plow.

Dearborn Cultivator, Project 231. This effort was an evaluation of the cultivator's suitability for preparing seedbeds for rangeland conditions.

Satisfactory seedbeds were prepared under adverse conditions with this unit. It is superior to other similar equipment in rocky situations. The unit is readily disassembled for packing into remote areas and is modified to be horse drawn.

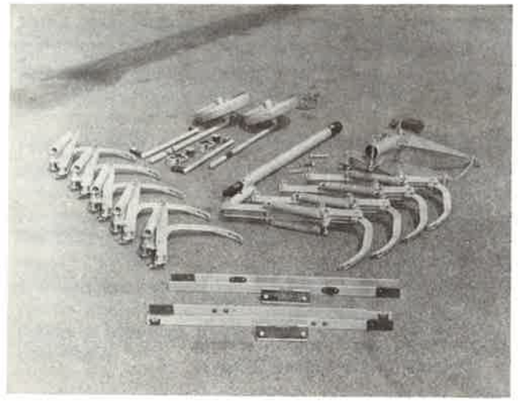
Project approved and initiated	1953
Project reviewed	1953-1955
Project terminated	1955
Project accomplished by the Forest Service (Northern and Rocky Mountain Regions and San Dimas Equipment Development Center)	



Dearborn cultivator.

Alpine Equipment, Project 231. This project was concerned with testing seedbed preparation capabilities of various types of equipment. A tractor-drawn tandem disk harrow was superior for high-mountain-park seedbed preparation in rock-free situations. A Dearborn cultivator performed satisfactorily on rocky sites with minimal parts breakage. Both types of equipment are light, can be readily dismantled and transported by packhorse, prepare satisfactory seedbeds, and can be horse-drawn.

Project initiated	1953
Project approved	1954
Project terminated	1953-1956
Project accomplished by the Forest Service (Northern and Rocky Mountain Regions and San Dimas Equipment Development Center)	

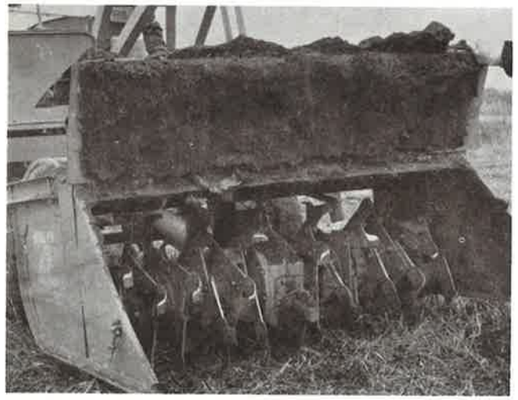


Dearborn cultivator disassembled for transport by packhorse.

Seaman Tiller, Project 34. The purpose of the project was to determine the tiller's effectiveness for chaparral brush manipulation.

The self-propelled model of the tiller tested was unsatisfactory for chaparral treatment. Redesign, using the basic operating principle, could possibly eliminate deficiencies encountered. Treatment costs by this means were considered excessive. Other heavy-duty rotary tillers are also available.

Project approved, initiated, reviewed, and terminated	1953
Project accomplished by the Forest Service (Rocky Mountain Experiment Station and Southwestern Region)	



Seaman Tiller.

Roll-Up Spike Tooth Harrow, Project 34. The project was concerned with determining the possible use of a flexible frame harrow in covering broadcast seed on logged areas.

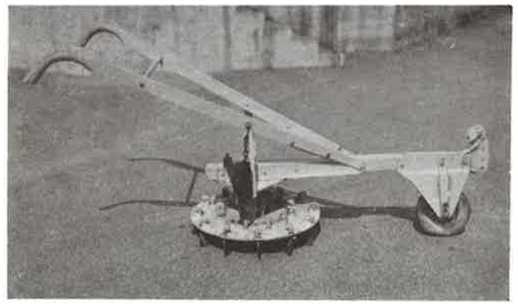
The roll-up characteristic of the harrow appeared to ease transport into remote areas. However, the presence of slash and stumps on logged areas limited the effectiveness of the harrow. The harrow was mainly adapted for smoothing the soil and covering seed on gentle terrain with few obstacles.

Project reviewed	1951
Project accomplished by the Forest Service (Pacific Northwest Region)	

Rotary Harrow, Project 34. The purpose of the project was to determine the suitability of the Lawton Roto-Harrow for preparing seedbed in relatively inaccessible situations.

Performance of the harrow, equipped with rigid teeth, was generally unsatisfactory, both for preparing seedbeds and for covering seed. Flexible cable teeth, 5/8-inch diameter and 12 inches long, materially improved its capability on rough, trashy areas. The harrow, as constructed, was not sufficiently sturdy to withstand extensive use. With improved construction, the unit would have utility in many situations that cannot be readily treated with heavier equipment. The unit was produced by Lawton Roto-Harrow Co., Vancouver, Wash.

Project approved	1950
Project initiated	1951
Project reviewed	1950-1954
Project terminated	1954
Project accomplished by the Forest Service (Southwestern and Pacific Northwest Regions and San Dimas Equipment Development Center)	

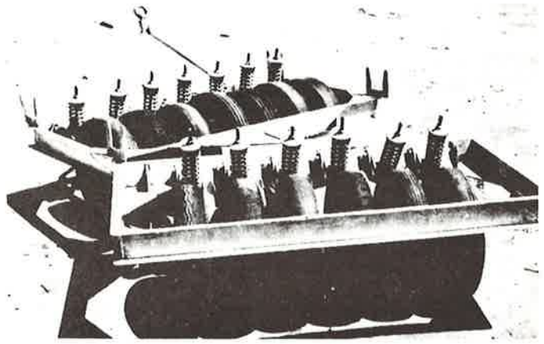


Trail maintenance rotary harrow.

Auto Tire Packer, Project 34. The initial purpose of this project was to determine the effectiveness of the auto tire packer in seedbed preparation and compaction. Subsequently, the feasibility of adapting a seeding unit to the packer framework was investigated.

Prepared seedbeds on moderately rough and rocky sites were satisfactorily compacted by the unit. Performance, at a reduced operating cost, compared favorably with other types of packing equipment. Simultaneous broadcast seeding can be accomplished by mounting an agitator seedbox on the front section of the packer. Drawings may be obtained from SDEDC.

Project initiated and completed	1954
Project reviewed	1955
Project accomplished by Bureau of Indian Affairs (Phoenix)	



Auto tire packer with independently suspended wheels.

Brush Roller, Project 1787. The project was concerned with further evaluation of a brush roller, designed by the Pacific Southwest Forest and Range Experiment Station, for various wildland treatments.

Two brush roller units, one 6 feet and the other 10 feet wide, have been used successfully under a variety of wildland situations in California. The roller essentially consists of mounting a series of rings, each 6 inches wide with a 30-inch outside diameter and 14-inch inside diameter, on a heavy pipe axle 8 inches in diameter. Additional weight can be added by filling the rollers and axle with water. Various shaped lugs or teeth can be welded on the outside circumference of each ring to scarify the soil surface. The rollers are simply designed, sturdily constructed, and require little or no maintenance. They have been used effectively on steep areas including fuelbreaks, rights-of-way, ski slopes, and watershed projects. They have also prepared seedbeds and covered broadcast seed. They are an economic and efficient means of breaking down brush skeletons on wildfire burns prior to drilling and for crushing brush for burning. These and similar units are available commercially. Information may be obtained from SDEDC.

Project approved and initiated	1965
Project reviewed	1965-1966
Roller specifications and drawing preparation deferred (in order to finance higher priority projects)	1967, 1969
Project terminated	1975
Project accomplished by the Forest Service (Pacific Southwest Experiment Station, Pacific Southwest Region and San Dimas Equipment Development Center)	

Brush roller.

Flexible auto tire cultipacker.

Calkins Rotary Subsoiler, Project 601. The purpose of the project was to determine the suitability of this implement to fracture hardpan formations and to improve moisture penetration in various compacted soil types.

Performance of the unit was most satisfactory in light to moderately heavy soils with little moisture that supported some herbaceous cover. Three wheels spaced at 3-foot intervals along an axle produce an effective swath of 9 feet. The five arms on each wheel can be adjusted to penetrate to a depth of 17 inches. Rocky situations caused wheel breakage. The unit as constructed in 1957 was not considered sufficiently sturdy to withstand normal rangeland use. Large rippers or subsoilers are generally better suited for these operations.

Project approved and initiated	1957
Project reviewed	1957-1958
Project terminated	1958
Project accomplished by Bureau of Land Management (New Mexico) and Forest Service (San Dimas Equipment Development Center)	

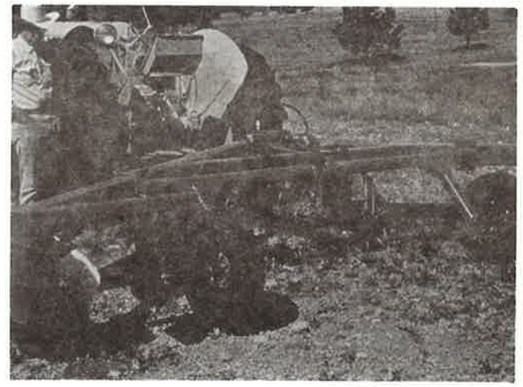
Calkins Rotary subsoiler.

Eccentric Disk, Project 34. This project was concerned with determining the suitability of an International Harvester Co. disk and a modified brushland plow for improving soil moisture relations and controlling competing vegetation on rangeland areas.

Performance of the modified brushland plow was superior for both pitting and brush control. The International disk satisfactorily controlled sparse brush, but was ineffective in medium to heavy stands. It was also less effective than the plow for pitting. Other eccentric disk implements have been manufactured for rangeland pitting.

Project approved, initiated, reviewed and completed	1949
Project accomplished by Bureau of Land Management and Forest Service	

Cut-out disks for pitting the soil.



Rangeland pitter uses two pairs of eccentric disks.

Contour Furrower, Project 1647. This project was concerned with developing an implement to install contour furrows on arid rangelands to retard surface runoff and thereby improve moisture conditions.

The Model A furrower employed subsoilers and paired disks to create three furrows 8 inches deep with a minimum width of 12 inches. Soil was cast to either side of the furrow. An adjustable automatic device installed dams in the furrow at intervals ranging from 9 to 96 feet. Tests indicated the unit could not withstand the stress encountered in heavy silt or hardpan soils.

The Model B unit was based on the same principle as the Model A, but was redesigned as a two-furrow implement and was strengthened. The damming device was improved and an attachment was added for simultaneously seeding the furrows. This unit performed satisfactorily under all but extremely rocky situations.

The Model B contour furrower is now manufactured commercially. Drawings are available from SDEDC.

Project approved and initiated	1952
Project reviewed	1953-1967
Project work deferred	1961-1964
Project terminated	1972
Project accomplished by Bureau of Land Management (Montana) and the Forest Service (San Dimas Equipment Development Center)	

Model A Contour Furrower.

Model B Contour Furrower.

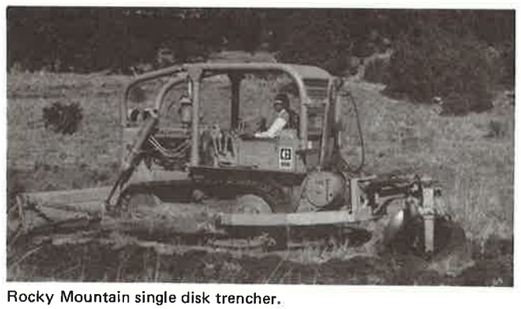
Contour Trenchers, Project 702. Land managers have need for trenchers capable of operating on steep slopes and under other adverse conditions in watershed rehabilitation programs.

The Holt disk trencher performed satisfactorily on 20 to 30 percent slopes and appeared superior to other equipment. It can be successfully used for a number of jobs like contour trenching, ditching (it casts a berm in either direction), levee construction, contour pitting (by using 3-point hitch), site preparation, and fireline construction. The Holt trencher is best suited to small tractors (size D-6 and under) because of excessive breakage with large tractors.

Other equipment investigated included a 45-inch disk trencher, a front-mounted single disk, a Rowan plow, and the Rocky Mountain disk trencher. The latter was an improved version of commercially available trenchers and was designed to alleviate former hitch problems.

Project approved	1957
Project initiated	1958
Project reviewed	1958-1962
Project terminated	1962
Project accomplished by the Forest Service (Intermountain Region and San Dimas Equipment Development Center)	

Holt double disk trencher.

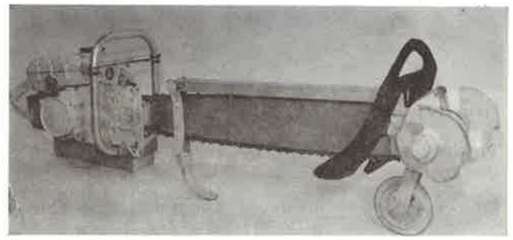


Rocky Mountain single disk trencher.

Power Saw Trencher, Project 902. This project was concerned with the development of a light, portable trenching tool based on the power saw principle.

The illustrated trenching attachment was developed for a McCulloch chain saw. Performance tests did not satisfy project requirements. Further investigation of this approach was not considered justified.

Project approved and initiated	1959
Project reviewed	1959-1960
Project terminated	1960
Project accomplished by Bureau of Land Management and the Forest Service (Pacific Northwest Region and San Dimas Equipment Development Center)	



Power saw trencher.

Hansen Sidehill Furrower, Project 34. Project 34 was an early undertaking by VREW to evaluate the adaptability of commercial equipment for controlling runoff on wildlands.

The Hansen Sidehill Furrower was a shovel-type implement manufactured by the Hansen Machine Co., Ephraim, Utah. The furrower weighed about 200 pounds and was designed to construct furrows on slopes under 60 percent. Tests indicated the furrower was widely adapted to a variety of conditions, including rocky soils and slopes up to 43 percent. Its rugged construction, light weight, simplicity of operation, and ease of transport contributed to the unit's value for horse or tractor use on small, steep, inaccessible areas.

Project approved and initiated	1951
Project reviewed	1952-1954
Project terminated	1954
Project accomplished by the Forest Service (Northern and Intermountain Regions, Rocky Mountain Experiment Station, and San Dimas Equipment Development Center)	

Portable Contour Trencher, Project 1006. This project was a continuing effort to evaluate equipment suitability for constructing contour trenches in areas with limited accessibility.

A commercial Merry Grader was modified to be operated by a two-person crew. Tests resulted in satisfactory trench construction on slopes of 60 to 70 percent. The primary use of the unit will likely be limited to critical watershed situations because of the demands on the crew when operating on steep terrain.

Project approved and initiated	1960
Project reviewed	1960-1961
Project terminated	1961
Project accomplished by the Forest Service (Pacific Northwest Region and San Dimas Equipment Development Center)	

Portable contour trencher.

Hula Dozer, Project 34. The project was mainly concerned with determining the Hula dozer's suitability for range improvement activities.

The unit was a hydraulically controlled tilt dozer equipped with four removable, evenly spaced teeth. Tilt and pitch of the dozer was controlled by the operator by two levers that actuated a hydraulic valve and pump arrangement driven from the engine. A hinged push bar was sometimes attached to the blade for tree clearing operations.

The Hula dozer was also suitable for clearing heavy brush stands and pinyon-juniper, and for moving rocks and dirt.

Although the Hula dozer is no longer available, three-way dozers (with hydraulic tilt, pitch, and angle control) are easily obtained commercially.

Project reviewed	1955-1956
Project accomplished by the Forest Service (Southwestern Region)	

Hula dozer with tilted blade.

Commercial three-way dozer.

Front-End Plow, Project 1224. In a continuing effort to develop suitable equipment for constructing contour trenchers, this project was concerned with the design and evaluation of a dozer-mounted front-end plow.

Front-end plow.

Two 24-inch plows were mounted on a Hula dozer. Plows were positioned to allow the uphill track to operate in the bottom of the completed terrace, to reduce tractor tilt on slopes. The unit was quite effective in gravelly and loose soils, but results were poor in heavy, moist soils. Good trenches resulted from long runs with gradual turns. Sharp turns resulted in a non-continuous berm and trench. Mounting the plows on the underside of the dozer resulted in a raised blade position that obstructed the operator's field of vision. This problem, however, can be corrected by using a rock or brush rake. Some difficulty was also encountered with sod accumulating on the plow. Further investigation of this equipment was not warranted.

Project approved and initiated	1965
Project reviewed	1965-1966
Project terminated	1966
Project accomplished by the Forest Service (Southwestern Region)	

Dike building equipment.

Terrace Building Equipment, Project 230. This project objective was to evaluate existing terrace or dike building equipment for possible use on rangelands in areas of low precipitation.

Investigations indicated that available equipment, primarily designed for agricultural lands, had little adaptability to wildland conditions. Equipment was expensive, difficult to transport, and required large tractors for towing. Experience indicated that "carry-all" equipment that provided some compaction was the most suitable for constructing dikes on wildlands for water spreading.

Project approved	1953
Project initiated	1954
Project reviewed	1953-1955
Project terminated	1955
Project evaluated by the Forest Service (San Dimas Equipment Development Center)	

Gouger, Project 2631. Gouging, or pitting, of rangeland or reclamation areas creates many small water-holding basins. These basins trap snowfall, intercept runoff, reduce wind erosion, and aid plant establishment and growth. This project was concerned with developing a machine to gouge basins in patterns with various dimensions.

A prototype gouger, developed at Montana State University by Dr. Richard Hodder, was tested and evaluated. Based on the evaluation, an improved gouger was designed and built by MEDC. The improved gouger featured automatic up and down motion so the operator no longer needed to constantly manipulate the hydraulic lift control while driving the tractor. Like the original, the improved gouger featured three blades and lacked a seedbox. The improved gouger performed well, but was too small for economic land reclamation.

After consulting with Dr. Hodder's staff, MEDC designed and built another modified gouger. This machine featured adjustable automatic cycling in either four-blade parallel or five-blade offset configuration.

Prototype Hodder Gouger.

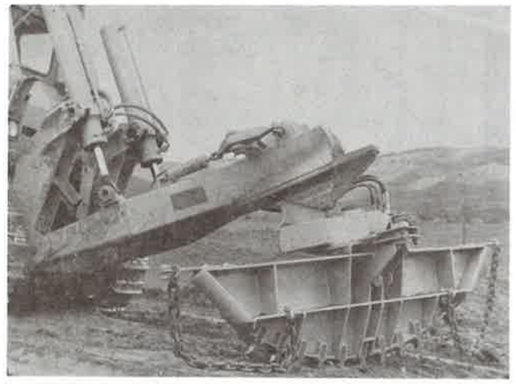
Modified gouger with automatic cycling mechanism and seedbox.

The depth and size of the depressions could be controlled from the tractor. The modified Hodder gouger also featured a Truax seedbox and drop tubes to seed a variety of species at prescribed rates. Performance was superior to other types of gouging or pitting equipment.

The project was completed with the preparation of final drawings and the publication of a project record. The gouger is now being operated by the Bureau of Land Management. Drawings and information are available from MEDC.

Project approved and initiated	1975
Project reviewed	1976, 1977
Project completed	1977
Project accomplished by Bureau of Land Management (Energy Mineral Rehabilitation Inventory and Analysis Program) Montana State University, and the Forest Service (Missoula Equipment Development Center)	

Basin Blade, Project 8041. The project goal is to develop a basin blade to excavate large depressions for stabilization and revegetation of steep slopes from 10 to 45 percent.



Basin blade forms large depression on steep slopes.

A prototype basin blade had been developed by Dr. Richard Hodder at Montana State University. This basin blade, attached to the back of a D-8 or D-9 size crawler tractor, was raised and lowered hydraulically by the operator to form basins of varying length, width, and depth. Tests indicated that it was an effective land rehabilitation tool, but the design only allowed operation in one direction along the contour. MEDC evaluated the prototype basin blade to determine what design changes were needed, then built a modified basin blade that incorporated the necessary improvements. The modified basin blade should have a much greater production rate because it can be operated in both directions. It was tested in 1979. Final drawings, specifications and reports will be prepared to complete the project. Information may be obtained from MEDC.

Project initiated and approved	1977
Project reviewed	1978, 1979
Project completed	1979
Project accomplished by Bureau of Land Management (Energy Mineral Rehabilitation Inventory and Analysis Program) Montana State University, and the Forest Service (Missoula Equipment Development Center)	

Soil Conditioner, Project 2629. The objective of this project was to evaluate, modify, or develop equipment for incorporating fiber mulch or solid wastes into the soil as a conditioner.

Strip mining destroys the structure of the topsoil by mixing the soil horizons and by severely compacting the soil with heavy equipment. The structure can be somewhat improved before seeding by incorporating amendments such as straw mulch, manure, or sewage sludge into the soil.

MEDC considered four mulching-tilling concepts for this purpose: a modified high-flotation spreader with a trailing rotovator; modified manure spreader and a rotovator, each pulled by a separate tractor; a front-mounted rotovator with a trailer mulcher; and a rotovator towed in front of a trailer mulch spreader. MEDC elected to modify a New Holland manure spreader and evaluate the system with both a Howard Rotovator and a disk harrow.

Modified manure spreader distributes straw mulch incorporated by a rotovator.

Modifications to the spreader included a cover, replacement beater rakes, and redesigned sprocket and jackshaft assemblies. The system was tested in Wyoming and Montana during 1977 using square blades of straw. The modified manure spreader distributed up to 2 tons of straw per hour, which proved satisfactory for reclamation operations. The rotovator incorporated the mulch without modification and performed better than the disk harrow.

The project was completed in 1979 with the publication of a project record detailing the test results and necessary modifications. The soil conditioner system is now being operated by the Bureau of Land Management. Information is available from MEDC.

Project approved and initiated	1975
Project reviewed	1976-1979
Project completed	1979
Project accomplished by Bureau of Land Management (Energy Mineral Rehabilitation Inventory and Analysis Program) and the Forest Service (Missoula Equipment Development Center)	

Seeding and Planting

The development of seeding and planting equipment suitable for wildland use has been the major thrust of VREW since its beginning. The rangeland drill developed in the early 1950's has been modified and improved over the years. Today, it remains one of the most successful pieces of equipment for seeding under rough rangeland conditions.

Other seeding and planting equipment includes broadcasters, interseeders, seedling planters, and transplanters. Much attention is now focused on equipment for strip-mine reclamation and revegetation of other disturbed land in harsh, arid environments. This reflects the difficulty and importance of establishing suitable diverse vegetative cover on these areas.

Broadcaster, Electric, Project 36. The project was an effort to develop a suitable electrically powered broadcast seeder that could be mounted on a pickup truck.

A suitable unit was fabricated for use in seeding some road fills and similar areas. Maximum distance of broadcasting seed was limited to about 15 feet. The source of power was the truck battery. The unit was operated by remote control from the cab. Unavailability of suitable electric motors resulted in project termination.

Earlier investigations in 1951 and 1952 under this project were concerned with gasoline-powered and traction-operated seeders. Both were deficient in some regard, so the effort was discontinued. However, a wide variety of improved broadcasters are now manufactured.

Project approved and initiated	1951
Project reviewed intermittently	1948-1957
Project terminated	1955
Project accomplished by the Forest Service (Northern and Intermountain Regions and San Dimas Equipment Development Center)	

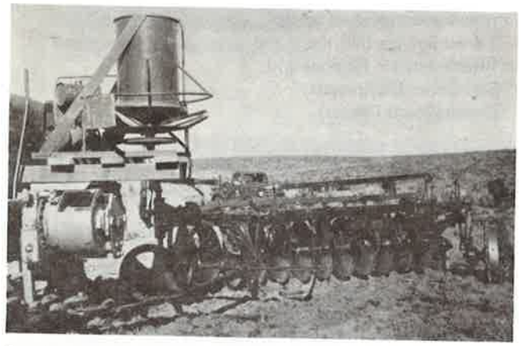
Truck-mounted electric broadcaster.

Modern electric broadcaster.

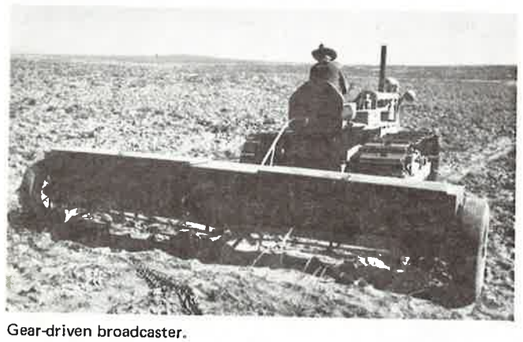
Broadcast Seeder, Project 901. This effort was concerned with investigating and evaluating available broadcasting equipment for seeding rangelands. Various types of broadcasters were evaluated including those with engine exhaust, separate gasoline engines, and gear drive dispersal mechanisms. Several of the gear-driven broadcasters performed satisfactorily, but other types did not meet project performance criteria.

A variety of broadcast seeders are now available. They have proved useful for broadcasting different sizes and shapes of seed on disturbed areas. Most modern broadcasters are driven by power take-off from a wheeled tractor.

Project approved	1961
Project reviewed	1960-1963
Project terminated	1963
Project accomplished by Bureau of Land Management	



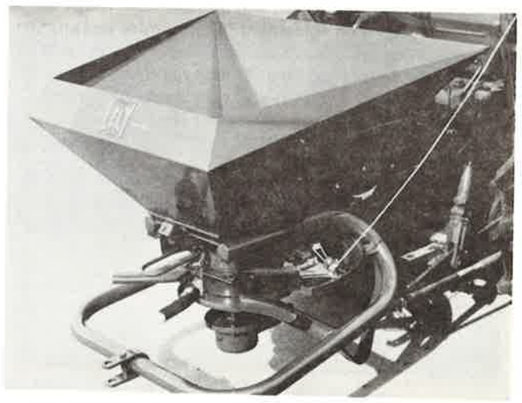
Broadcaster powered by a small gasoline engine.



Gear-driven broadcaster.

Modern wheel-driven broadcaster.

Crawler tractor-mounted broadcaster spreads seeds with compressed air.



Tractor-mounted broadcaster driven by power-take-off.

Tuttle Seeder, Project 34. The project was an early effort to determine the suitability of the Tuttle seeder for rangeland seeding.

The unit, manufactured by T.G. Tuttle and Sons, Portales, N.Mex., consisted of a seedbox 12 feet long mounted on the rear of a wheel tractor or on separate running gear. Field tests resulted in spotty, uneven seed distribution on rangelands. Proper calibration of the seeding rate was difficult and agitation of the seeds proved inadequate. Tests were discontinued after the first year. Improved seed boxes and metering mechanisms specially designed for trashy seed have since been developed by private industry.

Project initiated, reviewed, and terminated	1950
Project accomplished by the Forest Service (Southwestern Region)	

Brillion grass seeder distributes seed between two cultipackers.

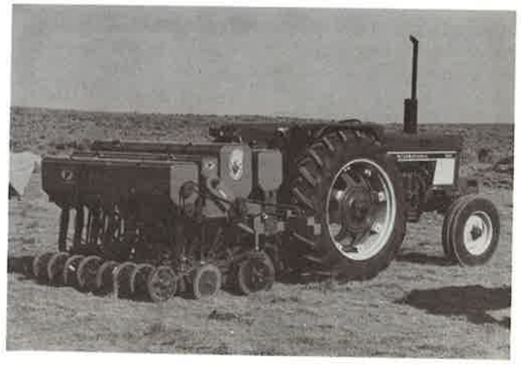
John Deere Grassland Drill, Project 34. The project was concerned with evaluating the grassland drill's performance under rangeland conditions.

Performance was acceptable on rock-free soils. Maintenance and other operational problems were common when operating in brushy and rocky situations. Grassland or pasture drills were designed to operate in sod or stubble without prior ground preparation but may not be suitable for more severe rangeland conditions. Pasture drills are available from several manufacturers.

Project initiated, reviewed, and terminated	1955
Project accomplished by the Forest Service	

John Deere end wheel drills.

John Deere Powr-till seeders.



Tye "Multiseeder" pasture drill.

Rangeland Drill, Project 35. The purpose of this project was to develop a drill specially designed and structurally suited for conditions encountered on rangelands.

The forerunner of the rangeland drill was constructed by the Fremont National Forest in 1950 with a commercial grainbox, and reinforced frame, large wheels, and special disk arms. The disks were designed to be mounted and suspended independently. This enabled each arm to ride over rocks or other objects without affecting the operation of the other arms. SDEDC, then at Arcadia, Calif., investigated the drill and in 1952 designed and fabricated a drill along the lines of the Fremont unit. Further modifications and refinements have since increased efficiency and versatility.

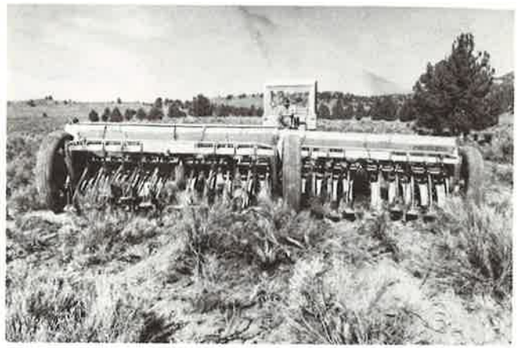
The 1952 version of the drill is basically unchanged and considered the standard. Its adaptability and efficacy were recognized early on. However, various users with particular needs proposed a number of additions or modifications over the years. Consideration of these proposals extended the project effort and resulted in several optional items. Additional options have been developed by a commercial manufacturer. Available options now include: a small grass-legume seed attachment, a fertilizer attachment, brush guard assembly, steel wheels, planting depth rings, a land measurer, adjustable-angle deep-furrowing arms with removable weights, a heavy-duty clevis-type swivel hitch, a hydraulic lift assembly for the arms, a double shaft agitator for trashy seed, and a picker wheel feed mechanism for fluffy or trashy seed. Drawings and specifications have also been developed for a half-size version of the standard model. Innovative users have modified components of the drill, such as the seed metering mechanism, to suit certain conditions or plant a variety of browse and tree species with good results.

The drill has operated under a wide range of conditions with satisfactory results. It has been suitably modified for deep furrow drilling in unprepared seedbeds. Usual operation discretion and maintenance must, of course, be observed when operating in adverse situations.

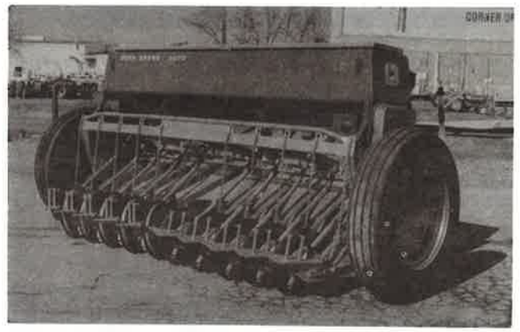
The rangeland drill is VREW's most successful project. It has been used for many years in the Western U.S. and in several foreign countries. It is now receiving considerable use for strip-mine reclamation as well as range improvement. Drawings, information, and service and parts manuals are available from SDEDC. An operations handbook for the rangeland drill has been prepared by the Bureau of Land Management.

Project initiated	1951
Project reviewed annually since	1951
Project terminated	1976
Project accomplished by Bureau of Land Management and the Forest Service, (San Dimas Equipment Development Center)	

Early Model B Rangeland Drill.



Later Model PD Rangeland drills.



Modern rangeland drill with a John Deere seedbox.

Deep Furrow Drill, Project 703. The purpose of this effort was to determine the practicability of using the rangeland drill for installing furrows for enhancing seedling establishment in areas of low precipitation, without additional seedbed preparation.

Results indicated that deep furrow drilling can be successfully accomplished with minor modification of the rangeland drill. A deeper and wider furrow is produced by removing depth bands and additional weighting of disks. Weights are placed on vertical shafts located above the disks. Soil condition determines the amount of weight needed. Pipe drags firm the soil over the seed for improved germination and seedling establishment. Advantages of this method for specific situations include: (1) elimination of competition in a band 3 to 4 inches along each furrow, (2) retention of desirable residual native species, (3) increased retention of surface water flow, and (4) elimination of seedbed preparation costs.

Between 1970 and 1973 adjustable-angle, deep-furrowing arms were developed under the rangeland drill project. The adjustable disk angle enables the width of the scalp to be easily controlled. These modifications are useful for interseeding under a variety of conditions. Drawings are available from SDEDC.

Project approved and initiated	1958
Project reviewed	1959-1960
Project completed	1960
Project accomplished by Bureau of Indian Affairs, Bureau of Land Management, Agricultural Research Service and Forest Service (San Dimas Equipment Development Center)	

Fully equipped modern rangeland drill with deep furrowing attachments.

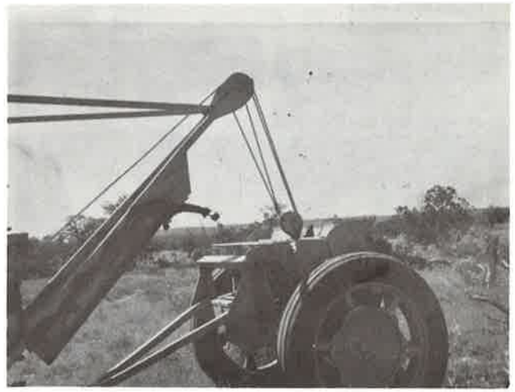
Rangeland drill with adjustable-angle deep-furrowing disk arms.

Tractor-Mounted Drill, Project 1567. The object of this undertaking was to develop a means of clearing woody material and drilling seed in one operation.

The effort consisted of mounting a half-size rangeland drill on a crawler tractor. The unit was designed specifically for a cable control dozer (because of its availability) equipped with a safety cab to allow rear mounting of the drill lift mechanism. A D-6 or larger tractor may be required.

Simultaneous juniper pushing and grass seeding were satisfactorily accomplished in about the same time as just pushing by an experienced operator. The present hookup is operational and considered quite satisfactory. However, redesign for tractors with hydraulic controls may be desirable since cable control units are no longer readily available.

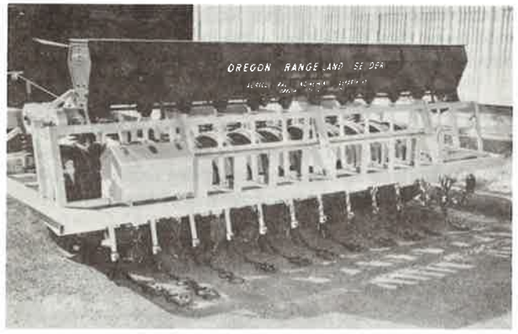
Project approved and initiated	1963
Project reviewed	1964-1966
Project completed	1966
Project accomplished by the Forest Service (Southwestern Region)	



Half-sized rangeland drill mounted on a crawler tractor.

Oregon Rangeland Seeder, Project 1009 and 1101. The project's concern was with performance of the rangeland seeder under variable conditions, with emphasis on dry and loose soils.

The unit was designed and fabricated by the Agricultural Engineering Department, Oregon State University. It was primarily intended for seeding in loose, unprepared seedbeds. The unit weighs approximately 5,000 pounds. The press drum simultaneously firms the seedbed and creates furrows in which seed is deposited. Drag chains cover the seed. Field trials resulted in some design changes and modifications.



Oregon Rangeland Seeder.

About 50 units of the Oregon Rangeland Seeder were produced by a commercial company. However, this company is no longer in business and remaining units are receiving only limited use.

Project approved and initiated	1960
Project reviewed	1960-1963
Project terminated	1963
Project accomplished by Bureau of Land Management, Agricultural Research Service, and the Forest Service (San Dimas Equipment Development Center)	

Interseeder, Project 1566. This effort was concerned with determining the suitability of existing equipment for interseeding to improve composition of cover vegetation without prior seedbed preparation.

SCS Interseeder.

Tests were conducted with the Hansen Browse seeder, rangeland drill, and a range seeder developed by the Soil Conservation Service. It was determined that the browse seeder was the most suitable for the range of conditions encountered. Results from various units continue to be reviewed.

Project approved and initiated	1964
Project reviewed	1964-1966
Project consolidated with Project 502	1968
Project accomplished by Soil Conservation Service and the Forest Service	

Browse Seeder, Project 502. The purpose of the project was the development of an appropriate means of seeding browse, forbs, and grasses for wildlife habitat improvement.

A satisfactory seeder was developed in cooperation with the Walter Hansen Machine Company. The unit was designed for use with 3-point hitch farm tractors. A drawbar for crawler tractors was developed by the Bureau of Land Management, to allow mounting two or more units. Herbaceous competition is removed by a scalper. A metering device accommodates browse, forb, grass, and tree seed of most sizes and/or mixtures. The seeder is capable of operating under a wide variety of conditions including very rocky sites. The seeder has been effective for both interseeding and controlling erosion.

Drawings are available from SDEDC.

Project approved and initiated	1956
Project reviewed annually	1956-1974
Project completed	1968
Project terminated	1974
Project accomplished by the Forest Service (Intermountain and Pacific Southwest Regions, Intermountain Experiment Station, and San Dimas Equipment Development Center), California Department of Fish and Game, Idaho Fish and Game Department, and Utah Division of Wildlife Resources	

Hanson Browse Seeder.

Seed Dribbler, Project 1786. Improved germination and seedling establishment occurred in crawler tractor tracks in many seeding projects as the result of firming soil over the seed. This prompted the investigation of a tractor attachment for dispensing browse, forb, and grass seed that is often in limited supply and costly.

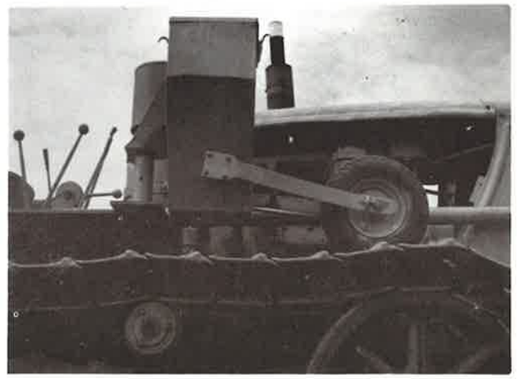
Two units were fabricated by the Hansen Machine Company for mounting on the deck of any crawler tractor. A direct drive from a rubber-tired wheel operates the seed metering mechanism. Seeds drop onto the track pad at a point over the front idler. As the tractor moves forward, the seed falls to the soil surface and is embedded by the tracks.

The units can be mounted on both sides of a tractor or used singly, as is common in pinyon-juniper manipulation. The unit is adaptable to various sizes of seed. However, it will not accommodate a mixture of variable sizes without wasting the smallest seeds. Capacity of the seed hopper base on common seeding rates is sufficient for 1 to 1½ hours of operation.

Seed dribblers are manufactured commercially. Information may be obtained from SDEDC.

Project initiated	1965
Project approved	1966
Project completed	1969
Project accomplished by the Forest Service (San Dimas Equipment Development Center)	

Seed dribbler mounted above a crawler-tractor track.

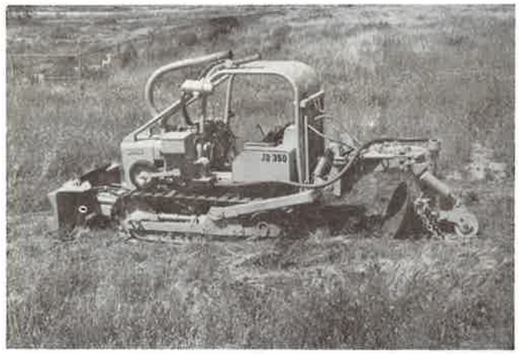


Thimble-seeder seed dribbler meters seed with a spoke-and-thimble mechanism.

Interseeder for Rocky and Brushy Areas, Project 2532. A survey of range improvement equipment needs indicated that an interseeder capable of operating in rocky and brushy areas should be developed. Accordingly, this project involved the design, assembly, and demonstration of an interseeder for rocky and brushy land.

The interseeder has five components: a John Deere 350 crawler tractor with a three-way dozer; an implement-carrying hitch; a disk trencher or fire plow to remove plant competition; a thimble seeder driven by the crawler track; and a pneumatic seed transfer system consisting of a turbocharger, a Venturi tube connected to the seed dribbler, and a cyclone separator mounted on the working implement. The working implement creates scalps about 8 to 10 inches deep and from 16 inches (Rocky Mountain single-disk trencher) to 40 inches (fire plow) wide. The thimble seeder meters the seed and the pneumatic transfer system delivers it into the prepared scalp. A chain drag covers the seed with a small amount of soil. The interseeder for rocky and brushy areas is being operated in Utah where a few minor design problems are being solved before final review.

Project approved and initiated	1975
Project reviewed since	1976 and continuing
Project accomplished by the Forest Service (San Dimas Equipment Development Center) and Utah Division of Wildlife Resources	



Interseeder for rocky and brushy areas.

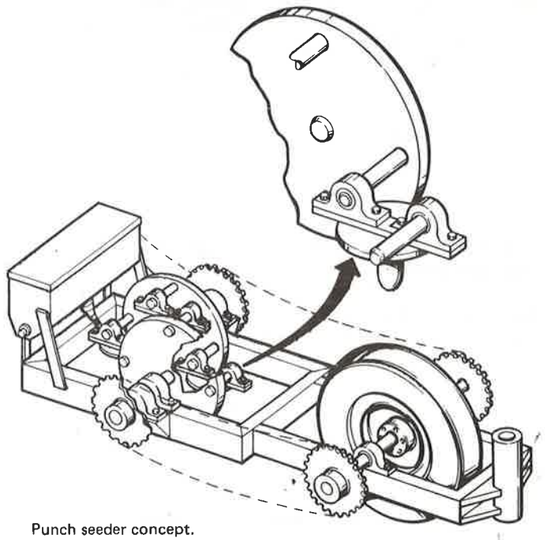
Punch Seeder, Project 2625. The objective of this project is to develop a suitable mechanical punch seeder for desert land.

Desirable grasses can be planted in fragile desert soils with minimum disturbance by placing the seed in small, cone-shaped holes. The holes provide a suitable microclimate for plant establishment without creating deep furrows.

SDEDC used a hand dibble to find how much force was necessary to create holes in typical soils. The criteria for a punch seeder were also determined: (1) minimum 12-inch spacing between holes and rows (single row prototype acceptable); (2) punch holes 3 inches deep with 3-inch diameters tapering to 1½ inches above the rounded bottoms; (3) firm the soil around the top of the holes; (4) place 3 to 8 grass seeds in the punched holes; and (5) seed at speeds greater than 1 mile per hour behind a wheeled tractor.

Two concepts, a large roller and a pneumatic dibble, lacked features desirable in a punch seeder. A third design, however, adapted from an intermittent transplanter that had been developed by the University of Idaho, appeared more feasible.

The principle involves offset parallel arms with a dibble mounted on the connecting links. The dibbles remain perpendicular to the ground while the arms rotate. The arms are powered with a single drive wheel. Seed can be placed during or after the formation of the holes.



Punch seeder concept.

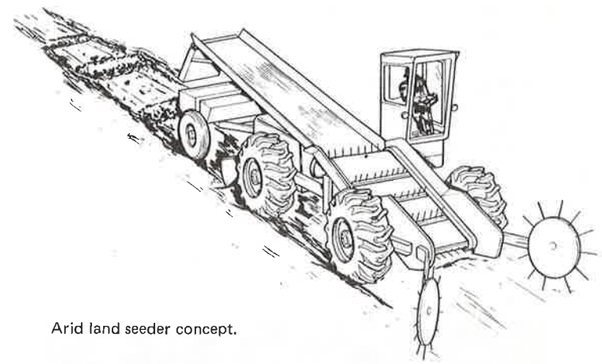
A prototype punch seeder will be constructed and tested when sufficient funds become available. Information may be obtained from SDEDC.

Project approved and initiated	1975
Project reviewed since	1976 and continuing
Project funding deferred	1978-1981
Project work accomplished by Agricultural Research Service, the Forest Service (San Dimas Equipment Development Center), and the University of Idaho	

Arid Land Seeder, Project 2360. Undesirable shrubs such as creosotebush, tarbush, mesquite, and chaparral now dominate much of the arid Southwest. Although these species can be controlled by various means, equipment capable of successfully seeding desirable grasses in dry, desert areas has not been developed. This project was initiated to develop seeding equipment that will also create a more favorable microclimate for seed germination and plant growth in arid regions.

Research has shown that plant establishment may be improved by planting seeds in water-holding basins and covering them with brush. The basins intercept runoff and direct moisture to the seed, while the brush cover reduces evaporation and ameliorates extreme temperatures. From prototype equipment constructed in 1965, SDEDC produced three design concepts for large-scale seeding equipment. These included: equipment towed behind a rootplow, a towed seeder separate from the rootplow, and a separate, self-propelled seeder. In each case, a rootplow would control the existing brush. The seeder would then pick up the the brush, dig a basin, pack the soil, plant the seed, and deposit the brush over the seed. After considerable discussion and evaluation the work group decided upon a self-propelled, rubber-tired, arid land seeder. Development is now deferred pending necessary funds.

Project funded	1974-1976
Project reviewed since	1975 and continuing
Project funding deferred	1977-1981
Project design accomplished by the Agricultural Research Service, the Forest Service (San Dimas Equipment Development Center), and the New Mexico State University	



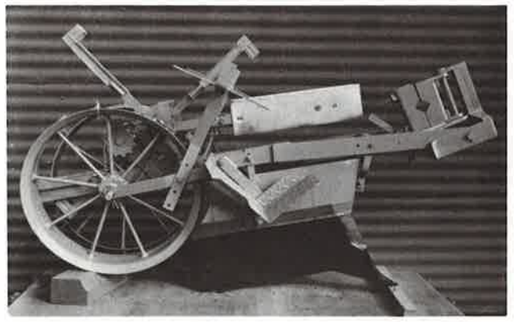
Arid land seeder concept.

Prototype arid land seeder.

Beach Grass Planter, Project 503. The purpose of the project was to investigate the adequacy of available equipment, with modification as needed, for effective restoration of vegetation on sand dunes and blowout areas.

Initial testing was with a conventional Holland planter and one that had been modified to improve the planting shoe and to include a self-feed mechanism. Performance of the modified unit, although superior to the conventional planter, was not completely satisfactory. Further tests involved a commercial transplanter, the Powell 42. Operating characteristics of this unit are similar to those of the Holland, with the added advantage of mechanical placement of grass clones in the planting arm. Unit modification included the installation of a rigid coulter ahead of the planting shoe, and improvement of flotation and packing wheels. The illustrated modified Powell planter resulted in a most satisfactory planting unit. Several other planting machines may be adapted for grass or brush seedlings.

Project approved and initiated	1955
Project reviewed	1956-1960
Project terminated	1960
Project accomplished by Bureau of Land Management, Soil Conservation Service, and Forest Service (Northern and Pacific Northwest Regions and San Dimas Equipment Development Center)	



Beach grass planter.

Steep Slope Revegetation Equipment, Project 2683. Equipment was needed to effectively and economically establish vegetation on steep (100 percent), unstable slopes that result from road construction or mining operations. The three broad aims of this project were to: evaluate and classify prime movers suitable for slope revegetation; develop and test a steep slope seeder; and develop a containerized or bareroot planter capable of steep slope operation.

A study of possible prime movers revealed only a few telescoping boom hydraulic cranes that could accurately guide equipment over steep, irregular slopes. The seeding and planting equipment was designed for use with these cranes.

A steep slope seeder was developed with two broadcast seeders mounted between two rows of scarifier tynes. The front row loosened the soil and created small furrows for the seed and fertilizer. The rear tynes can also be reversed for additional loosening and scarification of hard packed soils. A set of independently suspended packer wheels provided additional firming action.

The steep slope planter was designed for containerized stock to increase the chances for successful revegetation. The planter features a revolving carousel for the containerized stock; a hydraulic auger to drill holes for the transplants; and a packing spade to firm the soil around the transplants. The entire planting cycle is automatic; the operator merely positions the device and flips a switch. After the hydraulic auger drills the hole, the carousel rotates to position the transplant. The transplant is forced through a telescoping tube into the hole with a jet of water. The tube is retracted and the packing spade firms the soil, completing the cycle. The finished machine will feature two complete, independent planting units for a total capacity of 46 seedlings (23 in each carousel).

Steep slope seeder attached to a telescoping boom crane.

Steep slope planter for containerized seedlings.

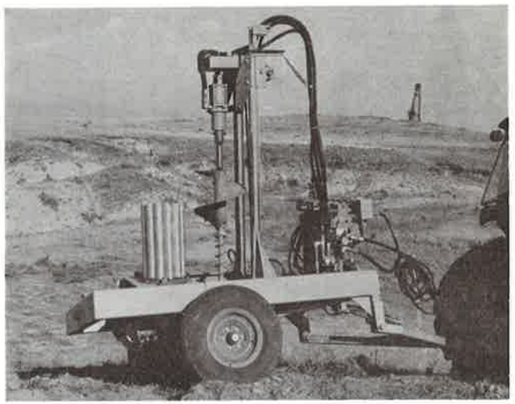
Preliminary test results of the steep slope equipment appear promising. SDEDC plans more field tests and the development of hitches to adapt the equipment to other prime movers. Preparation of drawings, specifications and test reports will complete the project.

Project approved and initiated	1975
Project reviewed annually since	1976 and continuing
Project accomplished by the Forest Service (Intermountain Experiment Station, Southwestern and Pacific Northwest Regions, and San Dimas Equipment Development Center)	

Dryland Tubeling Planter, Project 8042. The goal of this project is to develop an automated planting machine for the large containerized stock needed to successfully revegetate sites with harsh growing conditions.

With improved techniques and better facilities for growing containerized seedlings, the planting of containerized stock has increased dramatically. A variety of container-grown trees and shrubs are now available for disturbed land reclamation and habitat improvement projects. Larger containerized seedlings (from 40 to 80 cubic inches) have been planted successfully by hand on many disturbed areas. Native Plants, Inc. of Salt Lake City has supplied seedlings for project tests.

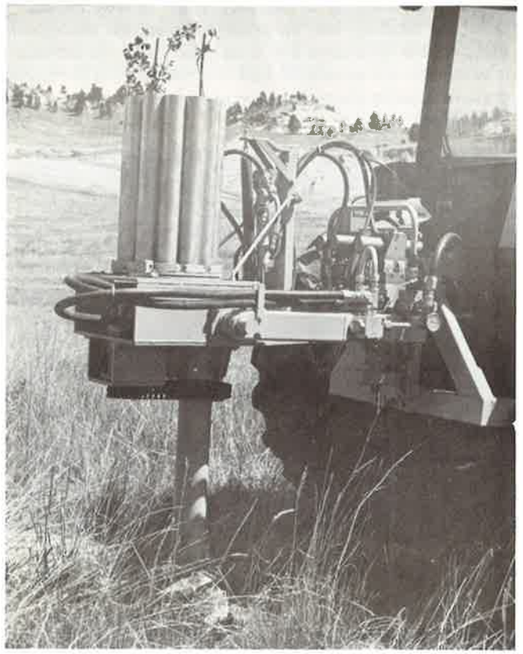
After determining the state-of-the-art and evaluating design criteria, MEDC built a prototype dryland tubeling planter. The machine is mounted on a trailer equipped with hydraulic leveling devices. It features a hydraulic auger with a scarifier to prepare the planting site, a rotating carousel which contains 24 seedlings, a sliding carriage mechanism to drop the containerized seedlings into the prepared holes, and two shovels that pack the soil around the transplants. The entire procedure is automatic and controlled from the tractor. The prototype dryland tubeling planter was tested on mine reclamation sites in Montana.



Prototype dryland tubeling planter mounted on a trailer.

Initial tests indicated problems with seedling placement and loose soil around the roots. The tubeling planter was redesigned with a hollow, reversible auger placed directly beneath the carousel. The unit mounts on a three-point hitch. The auger drills a hole as the unit is lowered. The carousel is then rotated and a seedling drops into the hole through the hollow auger. The auger is reversed and soil is packed around the seedling roots as the auger is withdrawn. The modified tubeling planter underwent further tests in 1981.

Project approved and initiated	1977
Project reviewed	1978-1981
Project work accomplished by Forest Service (Missoula Equipment Development Center) and Bureau of Land Management (Energy Mineral Rehabilitation Inventory and Analysis Program)	



Dryland tubeling planter with a hollow auger, mounted on a three-point hitch.

Transplanter, Project 2630. This project was concerned with developing equipment and techniques for transplanting trees or shrubs onto reclamation sites from nearby areas. Larger trees and shrubs (up to 4 inches in diameter) are more apt to survive than nursery stock in harsh, disturbed areas or on poor, undeveloped soils.

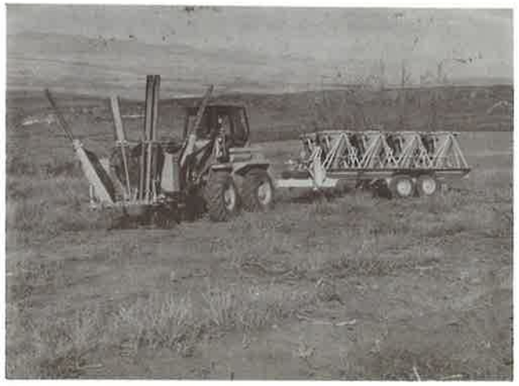
The project began with a demonstration and evaluation of a Vermeer TS-44A trailer-mounted tree spade. The tree spade functioned well and achieved greater transplant survival than other methods. However, the tree spade was uneconomical because too much time was spent transporting individual trees from one place to another. The trailer-mounted tree spade also had limited maneuverability and could not negotiate steep slopes.

To solve these problems, MEDC designed and built a trailer to haul eight transplants at a time and mounted the tree spade on an articulated front-end loader. The front-end loader allowed the transplant to be placed directly into the trailer and improved access to the transplant stock. The trailer was towed between the reclamation area and the transplant supply areas with the front-end loader/tree spade. This system reduced costs materially, making the tree spade more practical for disturbed land reclamation.

The transplant system has been turned over to the Bureau of Land Management for incorporation into their reclamation program. Drawings and specifications are available from MEDC.

Project initiated	1975
Project reviewed	1976-1978
Project completed	1978
Project accomplished by Bureau of Land Management (Energy Mineral Rehabilitation Inventory and Analysis Program) and Forest Service (Missoula Equipment Development Center) in cooperation with several mining companies	

Tree spade mounted on a front-end loader.



Towing the transport trailer with the front-end loader tree spade.

Dryland Sodder, Project 8046. The purpose of this project is to develop equipment capable of stripping up to 18 inches of topsoil and sod from mine sites and replacing it, intact, on critical reclamation areas. By moving the soil and vegetation intact, the structure of the surface soil is preserved. This helps insure revegetation of critical areas such as draws and gullies that are highly susceptible to erosion.

The problems of moving large slabs of native soil were identified and several design concepts were reviewed. The main problem involved loading and unloading the soil slabs, because the sparse vegetation cannot hold the thick layers of soil together. The concepts comprised two tilt trailers, a double-belt level trailer, a large cylinder sodder, and a modified front-end loader bucket. The modified loader bucket was selected for further development because of its high probability of success and reasonable cost. A prototype dryland sodder was constructed and tested in 1979. During the tests the plastic bucket lining buckled and the high back on the bucket obstructed operator visibility. A modified bucket with a spray coating and lower back solved these problems. Drawings and specifications are available at MEDC.

Project approved and initiated	1977
Project reviewed	1978, 1979
Project completed	1980
Project design accomplished by Forest Service (Missoula Equipment Development Center), Bureau of Land Management (Energy Mineral Rehabilitation Inventory and Analysis Program), and Montana State University	

Sprigger for Native Shrubs, Project 9120. Rhizomatous shrubs can be established on reclamation areas by planting root sprigs. The shrubs will spread naturally to adjacent sites within a few years. This project is concerned with developing a sprigger for harvesting sprigs to be planted on critical reclamation sites.

A commercial potato harvester was modified for use as a sprigger. The unit consists of an undercutting blade and a pair of wide inclined conveyors. The shrubs are mowed in a separate operation and the sprigger cuts their roots well below the surface. The shrub pads and soil are lifted onto the conveyor where the soil is shaken loose and falls back to the ground. The sprigs are carried to the top of the conveyors and gathered.

The unit was tested at Colstrip, Mont., but did not perform satisfactorily in the heavy, clay soil. Further design work is necessary before an adequate sprigger can be built.

Project approved and initiated	1978
Project reviewed	1979-1981
Project work accomplished by Forest Service (Missoula Equipment Development Center), Bureau of Land Management (Energy Mineral Rehabilitation Inventory and Analysis Program), and Montana State University	

Dryland sodder placing stripped sod and vegetation on a reclamation site.

Sprigger harvesting sprigs to be planted on reclamation sites.

Miscellaneous

Although not directly related to land rehabilitation, supportive or related equipment contribute to the safety and efficiency of land treatments. Mulchers conserve moisture and aid plant establishment. Fencing equipment speeds fence construction to control livestock distribution. Installation of plastic irrigation pipe is simplified by special equipment. The development of effective seed collectors should result in more plentiful and less expensive supplies of locally adapted seed. Transport equipment is necessary to move equipment quickly and easily to job sites. Improved hitches increase production and improve mobility. Other miscellaneous equipment has been developed to make land rehabilitation safe, more effective, or less costly.

Fitchburg Chipper. Results obtained with the Fitchburg Chipper were reviewed as a matter of interest and possible application of wood chips for mulch.

Douglas-fir and ponderosa pine logging slash and lodgepole pine poles and slash were used in the tests. The unit's performance was most satisfactory with materials less than 5 inches in diameter.

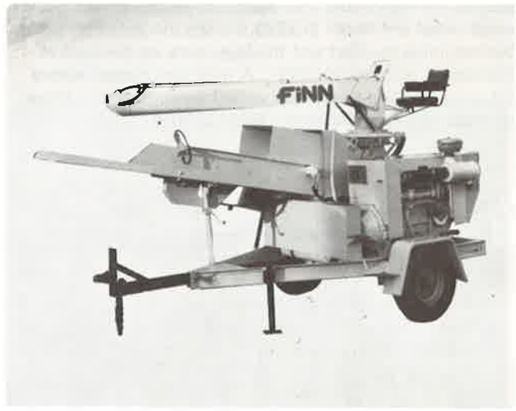
Project initiated	1952
Project reviewed	1953
Project accomplished by	
Forest Service (Pacific Northwest Region)	

Commercial chip harvester.

Mechanical Mulcher, Project 1102. The project investigated commercially available mulching equipment for use in road cut-and-fill stabilization treatments.

Several types of mulching equipment were considered. Suitable commercial mulching equipment is currently available for such stabilization projects. Simultaneously dispensing mulch, seed, fertilizer, and emulsion material is possible with certain makes of equipment. The equipment has proved useful for strip mine reclamation.

Project approved and initiated	1961
Project reviewed	1961-1962
Project accomplished by	
Forest Service (San Dimas Equipment Development Center)	



Power mulcher spreads straw mulch over an area.

Hydro mulcher applies seed, wood fiber mulch, fertilizer, or soil amendments mixed in a slurry.

Post Drivers, Project 504. This effort was to evaluate fence post drivers suitable for attachment on small tractors.

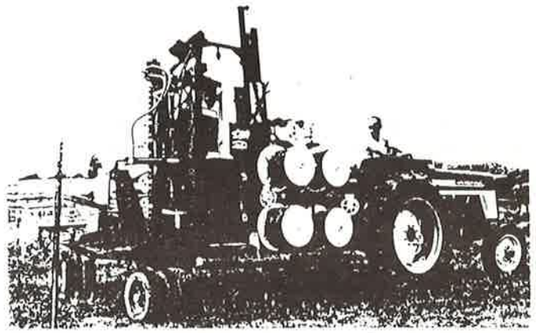
Investigation disclosed a number of satisfactory, commercially available drivers. The drivers can be mounted on the tractor or towed.

Project approved and initiated	1955
Project reviewed	1955-1966
Project terminated	1966
Project accomplished by	
Forest Service (San Dimas Equipment Development Center)	

Post driver mounted on a three-point hitch.

Fence-Building Machine, Project 1221. The project was to determine the suitability and efficiency of commercially available fencing equipment for variable rangeland conditions.

The Fury Fencer was tested under a variety of conditions. A crawler tractor was superior to wheel tractors on slopes. Efficiency of the unit was materially increased by using steel instead of wood posts. The unit has limited adaptability to variable topographic situations of most rangelands. Its most economic use is restricted to relatively gentle terrain. The Fury Fencer is manufactured by Somerset Welding and Steel Corp., Somerset, Penn.



Fury Fencer.

Project approved and initiated	1962
Project reviewed annually through	1966
Project terminated	1966
Project accomplished by	
Forest Service (Intermountain and Pacific Northwest Regions and San Dimas Equipment Development Center)	

Protection for Revegetated Areas, Project 2279. The goal of this project was to find an esthetically acceptable method to replace conventional barbed wire fencing to control livestock movement on ranges.

A problem analysis and survey of available methods and materials were conducted. These included fabric fences, repellent chemicals, noise barriers, and visual barriers. No effective economical alternative to barbed wire was found in this limited effort.

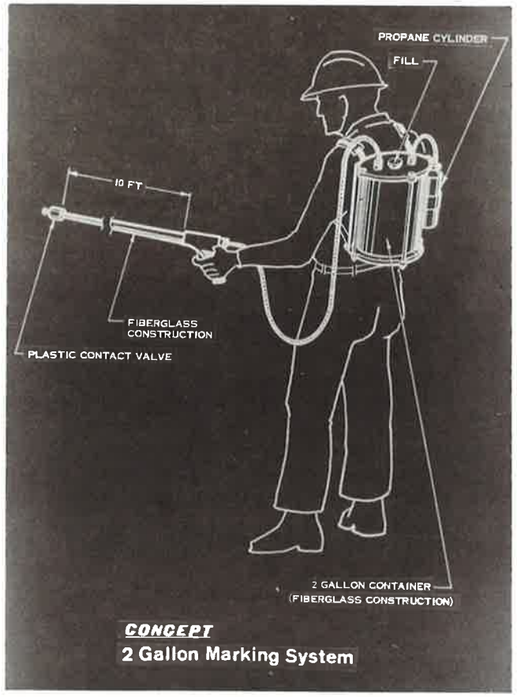
Project approved and initiated	1971
Project reviewed and terminated	1972
Project accomplished by	
Forest Service (Missoula Equipment Development Center)	

Temporary electric fence made from Glo-Gard visible ribbon.

Develop a System of Cattle Marking, Project 1940. This project was to develop an alternative to marking cattle with hydrogen peroxide and Nyanzol-D dye, because injuries had occurred to Forest Service personnel when hydrogen peroxide under pressure caused metal spray tanks to rupture.

The Chemistry Department at Montana State University tried to find alternative marking compounds with no success. As an alternative, a market search has been made and a fiberglass spray tank has been located that is suitable for use with hydrogen peroxide.

Project approved and initiated	1968
Project reviewed	1969-1973
Project terminated	1974
Project accomplished by	
Forest Service (Missoula Equipment Development Center) and Montana State University	



Concept for a cattle marking system using a fiberglass backpack tank.

Browse Seed Collector, Project 1010. The objective of this project is to develop an economic and effective mechanical means of collecting seed of native plants, with emphasis on shrub species.

A market search revealed the unsuitability of available commercial equipment to wildland conditions. The vacuum principle of collection was then selected as the most promising for a wider variety of seed. Other methods considered were headcutter, flail or reel, and pole-shaker. Equipment shortcomings, such as inadequate airflow, seed damage, and separation from other plant debris, have been resolved in prototype IV. Excellent results have been obtained with birch-leaf mahogany, fourwing saltbrush, and various other lightseeded species.

A commercial, portable, vacuum, insect collector was field evaluated as a browse seed collector. Results of the field testing were encouraging and it is planned to design a backpack specifically for collecting seed.

Project approved and initiated	1959
Project reviewed annually since	1959
Project funding deferred	1974-1981
Project accomplished by	
Bureau of Land Management and Forest Service (Intermountain Experiment Station; Southwestern, Intermountain and Pacific Southwest Regions; and San Dimas Equipment Development Center) with participation from California and Oregon Departments of Fish and Game, Colorado Division of Wildlife, and Utah Division of Wildlife Resources	

Browse seed collector in operation.

Plastic Pipe Layers, Project 1223. The effort was concerned with determining possible modifications to available equipment for laying plastic pipe.

The following types of equipment were investigated: (1) modified Le Tourneau ripper that carried the pipe, constructed the trench, laid the pipe, and closed the trench in one operation; (2) a truck-mounted reel that fed pipe into a previously formed road-grader trench; and (3) pipe reel and feeding attachments mounted on a Caterpillar model 12 motor grader, a Jayhawk S&S soil-saver-ripper, and to the rear wheel of a farm tractor. The motor grader unit was easily constructed and the least costly. Topography and rocky soils limited its performance. Pipe installation costs were materially reduced with the Le Tourneau unit, which operated satisfactorily in relatively rocky soils and steep terrain. Initial costs and power requirements exceeded those for the grader-mounted unit. A project record and drawings of the modified Le Tourneau ripper are available at SDEDC.

Towed ripper modified for laying plastic pipe.

Reel for laying plastic pipe can be mounted in a truck.

Project approved	1962
Project initiated	1963
Project reviewed	1962-1966
Project completed	1965
Project accomplished by	
Bureau of Land Management and Forest Service (San Dimas Equipment Development Center)	

Plastic pipe laying equipment attached to a motor grader.

Plastic Pipe Fusion Equipment, Project 8018. This project evaluated equipment and methods for joining sections of plastic pipe.

Polyethylene plastic pipe is often installed on rangelands to distribute water. The sections are usually joined with insert couplings and hose clamps. However, the hose clamps are difficult to feed through pipe-laying machinery and subject to failure if they rust or work loose. MEDC investigated alternative methods for joining polyethylene pipe, including adhesives, socket fusion, and butt welding.

A market search revealed two sources of heat fusion equipment and several adhesives. Representative products were obtained for testing purposes. Sections of polyethylene pipe were joined by each method and tested for tensile strength and cold water burst pressure.

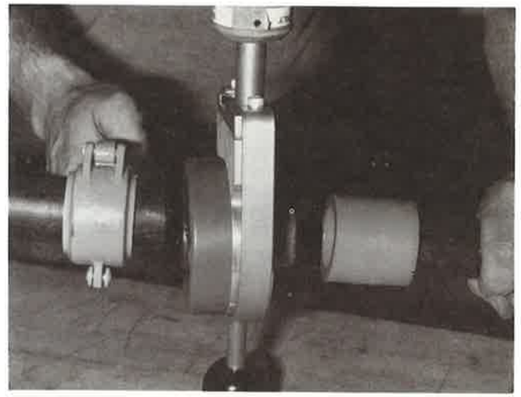
Test results showed that butt welded pipe, fused at temperatures between 450 and 500 degrees Fahrenheit, produced a stronger, more trouble-free joint than clamps and inserts. The socket fusion method did not work consistently because dimensional tolerances of the plastic pipe used in the tests often resulted in an improper fit.

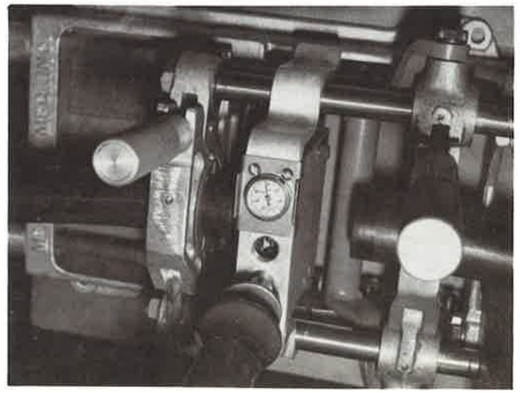
Adhesives were found to be unsatisfactory for joining polyethylene pipe, although they proved adequate for joining more expensive polyvinyl chloride pipe.

A project record was prepared to complete the project. Butt welding equipment is available from: McElroy Manufacturing, Inc., Tulsa, Okla. or P & S Engineering, Ridge Tool Co., Bartlesville, Okla.

Project approved and initiated	1977
Project completed and reviewed	1978
Project accomplished by	
Forest Service (Missoula Equipment Development Center)	

Cable plow may be adapted for laying plastic pipe.


Socket fusion device for joining plastic pipe.


Butt-welding equipment melts the ends of the pipe before they are joined together.

Lightweight Seed Collectors, Project 2623. This project is to develop a lightweight portable or backpack seed collector to gather browse and forage seeds. A lightweight collector would enable the operator to collect seeds from local stands of native plants that are adapted to the environment of a particular area.

Initial attempts were aimed at developing backpack seed collectors. When the performance specifications were drawn up, SDEDC issued two contracts, with McTighe Enterprises of Dana Point, Calif., and Developmental Sciences, Inc., from City of Industry, Calif., to construct prototypes.

Backpack seed collector.

The McTighe Enterprises machine had a bag-type seed collector, and the Developmental Sciences unit featured a cyclone separator. Both of these backpack units had gasoline engines and required two people for effective operation.

These machines were successful in that they demonstrated the feasibility of the backpack concept. However, both required considerable work before a production model could be developed. SDEDC is also working with an air broom manufacturer to develop a suitable backpack seed collector from a portable air broom.

Recent efforts include a collector mounted on a small cart and a series of collectors connected to a large industrial air compressor. These concepts appear promising despite their mobility limitations. SDEDC has been working with the University of California at Davis to develop other design alternatives.

Further tests and additional refinements are needed to perfect lightweight portable or backpack seed collectors. SDEDC plans to continue the development effort and pursue the concepts most likely to succeed.

Project initiated	1975
Project reviewed	1976 and continuing
Project work accomplished by	
Forest Service (San Dimas Equipment Development Center)	


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


Seed collector connected to a large air compressor.

High Production Grass Seed Collector, Project 2632. Seed collected from local stands, or particular ecotypes, has enhanced successful revegetation because the seeds are adapted to the climate and soils of the region. However, large quantities of locally adapted seed needed for direct seeding or nursery programs have not been available. The objective of this project was to locate or develop equipment to collect large amounts of locally adapted grass or forb seed.

Two types of grass seed collecting equipment were considered—combines and strippers. Desirable features of the combines or strippers were then identified: high production capability, reasonable cost, high maneuverability, optimum width (6 to 8 feet), and adequate power (self-propelled or pull type).

An extensive market and literature search revealed a great deal of information, but few machines were readily available that could meet the criteria. A report was published listing sources of new small combines, manufacturers of grass seed strippers, organizations using or developing seed collection equipment, and references to grass seed collection. This project was discontinued after publishing the report because suitable high production grass seed collection equipment, although expensive, was available.

Researchers and manufacturers have since improved grass seed strippers and small combines. Both types of equipment are commercially available from Kincaid Equipment Manufacturing Co., Haven, Kans., or may be custom or specially ordered from several other manufacturers.

Project approved and initiated	1975
Project reviewed and terminated	1976
Project accomplished by	
Forest Service (San Dimas Equipment Development Center)	

Reel type grass seed stripper mounted on a jeep.

Kincaid small plot combine.

Commercial sidehill combine.

Kincaid grass seed stripper.

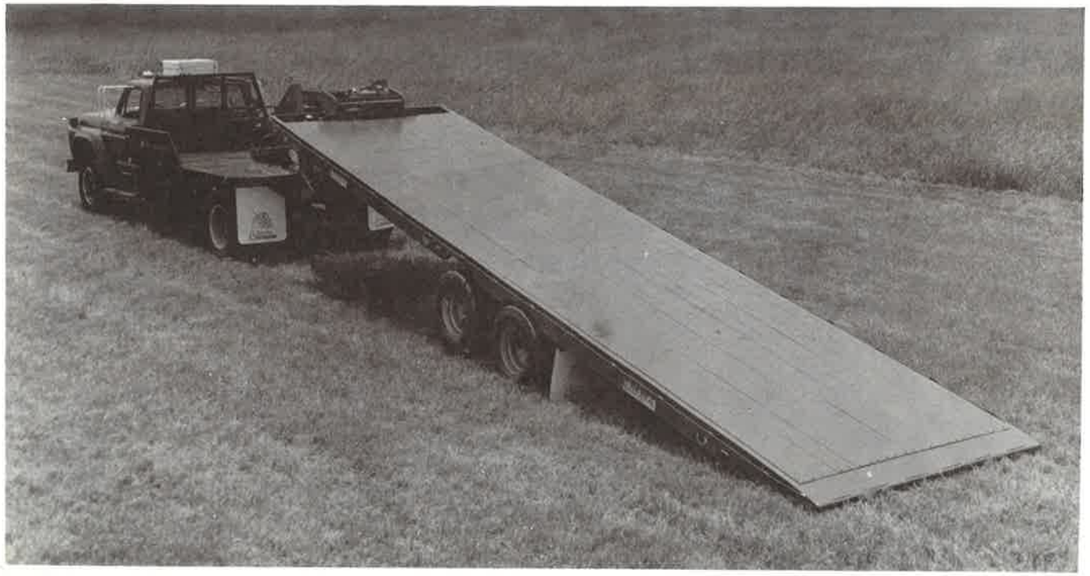
Tilt Bed Trucks, Project 34. Truck and trailer beds have been constructed or modified to facilitate transport of heavy equipment. A common feature uses a hinged bed and a hydraulic or mechanical means of tilting.

A stakeside truck was satisfactorily modified incorporating the tilt feature for transporting small tractors. Tilt bed trucks and trailers have since been substantially improved to enable easy loading and transport of most tractors and equipment. Many models are available.

Project approved	1953
Project reviewed	1953-1954
Project initiated and completed	1954
Project accomplished by	
Forest Service (Southwestern Region)	

Tiltbed truck made from a modified stakeside truck.

Modern tiltbed, rollback truck.



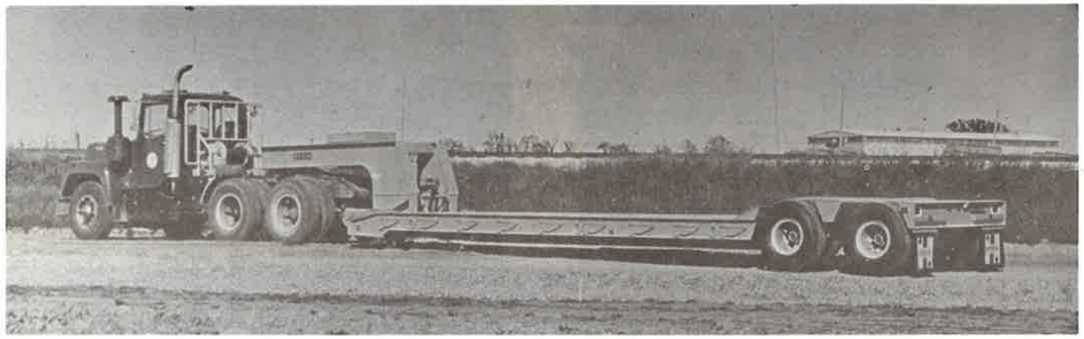
Tiltbed trailer.

Equipment Transport, Project 802. The project was concerned with the investigation of commercially-available means of transporting equipment efficiently and safely.

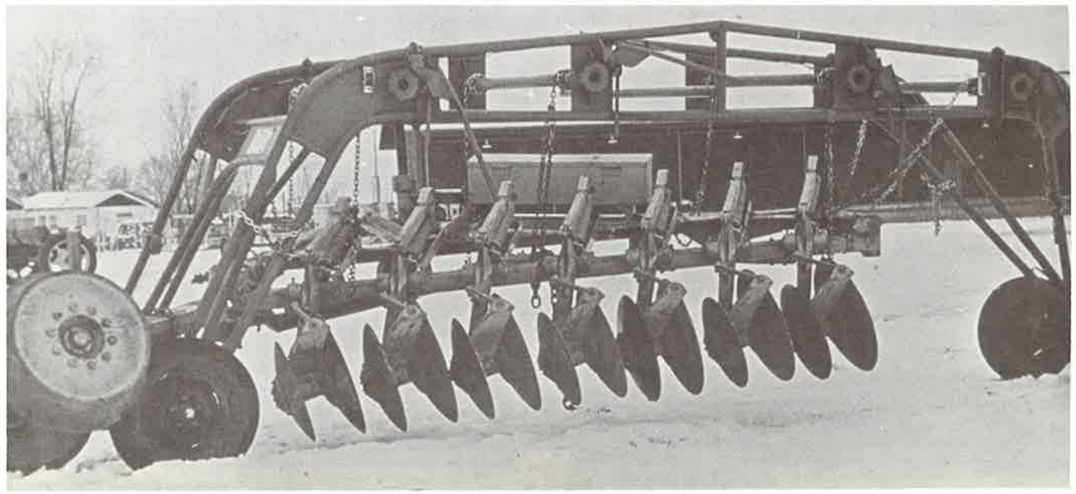
Various types of equipment including low bed trailers, flat bed trailers, and straddle-type implement carriers were used by field units of the Bureau of Land Management and the Forest Service. Investigation of improved means of transporting equipment continues to improve job efficiency and safety.

Project approved and initiated	1959
Project reviewed	1959-1968
Project accomplished by	
Bureau of Land Management and Forest Service (Pacific Southwest Region and San Dimas Equipment Development Center)	

Rangeland drill carrier.



Typical low-bed trailer.



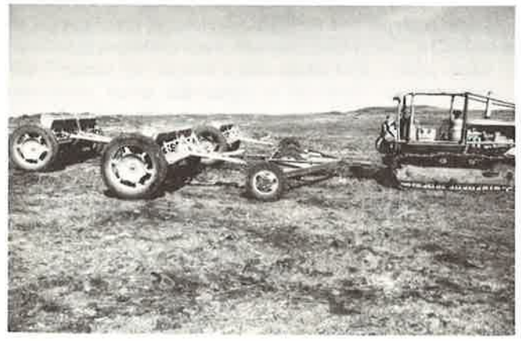
Brushland plow carrier.

Hitch Development, Project 701. The project was concerned with evaluating existing hitches and designing new hitches to allow use of various types of equipment for range improvement projects.

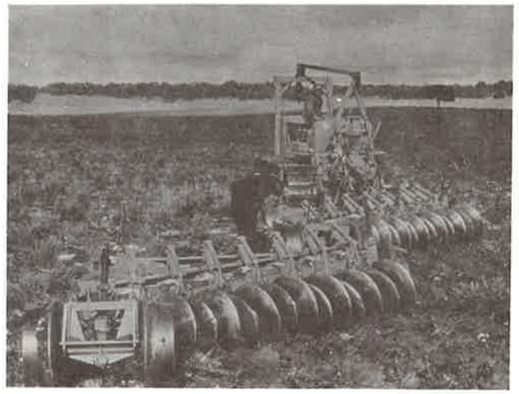
Various hitches for different purposes were evaluated. Multiple hitches for use with drills and plows were developed to reduce project costs. Hitches for trenching equipment were also developed or modified to allow trench installation. Results with the improved hitches have materially increased job efficiency at a reduced cost.

Project approved and initiated	1957
Project reviewed	1957-1963
Project completed	1963
Project accomplished by	
Bureau of Indian Affairs, Bureau of Land Management, and Forest Service (San Dimas Equipment Development Center)	

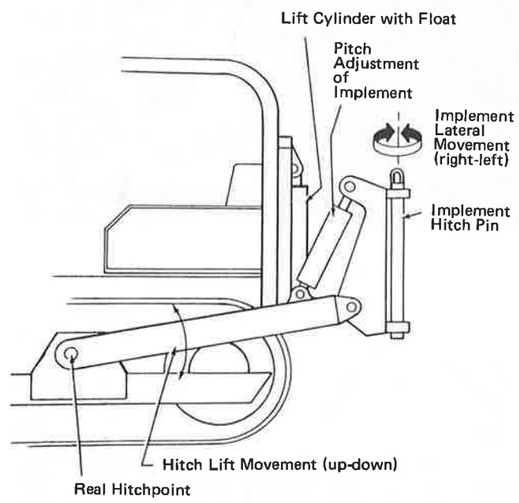
Two-drill hitch.



Three-drill cart and hitch.



Two brushland plows connected in tandem.

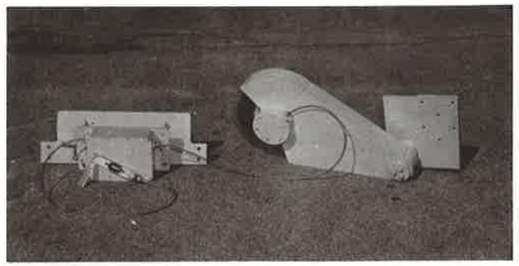


Implement-carrying hitch.

Precision Grade Indicator, Project 324. The project was concerned with fabricating and testing a leveling device to help tractor operators follow slope contours more precisely.

A leveling device was developed in cooperation with a manufacturer. The unit was mounted on a D-7 tractor for field testing. An acceptable degree of accuracy for contour work was not realized. Error percentage was small, ranging from ½ to 1 percent, but was cumulative in the direction of travel. A convergence or divergence of subsequent furrows resulted. SDEDC is keeping abreast of developments in this general area.

Project approved and initiated	1954
Project reviewed	1954-1957
Project completed	1957
Project accomplished by	
Bureau of Land Management and Forest Service (San Dimas Equipment Development Center)	



Precision grade indicator components.

Precision grade indicator installed on a crawler tractor.

Survey of Disks, Project 118. This undertaking was an effort to evaluate a means of reducing excessive disk-plow wear and extending disk life. Investigation of the problem and possible solutions were examined.

Hard-surfacing one side of disks were explored. Wear was not sufficiently increased to offset the cost of disk treatment. The effort was terminated in the initial year. Disk improvements have essentially eliminated the wear problem in most situations.

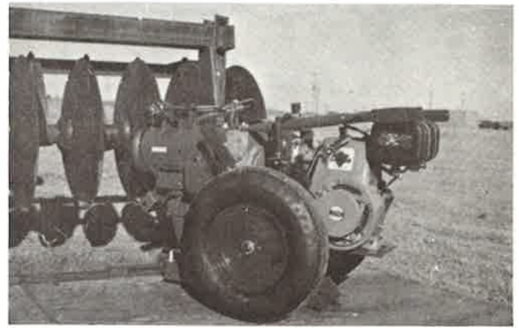
Project initiated, reviewed, and terminated	1953
Project accomplished by	
Forest Service (Southwestern Region and San Dimas Equipment Development Center)	

Cultivating action of large cut-out disks.

Disk Sharpeners, Project 118. The suitability of commercial equipment for sharpening plow disks in the field was investigated.

Units produced by three manufacturers—Amy, Hodges, and Mulkey—were field-tested on a Wheatland plow. The Amy sharpener was determined to be the most suitable on the basis of unit cost, job accomplishment, and ability to sharpen warped disks. The unit is powered by a small gasoline engine. It is available from Amy Manufacturing Co., Inc., Dighton, Kans.

Project approved and initiated	1953
Project reviewed	1953-1954
Project terminated	1954
Project accomplished by	
Bureau of Land Management and Forest Service (Intermountain Region and San Dimas Equipment Development Center)	



Amy disk sharpener.

Spray Project Boundary Marking, Project 1875. This effort was to evaluate the relative efficiency of methods used to mark spray project boundaries and flight swaths in the application of herbicides.

Various marking methods considered, such as balloons, dyes, smoke pots, and flagmen, are either costly or ineffective. A device called the Automatic Flagman, available from Air-Ag, Inc., Route 4, City-County Airport, Walla Walla, Wash. offered the most promise. It was approved by the Federal Aviation Administration for use on most airplanes and helicopters. The unit consists of a dispenser containing 100 markers. The markers are paper streamers, 12 or 20 feet long, weighted at one end. Marker ejection is pilot-controlled.

Trials were conducted with the unit mounted on a helicopter on big sagebrush projects in California and Montana, and on fixed-wing aircraft to mark retardant drop targets in California. The Flagman can become a very useful tool in many aerial operations. Aerial application of herbicides can be accomplished with smaller ground crews to reduce costs.

Project approved and initiated	1966
Project reviewed	1966-1968
Project completed	1968
Project accomplished by	
Forest Service (Northern and Pacific Southwest Regions and Missoula Equipment Development Center)	

Automatic Flagman mounted on a helicopter.

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