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United States
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**Equipment
Development
Center**

Missoula, MT

Vegetative Rehabilitation & Equipment Workshop

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History and Progress of VREW

Dan W. McKenzie, Forest Service, San Dimas, California
Text from *History of the Vegetative and Equipment Workshop (VREW) 1946-1981,* USDA Forest Service Missoula Equipment Development Special Report 8222 2805, 1982.

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 contribute to the VREW. Several Federal agencies are also 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

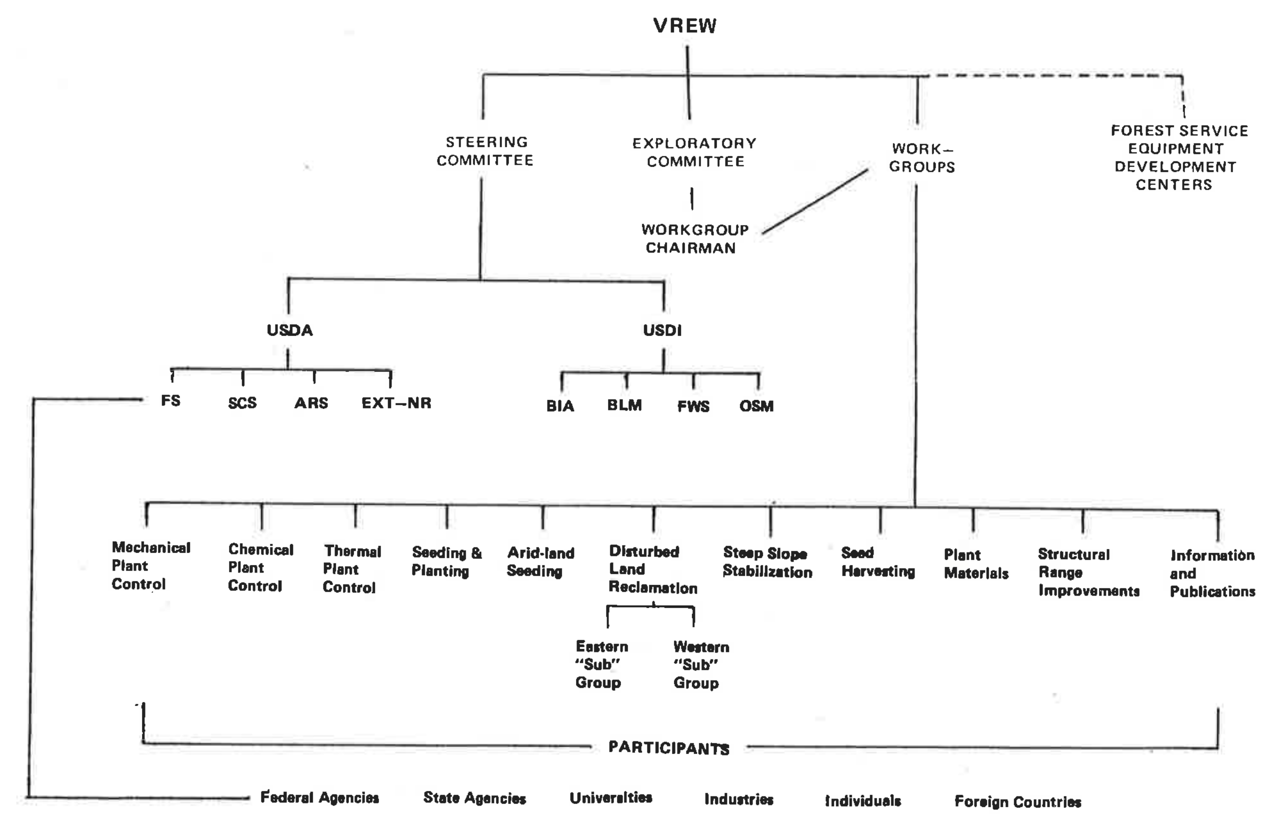

Figure 1.--Organization of the Vegetative Rehabilitation and Equipment Workshop (VREW).

with the Equipment Development Centers at San Dimas, Calif. (SDEDC), and Missoula, Mont. (MEDC). The VREW Chairman handles many of the administrative details of the workshop, acts as a liaison among agencies, and heads both the Steering and Exploratory Committees of the workshop.

The steering Committee comprises representatives from each major funding agency. They examine the projects and set priorities according to field needs, then assign the approved projects to existing workgroups 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. 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.

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 cost 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. Membership is open to anyone interested.

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, Oregon. 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, California. 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 committee meeting was held in Portland, Oregon on Dec. 9-11, 1946.

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, Colorado, 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 indivuals. 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.

VREW is increasing the effort to provide land managers with pertinent, up-to-date information. Much of this information is published in newsletters, Equip Tips, Project Records, VREW annual reports, service and parts manuals, operations handbooks, and the *Catalog—Revegetation Equipment.* 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.

Low-Volume Irrigation Pumping with Wind Power

R. Nolan Clark, Agricultural Engineer, Southern Plains Area Conservation and Production Research Laboratory, USDA ARS, Bushland, Texas (Presented by **Dan W. McKenzie**, USDA Forest Service, Equipment Development Center, San Dimas, California

Water-lifting windmills may serve as an alternative to engine-driven pumps for low-volume irrigation systems. The water lift of the 8-ft American multibladed windmill may exceed 150 ft (46 m) with a discharge capactiy up to 3 gpm (0.7 m^3/hr), while the discharge of the 12-ft for the same lift may exceed 7.7 gpm (1.7 m^3/hr). One of the recent research approaches to improving the overall efficiency of the American windmill is the variable stroke mechanism. With such a mechanism, the windmill will start at lower windspeeds and pump water approximately proportional to windspeed cubed rather than to windspeed as is the case without the mechanism. With doubled or tripled volumes of pumped water, the windmill may provide enough water for low-volume irrigation systems. However, such a mechanism is still at the experimental level and more field testing is needed.

A comprehensive laboratory and field study on the American multibladed windmill has been started (November 1986) by the Agricultural Research Service at the USDA Conservation and Production Research Laboratory, Bushland, Texas, with the following objectives: (1) To develop pumping and efficiency curves of the conventional windmill under different windspeeds and loads; (2) to test different variable stroke mechanisms in an effort to improve overall efficiency and to increase total volume of pumped water; (3) to model the windmill performance and study the feasibility and cost effectiveness of the improved units; and (4) to evaluate the potential of pumping water for low-volume irrigation systems, particularly drip systems.

The laboratory phase of the experiment involves testing the performance efficiency of the various parts of the windmill and evaluating the engineering feasibility of different designs of the variable stroke mechanism. Also, the data acquisition system for strain, discharge, and power input and output will be tested in the lab before field installation, which is scheduled for April 1987.

Field performance data from two windmills, one conventional as a control and the second with the variable stroke mechanism, will be collected using a high-speed data acquisition system. Different pumping lifts will be simulated from a 12-m deep sump, and various pump cylinder sizes will be tested. A drip system will be supplied with pressurized water directly from the windmill, and the overall system performance will be evaluated.

Range Structural Improvement Handbooks

Richard J. Karsky, Agricultural Engineer, USDA Forest Service, Equipment Development Center, Missoula, MT

As part of the continuing effort to provide information to land managers about suitable revegetation techniques and equipment, the Vegetative Rehabilitation and Equipment Workshop (VREW) has consolidated structural improvement handbooks now scattered through several federal agencies into four volumes. Each volume describes a facility's components, uses, advantages and disadvantages. It presents information on costs, safety and environmental concerns, and construction features. Where applicable, suggestions for redesign or new concepts for future development are included. Pertinent books and articles are cited.

The volume on *Handling, Sheltering, and Trailing Livestock* describes facilities needed to handle horses, sheep, and cattle, and facilities built to confine and control animals during sorting, weighing, transporting, or while applying pesticides or insecticides. The handbook details various kinds of corral systems, restraining facilities like chutes, cradles, and tables, and also describes miscellaneous facilites like scales and dipping vats. Sheds, shade shelters, windbreaks, and feeding and watering facilities are discussed as well as trailing livestock along driftways and driveways and through water crossings.

Fences describes the most common kinds of fences and gates used to control the movement of livestock, other animals, and people in the continuing effort to better manage grazing and protect people, animals, and vegetation. Electric, barbed wire, and a variety of wooden fences are detailed. Components and construction techniques are presented along with the advantages and disadvantages of specific designs and materials. Comparative costs are included and safety and environmental concerns are discussed.

Water—Pumping and Piping presents in general terms what the range manager needs to know to design an effective rangeland water system. Dug, bored, driven, jetted, and drilled wells are described. Electric, solar, and wind-powered pumps are discussed. Piping includes a description of common plastic, steel, and copper pipe and discusses the advantages and disadvantages of each as well as the most effective methods for joining pipe. Principles of water flow are presented. The handbook provides the manager with an overview for effectively interacting with experts in construction and legal requirements. Comparative operating and maintenance costs are presented and environmental concerns are discussed.

Water—Damming and Storing describes the advantages and disadvantages of earth, cement, and other less common dams and presents information on how to choose the most effective site for a dam. Details on constructing and maintaining dams as well as often encountered problems are included. Storage tanks are described in detail and construction, maintenance and site selection are included. Special developments like guzzlers, rubber-lined reservoirs, and raintraps are described.

Fences and *Facilities for Handling, Sheltering, and Trailing Livestock* are being printed and will be distributed soon. *Water—Pumping and Piping* is in production and should be distributed by December. *Water—Storing and Damming* is being reviewed by range experts and should be distributed early in 1988.

Common Sense Fencing

Billy H. Hardman, Range Implementation and Special Programs, USDA Forest Service, Northern Region, Missoula, Montana

New design and materials have made possible a concept in fencing that out-performs barbed wire and woven wire by a factor of at least 4 to 1 in all areas of animal control, maintenance, effective product life, installation requirements, and cost. The *Common Sense Fence* (TM) is the first permanent, multiple wire, long distance electric fence capable of providing 20 to 30 years of reliable, low-maintenance service. Remember, initial purchase price is only part of the total cost picture. Installation and maintenance costs over a 20- to 30-year fence life become significant when you consider the susceptibility of barbed and woven wire to wear and tear. The Common Sense Fence will ordinarily be on the job 2 to 4 times longer, take half the labor to install, and require less than one-quarter the time to maintain.

Four major advancements have been designed for this fencing system. They are:

1) A complete fiberglass self-insulating wire support system, posts and corners,

2) Latest solid-state electric technology controller,

3) Heavily galvanized 12-½ gauge high-tensile wire, and

4) Free-flowing spring-clip for attaching wire to posts.

Electric fences form a psychological rather than a physical barrier, so livestock stay away from the fences. Electricity rather than wire mass acts to control animals, so fewer posts and wires are required for livestock control. Corners and braces are easier to install for wood fences. The wire is more resistant to breakage and easier to string. Materials are easier to handle.

Aligned Fiber Composites, AFC, Inc., Hiway 52 South, Chatfield, MN manufactures the component parts for the Common Sense Fence.

Fence Developments

Dan W. McKenzie, Mechanical Engineer, USDA Forest Service, Equipment Development Center, San Dimas, California

Invisible Fence

The Invisible Fence Company of Wayne, Pennsylvania, markets a fencing system that is not visible and is designed to contain dogs within a given area. The system consists of the following elements:

1. A thin wire which is buried 1 to 3 inches in the ground.
2. A small radio transmitter, commonly located in a garage.
3. A lightweight leather dog collar with a transistorized radio receiver.
4. A conditioning or training program for the dog.

The radio transmitter sends a pulsed radio signal through the buried wire that encircles the containment area. When the dog comes within a preset distance (5 to 30 feet) of the buried wire, the receiver attached to the dog's collar picks up the radio signal and activates an audible warning tone—a beeping noise that warns the dog to move back. If the dog ignores the tone and doesn't move back within 2 seconds, it receives a mild shock. The dog will continue to receive shocks until it moves away from the signal zone of the wire.

The company has done some work in livestock control and is interested in this field. The complete address of the company is:

Invisible Fence Company, Inc
One Devon Square Building
Suite #225
724 West Lancaster Avenue
Wayne, PA 19087
(215) 964-0600

Single and Double Fence Braces

In constructing either a diagonal or horizontal fence brace, calculations indicate that a single brace 11 feet long (5.5 times average wire height) or longer is as strong or stronger than a double brace with two 8-foot panels. These calculations indicate that the need for double fence braces is unnecessary and their added cost is not justified provided that the members of a single brace are strong enough to carry the applied loading.

Portable Data Collection Field Terminals: Selecting the Best One For Your Needs

Meg Frantz, Applications Engineer, Omnidata International, Inc. Logan, Utah

Introduction

There are many problems associated with traditional methods of collecting data in the field. Paper strip charts and field notebook pages are vulnerable to smearing, tearing, and staining. The necessary gear is often cumbersome. And finally, the collected data must be reduced, often by hand, and entered into a computer for further analysis. Both are time-consuming and error-prone processes.

Electronic recording devices, whether for ongoing monitoring (e.g., weather stations) or for recording a human observer's measurements (e.g., the typical range transect), remove the difficulties encountered with strip charts and clipboard-and-pencil. Taking advantage of miniature electronics, they can be made truly portable. When housed in suitably rugged cases they can withstand the rigors of the outdoors. Since the data is recorded in digital form, it can be transferred directly to computer through a cable. This capability means that no one has to digitize from charts or keypunch from field sheets, which results in not only savings of time but also increased data quality.

What is a Portable Data Collection Field Terminal?

Field practitioners are turning to portable data collection terminals for recording what they formerly wrote in notebooks or on data sheets. These are small handheld devices with a keyboard for data entry. They resemble portable lap computers in terms of their memory and computational power. However, they typically have smaller keyboards and displays, and may remind you initially of the bulky hand calculators introduced fifteen or twenty years ago. They all feature a communications port for transmitting the collected data to a printer, microcomputer, or main frame computer.

How to Select Your Data Collector

In evaluating a portable data collector for purchase, here are some things to consider:

Is it suitable for my environment?

Electronics have limitations with respect to hot and cold temperatures, and no microprocessor or circuitry will function properly if wet. Check the manufacturer's specifications for operating temperature range, particularly if you work in environmental extremes. You will find differences across models. Check the construction of the unit as well, for its ability to keep out water and dust. Are all openings sealed? Will the keyboard permit water or dirt to enter? Since water tight construction costs a little more, some users in arid environments have opted to purchase a "water resistant" rather than "water proof" unit, and slip the terminal inside a plastic bag on occasional wet days. There is definitely a risk of losing field time or data this way, and you need to evaluate for yourself the comparative costs.

Omnidata International produces the polycorder, a portable data collector for laboratory and field application.

What tradeoffs shall I make with keyboard and display design?

Both keyboard and display are limited on portable data collectors, and you'll need to decide for yourself how important size is. It's easier to work with larger keyboard and display, but it may not be easier to haul them around in the field all day.

One approach to keyboard design is to scale down a normal typewriter keyboard, with the result that keys may be too small to manipulate properly with gloved or cold hands. Another approach is to reduce the number of keys on the board and use shift or function key prefixes to generate all the numeric and alpha characters. The drawback here is that the number of keystrokes may be increased significantly.

Both LED displays, the red light-up displays, and LCD displays, the Black-on-gray matrix displays, are typical on data collectors. Be aware that the LED display, which looks bright in your office, will be washed out and perhaps unreadable in bright sunlight.

What sort of power supply is needed?

Most portable data collectors are powered either by alkaline batteries or rechargeable nickel-cadmium batteries. Your real concern is the amount of operating time between battery changes or recharge cycles, and the manufacturer should be able to provide you with estimates. Power loss will result in loss of data, so most systems feature a backup battery in addition to the main battery. Generally, the unit will display some type of low battery warning. Some models even turn themselves off when power drops below a threshold, preventing you from draining the batteries completely.

How flexible is the device?

All portable data collectors allow you flexibility at least for labeling data and defining field widths. Others are fully programable so that you can devise your own input prompts, error checks, and editing criteria, much as you would on a microcomputer. The more programing power you have, the more applications you will find for the data collector. But, of course, more work is required from you at the outset.

Some data collectors are programable from the keyboard only, rather like a handheld calculator. Others allow you to write the source code on your computer using a text editor or word processor, and then load that code onto the data collection terminal. Still others provide a compiler to run on your microcomputer so that the program version you load onto the data collector is already in executable form.

In certain widely used applications, such as timber cruising, you may have the option to purchase the data entry program from the manufacturer. If you decide to go this route, clarify whether you may modify the program yourself or if the unit must be sent back to the factory to be reprogramed.

Does it have enough memory?

Since data storage schemes vary from device to device, and since the rate at which you can collect data varies from one application to the next, it's difficult to say how much memory is enough. If you were punching numbers into the terminal at the rate of two per second, you would use up about 29,000 bytes in an 8-hour day. Thus, a 64,000-byte data collector is probably ample for most applications, assuming you can dump data to a computer once per day. As technology changes, memory capacities on portable data collectors have typically become large enough that memory size is no longer a critical parameter when selecting a model.

Is it compatible with my computer (or printer)?

Most portable data collectors are equipped with RS-232 serial ports, although a few models have parallel RS-232 ports or IEEE ports either as a standard or optional feature. The designation "RS-232" or "IEEE" refers to an industry-wide standard specifying voltage levels, control and data format, and pin functions for communications ports. Make sure that the unit you are considering has the same port designation as your computer or printer.

Beyond selecting a data collector with a compatible port, you will eventually need to select the proper cable for communicating with your computer, and configure both computer and data collector with compatible communications protocol before everything runs smoothly. This task can be a source of frustration to users, particularly if you are unfamiliar with computer communications. Talk with the sales representative or the manufacturer's customer service division. Try to get a feel for the degree of support they will give you and their level of expertise in this area. Ask to see the data collector's documentation on communications. Good support and documentation may be well worth a higher price tag on the unit.

Mechanical Control

Mark Mosley, Range Conservationist, Soil Conservation Service, San Angelo, Texas

Texas offers quite a stage for using a variety of mechanical brush control practices. Different brush that requires different methods of control occurs on each major land resource area of Texas. The most important consideration for planning brush control is the desired objective. The needs of wildlife, kinds of livestock to be run, production goals, future land values, and financial resources influence the manager's decisions.

Heavy Equipment

Rootplowing—a large blade mounted onto the rear of a bulldozer undercuts target brush plants at a depth of 18 inches. The advantages are long-term control, high moisture retention, and preparation of a good seedbed. Disadvantages include high costs, as much as $40 per acre and up. This treatment is non-selective and must be done in patterns to retain wildlife habitat. Reseeding is needed as existing plants are usually destroyed. Noxious plants such as prickly pear can be spread this way.

Treedozing—a blade is mounted on the front of a crawler tractor for individual removal of noxious plants. This method is selective, allowing the operator to remove only the unwanted plants. Seeding is optional and depends upon the range condition. Disadvantages include high costs and high maintenance. Costs of $30 per acre are common. Treedozing can be done on areas of shallow soils that would limit rootplowing. Noxious plants can be spread this way.

Chaining—a large anchor chain is pulled between two bulldozers. This method is cheap, costing about $7 to $10 per acre. Grasses respond quickly following treatment. However, many brush species resprout following treatment and regrowth is more difficult to kill than the original growth. This treatment is non-selective and can spread many species. It must be used in combination with other treatments such as prescribed burning, aerial spraying, or goats.

Rollerchopping—a large drum with blades mounted perpendicular to the line of travel mashes and crushes brush plants to the ground. Costs are about $20 per acre. Results are similar to chaining.

Shredding—industrial shredders mounted either on bulldozers or self-propelled mow the target brush species. Costs can exceed $25 per acre. Shredding kills very few plants. Follow-up treatment will be needed. Maintenance costs will be high.

Low-Energy Grubbing—a blade is mounted on either the front or the rear of a farm tractor or small dozer. This method offers relatively low costs ranging from $4 to $20 per acre, depending upon the skill of the operator, density o brush, size of the brush, and the terrain. Because of the smal size tractors, maintenance costs are lower than for heavy equipment. Rubber-tired equipment needs modification to reduce flats. This method is selective and can be used to thin stands to tolerable densities. It also greatly extends the life of more costly treatment such as rootplowing. Ground disturbance is minimal compared to that produced by heavy equipment.

Hand Treatment—prickly pear and certain species of juniper can be controlled by hand grubbing or by axing. Labor shortages and high labor costs limit the use of this practice. However, it is selective.

Carpet Roller—a rolling drum with a carpet attached is mounted to the front of a small tractor. Herbicide is sprayed on the roller as it passes over brush species. For this method to be effective, the brush must be small enough to allow the tractor to run over it. This method minimizes drift, cuts cost, and can be used as an effective follow-up to other methods. Not many of these rollers exist.

Disc Chain—an anchor chain is fitted with heavy discs and pulled behind a crawler tractor. This equipment is more commonly used to prepare seedbeds on rangeland but could be useful in maintaining small brush where reseeding is needed. This method costs from $10 to $15 per acre. This is an excellent tool for seedbed preparation but is limited because few disc chains are available.

Chemical Control

Pete W. Jacoby, Professor, Texas Agricultural Experiment Station, Vernon, Texas

Despite many restrictions limiting their use, herbicides remain a key method of controlling unwanted plants in range and pastureland. Herbicides are popular with land-owners because they are cost effective, quickly applied, selective in the plants controlled, and non-disturbing to the soil surface. The purpose of this presentation is to discuss the more prevalent herbicides available for rangeland use and their status and attributes.

Herbicides can be divided into two general categories based on their method of application and entry into the target plant—foliar-absorbed and root-absorbed. Of the foliar-absorbed group, 2,4-D is the oldest and best-known product. It is manufactured by numerous companies and is an effective control agent for broadleaf weeds and several varieties of brush including big sagebrush. EPA has recently shown reluctance to register new formulations containing 2,4-D and certain special interest groups would like to see the product banned from use.

Other effective foliar-absorbed herbicides are dicamba and picloram. Dicamba is a product of Sandoz and is a good weed control chemical that is effective on certain varieties of woody species. Picloram is a product of Dow that is effective on a wide variety of weeds and brush. Both picloram and dicamba are mixed with other herbicides such as 2,4-D to broaden the spectrum of control. Such mixtures must be in accordance with Section 2EE of FIFRA and be approved in the state where they are used. Several new foliar-absorbed products have been introduced into the rangeland market and include triclopyr and clopyralid from Dow and metsulfuron methyl from DuPont. Triclopyr is currently available only in Texas, Oklahoma, and New Mexico. The DuPont product is being tested in Texas and New Mexico under an experimental use permit for controlling broom snakeweed. Clopyralid from Dow recently received a federal label and will be marketed largely for mesquite control, although recent data from Utah indicates the product can achieve sagebrush control without damaging associated desirable shrubs such as bitterbrush and serviceberry.

Root-absorbed herbicides for rangeland use include hexazinone from DuPont and tebuthiuron from Elanco. Hexazinone is a liquid that is applied to the soil surface near the target plant. A colored dye facilitates treatment by enabling the applicator to see which plants have been treated. Tebuthiuron is a pelleted herbicide incorporated into the soil by rainfall and can be broadcast by hand or aerial methods.

Generally, fewer new products are being developed for rangeland markets. However, effective products are available for controlling many species of unwanted plants. Major research and management efforts will be required to integrate these products into general management schemes for treatment longevity and cost effectiveness.

Seeding Chaffy Grass Seed and Grass Seed Mixtures

Harold T. Wiedemann, Texas Agricultural Experiment Station, Vernon, Texas

A chaffy grass seed metering device developed by the Texas Agricultural Experiment Station (TAES) has largely overcome the severe dispensing problems associated with these grasses. The semi-circular seedbox, auger agitator, and pickerwheel metering system has easily metered 97 percent of seed from the seedbox at relatively uniform, predictable rates for seven, notoriously hard-to-seed grasses. To seed grass mixtures with both chaffy and slick-seeded grasses, two separate seedboxes and metering systems are required. Conclusions from tests with a six-species seed mix used in land reclamation in the western United States were:

1) Galleta and fourwing saltbush metered well both individually or as a mix with the TAES chaffy metering device.

2) Winterfat metered better in a chaffy-seeded mix than individually.

3) Ephedra, Indian ricegrass, and shadscale metered best as a mixture dispensed from a slick-seed metering mechanism.

4) The mixture of all six species could be metered with the TAES device but considerable variation was present within the mix.

5) Best field results would be obtained by filling the seedbox before 85 percent of the seed had been dispensed.

The improved performance of the TAES metering device has resulted in six drill manufacturing companies adopting the seed metering concept.

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How to Provide Range Improvement Information to Users

John Vallentine, Utah Division of Wildlife Resources, Great Basin Experiment Station, Ephraim, Utah

What information—special treatments, structures, developments for rangelands.

Who are users—range technicians, ranchers, public land managers and administrators, agribusiness personnel, service/support, educators, students, etc.

What's already available

1. Range improvements courses (required by OPM)
2. Text: Range Development and Improvements
3. VREW and SRM papers
4. Rangelands and JRM
5. VREW publications (state-of-the-arts, annual proceedings, pamphlets)
6. RI literature finding aids
   a. Bibliography of Agriculture
   b. U.S.—Canadian Bibliography (1935-1937)
   c. U.S.—Canadian Bibliography (1978-1980)
   d. U.S.—Canadian Bibliography (1981 to present)
   e. "Selected Literature" in Rangelands
   f. Computer search services
7. Field days, field trips, tours, workshops

What VREW could/should do!

1. Continue VREW workshops (in conjunction with SRM).
2. Continue state-of-the-art publications.
3. Direct more short articles to Rangelands and other semi-technical magazines.
4. Cooperate with Extension Service on fact sheets for notebooks series.
5. Develop an annual price/cost release for RI practices.
6. Work with one university in developing a home study course in RI.
7. Host or co-host state or regional workshops (example: Twin Falls in 1981 and Elko in 1982).
8. Provide guidelines/assistance for agency inservice workshops or self-training efforts.
9. Develop audio-visuals (slide series, film strips, TV video cassettes).

Equipment Development Needs

Harold T. Wiedemann, Texas Agricultural Experiment Station, Vernon, Texas

Problems with the Past

Much of the equipment developed for range improvement on federal lands, and more especially equipment design projects were undertaken with little regard for economics. Machines were built bigger, heavier, bulkier and more costly to operate. Cost of installations far exceeded the capacity of the land to justify the operation even when aesthetics were considered. Consequently, range improvement practices were gradually de-emphasized, especially during the high inflation of the 1970's and cost accounting of the 1980's. As a judgmental factor, we must ask ourselves, "How much of the equipment designed by VREW has ultimately been utilized by the private sector?"

Future Survival

The key to VREW's survival is innovative new approaches. These include development of both equipment and techniques for effective rangeland improvements. Short-term action may necessitate publication of current technology, but long-term stability will require new technology. Many new demands will be placed on federal lands by the public and cost accounting will be ever present; however, this will open many new opportunities.

Opportunities for the Future

Land is our foremost resource, and it should be considered in a holistic view. Therefore, we should be considering challenging new alternatives for future rangeland improvements. These will include:

Conservation—Replacement of plants that degrade with plants that enhance the land and retard erosion.

Water—Water from rangeland may soon be our most valuable commodity and municipalities may encourage the seeding of plants that enhance the quality and quantity of water runoff.

Grazing—The value of wildlife may become more important than livestock and range plant control and seeding will be directed to improve wildlife habitats as well as habitats for the cohabitation of both wildlife and livestock.

Aesthetics—Plants that are pleasing to the eye may encourage seeding such things as wildflowers and other appealing plants, and the use of selective thinning to improve habitats for both humans and animals.

Agronomic/forest crops—Planting of crops in selected areas may enhance the survival of animals and assist in the establishment of permanent forage plants.

Opportunity for Design

1. Development of machinery to control plants based on growth patterns of the plant and better adaptation of hydraulics for highest machine efficiencies. Example: low-energy grubbing.

2. Development of plant sensing spray booms for more accurate and safe individual plant treatments with herbicides.

3. Development of seedbed preparation equipment based on plant growth requirement and novel new design. Example: disk-chain.

4. Development of improved seed metering and placement devices for both ground and aerial seeding.

5. Development of new innovations for seed harvesting and processing. Example: Woodward Flail-Vac Seed Stripper and Woodward Seed Conditioning System.

Develop and Test Disk-Chain Implement

Harold T. Wiedemann, Texas Agricultural Experiment Station, Vernon, Texas

Introduction

With 150 million acres of rangeland in poor condition in the western United States, a critical need for revegetation exists (Wiedemann et al., 1985). The invasion of brush on much of this rangeland further complicates the problem since costly removal methods are required before seeding equipment can be used. Interest in seeding rangeland with improved grasses has been present for over 40 years, but the practice has been severely limited by the high cost of conventional techniques.

Disk-chaining, which utilizes a diagonally pulled anchor chain with disk-blades welded to alternate links (Fig. 1), appears to be an economical method of preparing seedbeds on log-littered, rootplowed rangeland, and results appear reliable under a broad range of conditions (Wiedemann and Cross, 1982 and 1985). It is well suited to covering extensive acreages, and when combined with aerial seeding, the practice may offer a practical method of converting depleted rangeland to productive grassland. A cost-effective system could presently be used on 50 million acres.

All previous disk-chaining studies have been conducted on rootplowed land. However, it appears that the disk-chain could be used on undisturbed native rangeland infested with low growing shrubs to gain limited brush control and to prepare a seedbed for range revegetation. Information is needed concerning the amount of draft and operating mass required for adequate disking action on undisturbed rangeland soil.

Objectives

The objectives of this study were: 1a) to compare the disk-chain draft requirements of the triangular and diagonal pulling techniques, 1b) to improve the design of the triangular systems, and 2) determine the draft requirements and depth of cut of six disk-chains of different operating masses in disturbed rangeland soil and undisturbed, native rangeland of clay loam and sandy loam soil types.

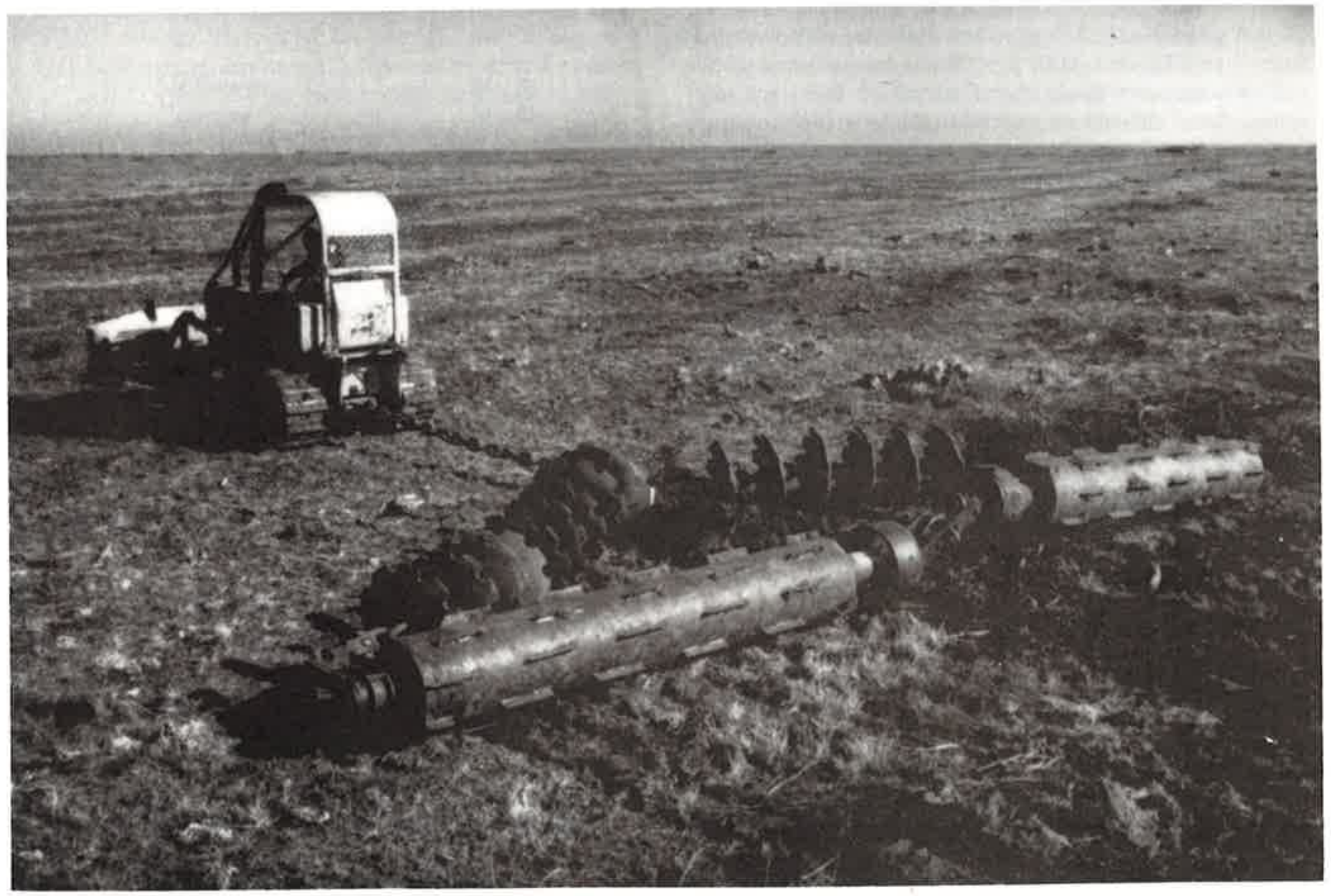

Fig. 1. Disk-chain developed by the Texas Agricultural Experiment Station for seedbed preparation on rough, log-littered rangeland.

Development of Triangular Disk-Chain

Development of the triangular method of pulling disk-chains with a single tractor has substantially increased the potential for its use compared to the early diagonal method which required two tractors. The two pulling techniques are discussed in detail by Wiedemann and Cross (1985), and portions of that research have been included in this report to enhance the design and future use of disk-chains.

Disk-chain and Pulling Procedures

Disk-chains constructed from 1 and 7/8- and 2-inch anchor chains and 24-, 28- and 30-inch disk blades were utilized in prior tests. Resulting operating masses were 74, 79 and 123 lbs/blade for the 1 and 7/8 x 24, 1 and 7/8 x 28, and 2 x 30 disk-chains, respectively.

In the triangular pulling configuration, shop-made swivels were attached to each end of each disk-chain gang (Fig. 2). The front end of each gang was attached to a corner of a small triangular shaped plate. A towing chain, attached to the third corner of the plate, was pulled from the drawbar of a crawler tractor. The rear portion of each gang was attached to a 28-foot rolling brace. The brace's center 20 feet was 12-inch O.D. pipe and the outer ends were made from 7 and 7/8-inch O.D. pipe. Hubs for each end of the rolling brace were made from Caterpillar[1] D-6 track idler rollers. Small cleats were welded to the large pipe to assure rolling action. The clevis connection between the chain and the hub was constructed so the disk-chain's angle of pull (width of operation) could be varied.

The chain's angle of pull was measured from the line formed by direction of travel of the pulling tractor to the line formed by the disk-chain so that a wider angle resulted in a wider operating width. This pulling angle measurement was established in earlier draft studies (Wiedemann and Cross, 1982). Chains were pulled at 40-, 50-, and 60-degree angles.

In the diagonal pulling configuration (Fig. 3), the two disk-chain gangs were pinned together and attached with swivels between two tractors as outlined by Wiedemann and Cross (1982). All tests with the diagonal technique used its optimum pulling angle.

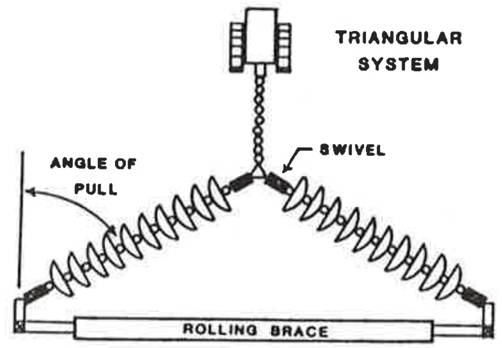

Fig. 2. Plan view of triangular pulling configuration.

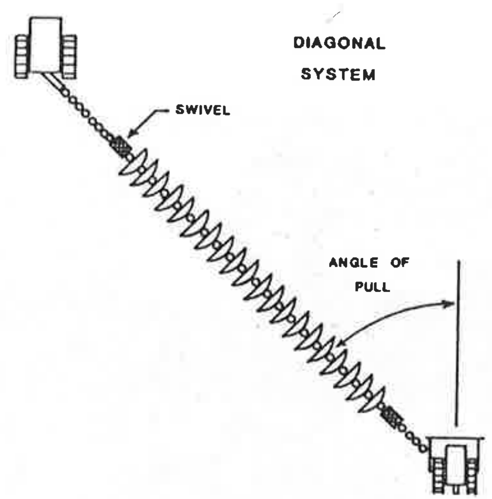

Fig. 3. Plan view of diagonal pulling configuration.

[1] Mention of trade name is for identification only and does not imply an endorsement or preference over other products not mentioned.

All operating width comparisons were based on chain length using the following formula:

$$W = \left(L * \frac{P}{12} * \sin\phi\right) + A$$

where:

- W = operating width, feet
- L = number of chain links
- P = pitch, inches
- ϕ = angle of pull, degrees
- A = width of attachment hardware located in the center portion of the triangular chain, feet.

Draft tests were conducted in well-tilled clay loam soil with a soil moisture content of 10 percent and cone index (CI) of 228 psi (ASAE standard procedure, maximum value between 0 and 8 inches).

Angle of Pull

When pulling the disk-chain in the triangular configuration, the 60-degree angle of pull resulted in significantly less ($P<0.01$) average draft than for the 40- and 50-degree angles. Soil cutting was judged adequate for all disk-chains at all angles. Thus, the 60-degree angle was selected for optimum performance. A plot of the percentage change in draft with a reduction in the pulling angle from 60 to 40 degrees is illustrated in Fig. 4.

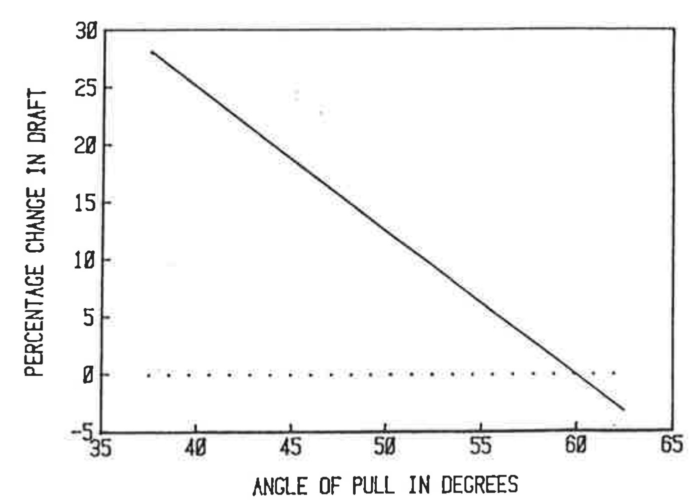

Fig. 4. Percentage change in draft when angle of pull is adjusted from optimum 60 degree position for the triangular pulling technique. Data adapted from Wiedemann and Cross (1985).

Draft Reduction

When contrasting pulling techniques, the optimum method of pulling each system was used: i.e., 45-degree angle for the diagonal system and 60-degree angle for the triangular system. The triangular technique reduced draft requirement by 36 percent compared to the diagonal system (164 contrasted to 257 lbs pull/blade and values were significantly different, $P<0.001$). Additionally, the triangular pulling method increased operating width by 23 percent. The operating width of our 60-degree triangular unit was 24.3 feet.

Roller Design

The initial 24.3 foot roller constructed from 12-inch O.D. pipe worked very well over a broad range of field tests with the 1 and 7/8-inch anchor chain. However, the proposed tests utilizing 2½- and 3-inch anchor chain required operating widths up to 40 feet. It was evident after several trial pulls that a flexing roller of a larger diameter was necessary. Final design was a 20-inch O.D. roller of ¼-inch wall thickness with a centrally mounted joint capable of flexing only in a vertical direction when the disk-chain was in motion The flexing joint is held rigid in the horizontal direction by a 2½-inch O.D. pipe brace extending from the flexing joint (pin connection) to the triangular pulling plate at the head of the disk-chains (clevis connection). This allowed the roller to flex vertically (up and down), yet remain rigid horizontally (forward and backwards), and the center brace could oscillate sideways to facilitate a change in the pulling direction. Hubs for the roller and flexing joint were made from Caterpillar D-8 track carrier rollers. A telescoping roller design was used to facilitate the many changes in operating width during testing, A 7 and 7/8-inch O.D. pipe with 3/8-inch wall thickness was used for the shaft of the telescoping extension. The telescoping design is not recommended for a commercial unit. It is further recommended that large, heavy-duty hubs be constructed using a 4-inch diameter shaft for improved strength over the track-roller hubs we used. The flexing roller appears necessary when operating widths are over 25 feet based on experience of the authors.

Influence of Operating Mass on Disk-Chain Performance

Equipment and Procedures

Disk-Chain

Six disk-chains were constructed using 1 and 7/8-, 2½- and 3-inch anchor chains and 24- and 28-inch diameter notched disk blades. Operating mass per blade (weight of two chain links plus one disk blade) was 74, 97, 130, 154, 204 and 228 lbs for the 1 and 7/8 x 24, 1 and 7/8 x 28, 2½ x 24, 2½ x 28, 3 x 24 and 3 x 28 disk-chains, respectively, Table 1. All units were pulled in a triangular pulling configuration which utilized two gangs of disk-chains held in place by a rolling brace, Fig. 7. Each gang consisted of 10 blades and 21 chain links. Details of the triangular system and method of testing are explained by Wiedemann and Cross (1985). The angle between the roller and the line formed by the disk-chain was 30 degrees [angle of pull was 60 degrees]. Operating width was 87 percent of chain length plus 36 inches of attachment hardware located in the center of the chain. Our widths were 25.8, 33.5 and 39.5 feet for the 1-7/8-, 2½- and 3-inch chains, respectively. The flexing, 20-inch diameter roller with a telescoping extension for operating width adjustment was used with all disk-chains. All tests were conducted at 3 mph over a randomly selected 1,000-foot test run. Depth of cut was determined for each treatment replication from three randomly located sample transects perpendicular to the direction of implement travel. Twenty depth measurements, one for each disk blade, were taken in each transect.

Table 1. Disk-chain specifications

Item	Chain link dia	Chain link pitch	Chain link wt	Disk blade dia x thick	Disk blade wt	Roller[1] length pin/pin	Blade spacing	Disk-chain Length 1-gang	Disk-chain Operating[2] width	Disk-chain Operating[2] mass/blade
	in	in	lb	in	lb	ft	in	ft	ft	lb
1 7/8 x 24	1 7/8	7.5	21	24 x 1/4	32	27.8	15	13.1	25.8	74
1 7/8 x 28	1 7/8	7.5	21	28 x 3/8	55	27.8	15	13.1	25.8	97
2½ x 24	2½	10	49	24 x ¼	32	35.4	20	17.5	33.4	130
2½ x 28	2½	10	49	28 x 3/8	55	35.4	20	17.5	33.4	154
3 x 24	3	12	86	24 x ¼	32	41.5	24	21.0	39.6	204
3 x 28	3	12	86	28 x 3/8	55	41.5	24	21.0	39.6	228

[1] Roller 20 inch OD diameter with ¼ inch wall thickness, pin to pin length.
[2] Triangular system with 30° angle between roller and line formed by disk-chain.
Width equals 87% of length of two gangs plus 36 inches of attachment hardware.
Mass/blade equals weight of two links plus one disk-blade.
Each gang had 21 chain links and 10 disk blades.

Study Area

The rangeland site near Vernon, Texas was Hollister clay loam soil which had been cleared of brush by rootplowing 15 years prior to our study. Native herbaceous production was 2,023 lbs/ac (oven dried), and this location was termed "undisturbed". The cone index (CI) value of this soil at time of disking was 351 psi (maximum value between 0 and 3 inches) as determined by procedures in ASAE Standard S313.2. Additional measurements and specifications to quantify soil conditions at time of testing are reported in Table 2. A second location adjacent to this site had been rootplowed 14-inches deep to remove stumps then disked 8-inches deep. Hard red winter wheat was seeded following disking, and 2,844 lbs/ac of mature wheat was present on the site at the time of our tests. This site was termed "disturbed" and the CI value of the soil was 164 psi. Soil at the second rangeland site, near Paducah, Texas, was Miles fine sandy loam and undisturbed. Native herbaceous production of this site was 883 lbs/ac plus a sagebrush (*Artemisia filifolia*) infestation of 1531 plants/ac. The CI value of the soil was 1,238 psi.

Soil moisture conditions at the time of our tests were near or below wilting point for all soils, Table 2. This resulted in high soil strength measurements (CI values) and especially in the sandy loam. These conditions, however, reflect the more probable condition of rangeland needing renovation.

Table 2. Physical characteristics of soils and herbaceous vegetation for research sites.

Depth of sample inches	Soil[1] moisture %	ASAE Cone[2] index psi	Moisture retention[3] wilt point %	Moisture retention[3] field capacity %
		Undisturbed Hollister clay loam		
0–3	15.8	351 ± 20	15.2	35.1
3–6	18.4	398 ± 23	16.3	33.4
		Disturbed Hollister clay loam		
0–3	18.6	164 ± 15	15.0	35.3
3–6	21.7	173 ± 15	16.9	37.5
		Undisturbed Miles fine sandy loam		
0–3	0.9	1238 ± 20	4.1	15.7
3–6	1.4	1238 plus	3.8	14.0

[1] 10 samples
[2] ASAE Standard S313.2 with 0.2 in² point, 100 samples, maximum value
[3] 10 samples, wilt point = 10 bar, field capacity = 1/10 bar

Site	Herbaceous[1] vegetation lbs/ac	Sand sagebrush[2] density plants/ac	Sand sagebrush[2] canopy %
Undisturbed clay loam	2023 ± 24	—	—
Disturbed clay loam	2844 ± 378	—	—
Undisturbed sandy loam	883	1531	16

[1] 10, 0.25-m² quadrates clipped, oven dry wt.
[2] 25 pts., PCQ technique

Recording Device

Drawbar pulling force was measured with a load cell attached in the towing chain. Data were stored in a tractor-mounted microprocessor with a memory chip and later recorded with a portable printer (Wiedemann and Cross, 1983).

Statistical Analysis

Treatments were arranged in a completely randomized block design with four replications for each soil condition. Comparisons were by one-way analysis of variance with mean separation using Duncan's method. Linear regression analysis was utilized to describe the relationship between draft or depth (Y) and operating mass per blade or cone index (X) as the independent variables. The combined influence of mass and soil strength (cone index) on draft or depth was determined by multiple linear regression techniques. All ± values following means are standard errors unless otherwise stated.

Results and Discussion

Draft Requirements

Draft per blade was significantly different ($P<0.01$) for each disk-chain and was positively correlated to operating mass per blade ($r^2 = >0.98$) for each soil condition, Table 3, 4 and 5. Therefore, draft can be predicted for a combination of chain and blade sizes within the range of operating masses tested. Addition of 1 pound of mass resulted in an increase of 1.9 pounds of draft in both the clay loam and sandy loam undisturbed soil and 1.8 pounds in the disturbed clay loam. Draft varied from 126 lbs/blade for the 74 lb/blade (1 and 7/8 x 24) disk chain to 444 lbs/blade for the 228 lb/blade (3 x 28) disk-chain, Table 3 and 4. Draft appeared to be influenced very little by soil type or condition. The coefficient of determination (r^2) of 0.98 for draft on mass for all conditions indicated the linear relationship $Y = 0.18 + 1.86X$ with a standard deviation of 14 lbs is a valid prediction equation over a broad range of conditions. This prediction equation is graphically illustrated in Fig. 5. The regression equations developed to predict draft for each soil condition are listed in Table 4.

Depth of Operation

Soil cutting was visually judged unsatisfactory for the 1-7/8- chains (74 to 97 lbs mass/blade), fair for the 2.5-inch chains (130 to 154 lbs mass/blade) and good for the 3-inch chains (204 to 228 lbs mass/blade) in the undisturbed clay loam with a CI = 351 psi. Depth of cut measurements supported these observations. Minimum depth was 1.8 inches for the 1-7/8 x 24 disk-chain and maximum depth was 3.3 inches for the 3 x 24 disk-chain, Table 3. Depths of cut for the 2½- and 3-inch chains were significantly greater than the 1-7/8-inch chain. The regression equation for depth on mass was $Y = 1.34 + 0.009X$ with an r^2 of 0.82 for this soil condition. This prediction is very dependent on soil strength and is of little value unless a trend can be developed for various CI values.

In the undisturbed sandy loam which had a very high CI value of 1238 psi, disking action was unsatisfactory for the 1-7/8-inch chains, poor for the 2½-inch chains and fair for the 3-inch chains. Depth of cut for the 1-7/8 x 24 disk-chain was only 1.0 inch and maximum cutting depth was only 2.0 inches for the 3 x 24 disk-chain, Table 4. Penetration depths of the 2½- and 3-inch chains were significantly greater than the 1-7/8-inch chain. The depth on mass regression equation was $Y = 0.40 + 0.007X$ with an r^2 of 0.89. Commercial disk-chaining in hard soils of this nature will require two passes with the heaviest units for satisfactory soil and plant disturbance or the operation should be conducted when soil moisture is higher than the soils wilting point. Results of a second pass with the disk-chain gave a curvilinear relationship for draft on mass described by the formula $Y = -632.8 + 184.5 \log X$, $r^2 = 0.99$, in this soil.

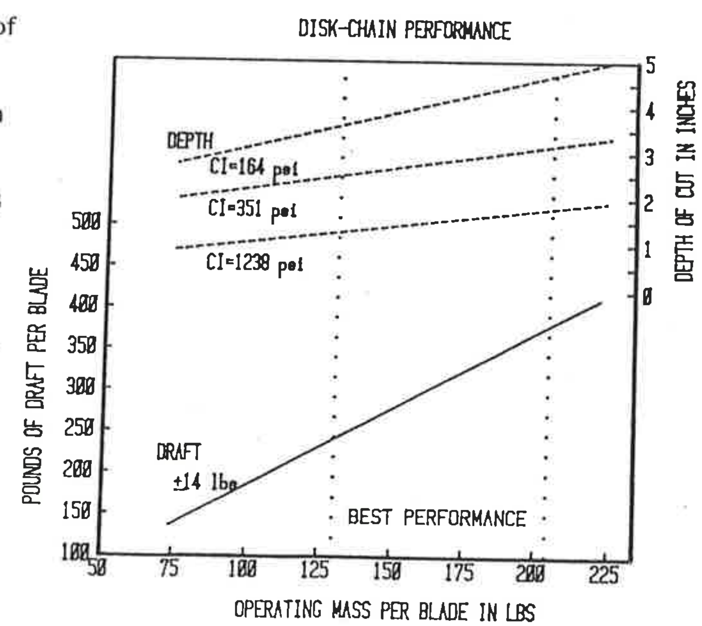

Fig. 5. Predicted draft (± 14 lbs) and depth of cut (± 0.1 inches) of disk-chains pulled at 3 mph in native rangeland soil of various cone indexes (CI in psi). Prediction formulae, standard deviations and r^2 values are listed in Table 4.

Table 3. Disk-chain operating characteristics at 3 mph in Hollister clay loam soil[1].

Disk-chain size	Operating mass	Draft	Plowing depth
inches	lbs/blade	lbs/blade	inches
	Undisturbed soil — CI = 351 psi -- 3.06 mph ± 0.01		
1 7/8 * 24	74	138 a	1.8 a
1 7/8 * 28	97	184 b	2.1 a
2 1/2 * 24	130	259 c	2.8 b
2 1/2 * 28	154	293 d	3.0 b
3 * 24	204	383 c	3.3 b
3 * 28	228	444 f	3.1 b
	Disturbed soil — CI = 164 psi — 3.14 mph ± 0.07		
1 7/8 * 24	74	138 a	2.7 a
1 7/8 * 28	97	180 b	2.9 a
2 1/2 * 24	130	256 c	3.8 b
2 1/2 * 28	154	297 d	4.2 b
3 * 24	204	346 e	4.8 c
3 * 28	228	428 f	4.9 c

[1] ASAE Cone Index data in Table 2. Values within columns followed by the same letter are not significantly different at the 5% level.

Table 4. Disk-chain operating characteristics at 3 mph in undisturbed sandy loam soils[1].

Disk-chain size	Operating mass	Draft	Plowing depth
inches	lbs/blade	lbs/blade	inches
	Miles fine sandy loam — CI 1238 psi — 3.03 mph ± 0.06		
1 7/8 x 24	74	126 a	1.0 a
1 7/8 x 28	97	161 b	0.9 a
2 1/2 x 24	130	254 c	1.6 b
2 1/2 x 28	154	272 d	1.5 b
3 x 24	204	380 c	2.0 b
3 x 28	228	408 f	2.0 b
	Draft of second pass in the Miles soil — 2.99 mph ± 0.09		
1 7/8 x 24	74	157 a	—
2 1/2 x 24	180	277 b	—
3 x 24	204	343 c	—

[1] Values within colums followed by the same letter are not significantly different at the 5% level. ASAE Cone Index data in Table 2.

Table 5. Prediction equations for draft or depth (Y) of various operating masses (X) of a disk-chain pulled in different soil conditions.

Soil	CI psi	Regression equation	Standard deviation	r^2
		Draft (Y) in lbs/blade on mass (X) in lbs/blade		
Clay loam	164	Y = 13.36 + 1.77X	17	0.98
Clay loam	351	Y = −2.34 + 1.93X	6	0.99
Sandy loam	1238	Y = −10.46 + 1.88X	13	0.99
All soils	—	Y = 0.18 + 1.86X	14	0.98
		Depth (Y) in inches on mass (X) in lbs/blade		
Clay loam	164	Y = 1.65 + 0.015X	0.1	0.95
Clay loam	351	Y = 1.34 + 0.009X	0.3	0.82
Sandy loam	1238	Y = 0.40 + 0.007X	0.1	0.89
All soils	—	Y = 1.13 + 0.01X	1.0	0.25

Disking action in the disturbed clay loam soil with a CI of 164 psi was fair for the 1-7/8-inch chains, good for the 2½-inch chains and very good for the 3-inch chains. Depth of cut was 2.7 inches for the disk-chain with the lightest mass and 4.8 inches for the unit with the heaviest mass. The units with 3-inch chains appeared to be operating at near maximum depth. The equation Y = 1.65 + 0.015X well defined the mass on depth relationship with an r^2 value of 0.95.

Combination Effects

Utilizing both operating mass (M) and maximum cone index (CI) for the top 3 inches of soil to determine their relationship to draft resulted in the equation Y = 0.016 + 1.93 M – 0.009 CI with r^2 = 0.97. Mass was highly sinificant (P<.001) and cone index was not significant (P>0.1). Thus, there was an advantage in this combination and the equation was not used for predictions.

Utilizing the same two independent variables, mass and CI, appeared to be very helpful in predicting the depth of cut. Mass in lbs/blade was positively correlated to depth (r = 0.50) and cone index was negatively correlated (r = −0.78), and both variables were significant (P<0.01). The prediction equation for depth of cut in inches was Y = 2.25 + 0.01 M – 0.002 CI with a standard error of the estimate of 0.5 inches and an r^2 of 0.86.

Optimization

Optimizing disk-chain size, draft and performance narrows the window of success but still a variety of options are viable. These options are illustrated in Fig. 5 and are bounded by an operating mass between 130 and 204 pounds per blade, draft between 242 and 380 lbs/blade and depth of operation between 1.3 and 4.7 inches. Nine different size chains are available for the conditions listed.

High soil strength caused by the lack of soil moisture reflected the probable condition of rangeland needing renovation. Therefore, the 3-inch chain with 24-inch diameter disk blades at 204 lbs/blade operating mass would be the optimum choice for all conditions. If the disk-chain was going to be used predominately in disturbed or more friable soils (less than 351 psi CI) the 2½-inch chain with 24-inch blades (130 lbs/blade operating mass) would be a better choice.

Additional Considerations

We observed during testing that the 24-inch blades generally remain in a more vertical position than 28-inch blades. The larger the blade diameter the greater the torque to twist the blade from the vertical position for a given force at the base of the blade. This was evident in some tests where the more erect 24-inch blades resulted in deeper cuts than the 28-inch blade. Blade "flopping" was most noticeable with light chain operated in extra high strength soils. Performance of disk-chains using 30-inch blades was unsatisfactory because of severe blade flopping (Wiedemann and Cross, 1982). Therefore, our preference is the 24-inch diameter blade, but no larger than a 28-inch blade.

Blade spacing of 20 inches on the 2½-inch chain (every other link blade spacing, Table 6) and operating depths of 2.8 inches or greater resulted in fairly level surface conditions following tilling. However, the 3-inch chain with 24-inch blade spacing and less than 3.3 inch plowing depth resulted in a distinctive furrow/ridge pattern which was on 21-inch centers. At depths greater than 4 inches the 3-inch chains gave more even tilling. The furrow/ridge pattern may be valuable when seeding, especially in semi-arid conditions, but this concept has not been tested.

Table 6. Blade spacing using the triangular pulling technique.

Chain size	Spacing (inches) actual	operating
1 7/8	15	13.1
2 1/2	20	17.4
3	24	20.9

Conclusions

Triangular Disk-Chain

The angle of pull selected as optimum for the triangular pulling technique was 60 degrees. Narrower angles resulted in significantly greater draft and narrower operating widths. The triangular technique pulled at this optimum configuration reduced the pulling force by 36 percent and increased the operating width by 23 percent compared to the diagonal method operated at its optimum position.

A flexing joint centrally located in the rolling brace of the triangular system allowed the necessary vertical movement of the 20-inch O.D. roller to permit proper operation of the disk-chain when traversing rough land surfaces. The specially designed, flexing roller is recommended for operating widths over 25 feet.

Influence of Operating Mass

Draft of disk-chains was positively correlated to operating mass and each additional pound of mass increased draft by 1.9 pounds of force. Draft was not significantly (P<0.1) influenced by soil cone index (soil condition). Thus the draft prediction equation, Y = 0.18 + 1.86X which considers only operating mass (X), appears valid over the broad range of soil conditions tested.

Optimum operating mass per blade for disk-chains used on native rangeland with high strength soils (CI above 300 psi) is 204 lbs/blade. Disk-chains of this mass (3-inch chain and 24-inch disk blades) would require a pulling force of 380 lbs/blade ± 14 (standard deviation) and would be predicted to operate at 3.2- to 1.8-inch depth in soils with a CI of 351 to 1238 psi, respectively. Disking action for this unit was judged good to fair in these conditions. Disk-chains with an operating mass below 130 pounds per blade resulted in unsatisfactory disking action while disk-chain masses of 130 and 154 pounds per blade gave poor action in the above conditions. Disking twice with the heaviest operating mass would be necessary for good soil and plant disturbance in soils with CI values of 1200 psi.

Optimum operating mass for disk-chains used on native rangeland with low strength soils (CI less than 351 psi) is 130 lbs mass/blade (2½-inch chain and 24-inch disk blade). The draft requirement of this size disk-chain in a soil with a CI of 164 psi would be 242 lbs/blade and predicted depth of cut would be 3.6 inches. Depths close to 5 inches could be obtained with the 204 lb mass/blade in this soil condition.

Based on the broad range of soil strengths encountered in this study, the disk-chain with 3-inch chain and 24-inch disk blades would give the best overall performance.

Expected depth of operation over a broad range of conditions can be predicted most accurately by the equation Y = 2.25 + 0.01 M – 0.002 CI which combines the effects of mass (M) and cone index (CI).

Acknowledgment

We appreciate the cooperation and financial support provided in part by the USDA Forest Service; Ingersoll Products; E. Paul and Helen Buck Waggoner Foundation, Inc.; W.T. Waggoner Estate; Tongue River Ranch; and Gerral Schulz and Bridget Pinchak, Texas Agricultural Experiment Station, who assisted with the research.

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A Progress Report on the Disk Chain for Revegetating Rangeland

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The Missoula Equipment Development Center (MEDC) began evaluating a disk chain in 1984. Initial development with tillage disks welded to anchor chain was first done on the King Ranch in Texas and then by the Texas A&M Experiment Station in Vernon, Texas, and the USDA Forest Service San Dimas Equipment Development Center in California. The project was assigned to the Missoula Center and in 1984 a contract was awarded to the Texas A&M Experiment Station to continue development on the disk chain. Specifically, they were to determine the optimum chain and disk size and determine the operating angles of the implement as they relate to travel direction and draft forces. TAES developed equations to predict draft forces and cutting depth for various chain and disk sizes and soil conditions. The results are presented by H.T. Wiedemann of TAES in this report.

At the same time Texas A&M Experiment Station was accomplishing their work, MEDC built a disk chain implement for testing by the Forest Service Intermountain Station Shrub Sciences Laboratory in Provo, Utah. It included new designs for the rolling-brace, end-bearing assemblies and a method of varying the rolling brace width. The MEDC implement featured 2 and 7/16-inch anchor chain and 20- to 24-inch notched disks on alternate chain links. The end-bearing assemblies used machined shafts 4 inches in diameter and tapered roller bearings in a sealed housing instead of the crawler-tractor rollers used in the Texas A&M implement. Four bolts, or extensions, allowed chain angles of approximately 60°, 52°, and 45°. Blade weight was about 125 pounds per blade. Drawings are available at MEDC.

After trials by the Intermountain Station in Utah, Nevada, and Idaho, the disk chain was returned to MEDC to modify the split roller system and 3¼ inch chain with disks on each link to provide vertical flex for the roller on uneven ground. Only 15 links of the large chain were used so the old chain (2 and 7/16-inch links, 24-inch disks on alternate links) could be interchanged if needed. Disk blades on each link reduced the distance between blades for more intense ground coverage, and allowed cheat grass on burned areas to be more efficiently removed. Blade weight is about 145 pounds or 20 pounds per blade greater than the 2 and 7/16-inch x 24-inch alternate link blade spacing.

Split roller system.

The modified implement was returned to the Intermountain Station for evaluation in the Fall of 1985. A short-wide trailer was added to the system for broadcast seeding. It is designed to be towed by the center joint between the rollers. The seeders are powered by the tractor's electrical system and throw seed ahead of the rollers and behind the disk blades.

Drill boxes mounted over rollers.

The tests showed the following results:

The first and second chain links at both ends of each chain (2 and 7/16-inch x 24-inch) were at the link-to-link contact point more rapidly than other center links, apparently because there is more flexing of the link-to-link joint at the ends of the chain than at the center. The two links at each end on both chains were welded together to eliminate the wear at their junction and did not degrade disking performance.

The leading disk on each chain carried the greatest tilling load. These disks have the most severe angle of contact with the ground because of the curve of the chain during operation. The result was an occasional break at the disk-to-chain weld on the leading disks. They were rewelded in the field.

The one-piece rolling brace lifted the trailing end disks from the ground when the roller encountered ground irregularities. The split roller design improved the ability of the rollers to conform to the ground.

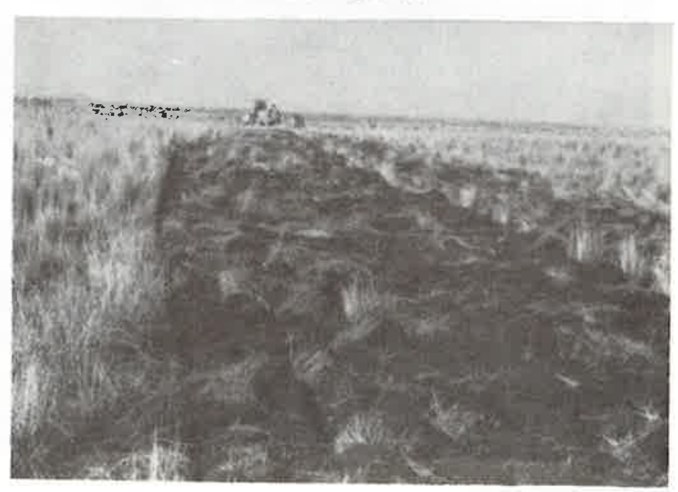
A link in the middle of each chain was modified to make it act as a swivel. This relieved a binding tendency between links in turns. The inside disks have a shorter distance to travel than the outside links, but the chain prevents a difference in the disk rotation rate. The swivels allow a difference in rotation and although the difference in rotation of the chain on either side of these swivels is slight, it is enough to relieve the binding and substantially reduce the link-to-link wear. Further testing shows that link-to-link wear is not significant.

The implement with these additional modifications was tested for green stripping (grass firebreaks) in southern Idaho. It worked well in eradicating cheat grass. However, improperly heat-treated blades were used on the 3¼-inch chain. They were a disaster. Disk breakage and weld breakage were continual. Disks must be "martempered" or "austempered", not "quenched and tempered." The small trailer was too light and it bounced over the disked ground so much that it broke the seeder mounts. Drill boxes were mounted over the rollers to correct the problem.

In FY 1987 the BLM Boise District funded MEDC to build a different disk chain. Two rollers will each be attached to a frame that will carry grass seed drill boxes over each roller. The boxes will drop the seed onto the rollers and then onto the ground as the rollers turn. The seed will be pressed into the soil surface by the rollers. The drill boxes will be powered by wheels that ride on the rollers. Each assembly will have three seed boxes—one for fluffy or trashy seed, one for small smooth seed like alfalfa, and one for cool season grass seed. The frame will also carry the end bearings for the rollers. These will be commercial heavy-duty flange blocks rather than the shop-made assemblies.

The BLM Boise District shop is building the disk chain assemblies. These will feature a bolt-on disk arrangement rather than the cut-and-weld attachment. Delivery is scheduled for October 1987.

The new implement will be extensively tested in various field conditions and results will be reported.



Disk chains are effective tools for preparing rangeland for seeding.

Information and Publications

Dick Hallman, Chairman, USDA Forest Service, Equipment Development Center, Missoula, Montana

Activities

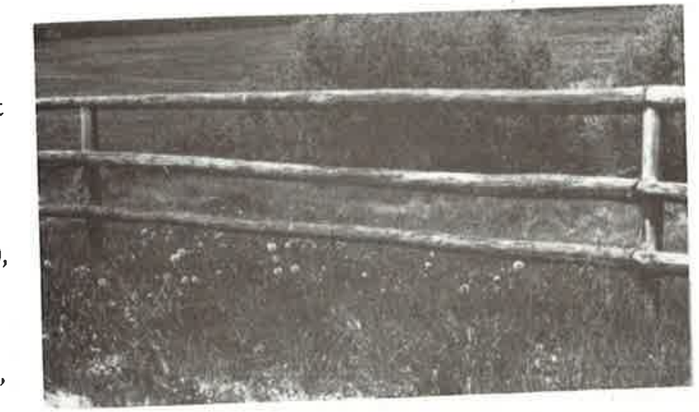
1. The VREW 40th Annual Report on the February 9-10, 1986, Orlando, Florida, meeting was prepared and 2,500 copies were printed and distributed.

2. The agenda for the 41st annual meeting, February 8-9, 1987, in Boise, Idaho, was prepared and distributed.

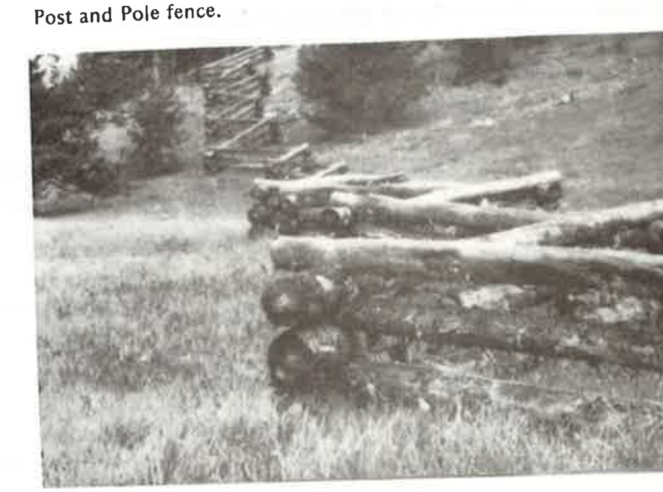
3. The VREW slide program has been updated. The presentation describes how VREW started, how it is organized, and it describes some of the many accomplishments.

4. The Missoula Equipment Development Center has been funded by the VREW to prepare and publish a four-volume Range Structural Habitat Improvement Handbook. The volumes are:

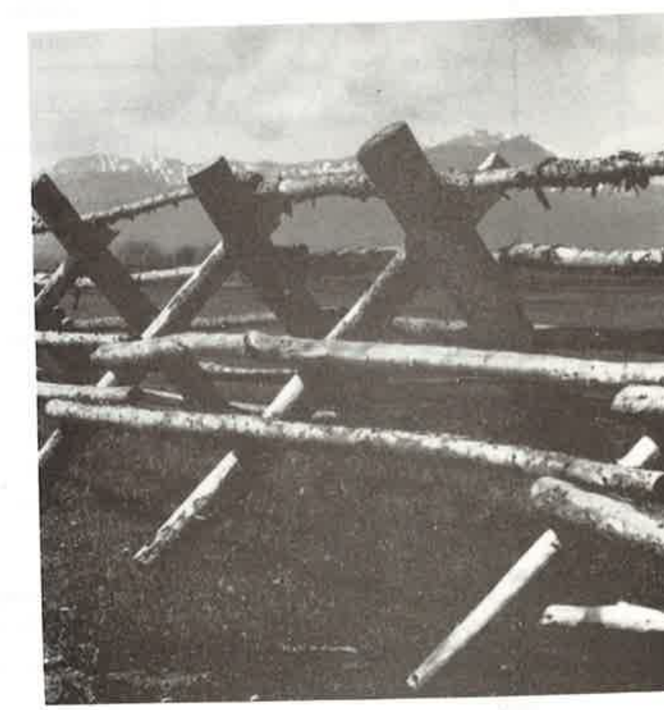
- Fences
- Handling, Trailing, and Sheltering Livestock
- Water—Pumping and Piping
- Water—Damming and Storing



Post and Pole fence.



Log Worm fence.



Jack Leg fence.