Mike Pellant

United States
Department of
Agriculture

Department of the
Interior

Forest Service

Equipment
Development
Center

Missoula, Mont.

San Dimas, Calif.

Vegetative Rehabilitation & Equipment Workshop

36th Annual Report
Denver, Colorado
February 4 & 5, 1982

2200—Range
8222 2807

Contents

Agenda

Meeting Theme: VREW's Mission—Is It Changing in the Future?

Thursday—Feb. 4

Welcome and Introductions . . . . Ted Russell, *Chairman,* VREW
Forest Service, Wash., D.C.

Introductory Remarks: VREW's Mission—Is It Changing in the Future? . . . . Craig W. Rupp
Regional Forester, R-2
Forest Service, Denver, Colo.

Morning Discussion Leader . . . . Bob Papworth
BLM, Wash., D.C.

Panel Examining VREW's Mission:

Panel Chairman. . . . . Ted Russell, *Chairman,* VREW
Forest Service, Wash., D.C.

Federal Role in VREW for the Future. . . . . Bill Davis
Forest Service, Ogden, Utah

Private Industry's Viewpoint of VREW Equipment. . . . . Kent A. Crofts
Colorado Yampa Coal Co., Steamboat Springs, Colo.

How Do We Market the Products of VREW? (from manufacturer's viewpoint) . . . . John Laird
Laird Welding and Mfg. Works, Merced, Calif.

How Does Economics Play a Role in VREW's Future?. . . . . Ray Dalen
Forest Service, Albuquerque, N.Mex.

Federal Photovoltaic Utilization Program. . . . Albert C. Lawson
Jet Propulsion Laboratory, Pasadena, Calif.

Seeding and Planting Workgroup Report . . . . . . Bill McGinnies
USDA-ARS, Fort Collins, Colo.

Lely Vertical Axis Tiller . . . . Bill McGinnies
USDA-ARS, Fort Collins, Colo.

Development of an Articulating Planter for Seeding Rough Lands . . . . Jim Truax
Truax Co., Minneapolis, Minn.

High Rate Mulch Spreading Equipment . . . . . Bob Anderson
Lo-Co Equipment Co., Windsor, Colo.

Rangeland Imprinting in Utah . . . . Thane J. Johnson
BLM, Salt Lake City, Utah

Afternoon Discussion Leader. . . . . Sam Miller
BIA, Wash., D.C.

Arid Land Seeding Workgroup Report. . . Harold T. Wiedemann
Texas Agriculture Experiment Station
Texas A & M University, Vernon, Tex.

Establishing Range Seedings By Irrigation . . . . Brice Boesch
Bishop Associates, Inc, Denver, Colo.

Revegetation of Pipeline-Disturbed Land . . . . Harry Somme
The Tye Co., Lockney, Tex.

and Imprinting Activities . . . . Robert M. Dixon
USDA-ARS, Tucson, Ariz.

Seed Coating "Hard to Drill" Seeds. . . . . . . Wendall R. Oaks
Soil Conservation Service, Los Lunas, N.Mex.

Plant Materials Workgroup Report . . . . Wendall R. Oaks
Soil Conservation Service, Los Lunas, N.Mex.

Disturbed Land Reclamation Workgroup Report (Western Subgroup). . . . . Ron Younger
BLM, Salt Lake City, Utah

Transplanting Attachment for Front-End Loader for Use in Mine Reclamation . . . . Kenneth E. Carlson
Colorado State University, Fort Collins, Colo.

Western Reclamation Group Progress Report. . . . . Wayne E. Sowards
Utah International, Inc., Craig, Colo.

Disturbed Land Reclamation Workgroup Report (Eastern Subgroup) . . . . Willis Vogel
Forest Service, Berea, Ky.

Feasibility of Direct Seeding Trees on Surface Mines in Kentucky . . . . Tom Richards
University of Kentucky, Lexington, Ky.

Seed Harvesting Workgroup Report. . . . . . Stephen B. Monsen
Forest Service, Boise, Idaho

Woodward Flail-Vac Seed Stripper . . . . C. L. Dewald
USDA-ARS, Woodward, Okla.

Steep Slope Stabilization Workgroup Report . . . . Bob Hamner
Forest Service, Portland, Oreg.

Mechanical Plant Control Workgroup Report . . . . Loren Brazell
BLM, Reno, Nev.

Mechanical Plant Control Equipment . . . . Stan Brown
Roscoe-Brown Corp., Lenox, Iowa

Information and Publications Workgroup Report. . . . . Dan W. McKenzie
Forest Service, San Dimas, Calif.

Friday—Feb. 5

Discussion Leader . . . . Larry Kleinman
Peter Kiewit and Sons' Co., Sheridan, Wyo.

Solar Water Pumping Systems . . . . Ronald W. Matlin
TriSolarCorp, Bedford, Mass.

Chemical Plant Control Workgroup Report. . . . . Ray Dalen
Forest Service, Albuquerque, N.Mex.

Structural Range Improvements Workgroup Report. . . . . Billy H. Hardman
Forest Service, Missoula, Mont.

Range Water Systems Improvements. . . . . Dan W. McKenzie
Forest Service, San Dimas, Calif.

Introductory Remarks: VREW's Mission—Is It Changing in the Future?

Craig W. Rupp, *Regional Forester,*
Rocky Mountain Region, Lakewood, Colo.

I am pleased to be with you at this workshop. I'm proud to be with a group whose goals are rehabilitating and improving our wildlife habitat and rangeland.

The purpose of this year's Workshop is to examine the question of a changing mission. Change! The only sure thing today is change! In the past, when change was called for to meet new challenges, we expanded from the range seeding committee to the more all-encompassing Vegetative Rehabilitation and Equipment Workshop. And now, we are again examining our role. While doing this, let's not put aside the tried and true concept of cooperation, coordination, and consultation. We need to sustain the working relationships of representatives from industry, universities, State governments, farmers, ranchers, Federal agencies, and representatives from neighboring countries and to forge new partnerships to accomplish the purpose of the Workshop.

To illustrate the principle that much more can be done through cooperation, coordination, and consultation in vegetative rehabilitation, I point with pride to our National Grasslands. These lands stand as evidence of a successful Federal project in which submarginal lands become productive. The program of land conservation and utilization stabilized both the land and the local economy. This could not have happened without the partnership between associations of interested farmers and ranchers, State government officials, universities, and many of the agencies of the Department of Agriculture. These National Grasslands are an excellent example of cooperation, coordination, and consultation between interested individuals.

We all need to learn more about the subjects the workgroups will be discussing; for example, some that I think are particularly vital today from this Region's need are:

- Information and publications.
- Seeding and planting.
- Disturbed land reclamation.

We must consult with each other and cooperate to accomplish our mutual objectives. Technology transfer, or getting the knowledge communicated and out to where it's needed and can be used, is a tremendous challenge that may in itself create some changes.

I would like to spend a few minutes on an old idea with a new twist, that is, integrating the management needs of all resources into one program. We have made a start, but we are not yet finished. The VREW joined with those interested in mined-land reclamation. They meet, plan and function together. But, is the Workshop integrating the goals and objectives of the mineral interests with the objectives of those who will use the land following restoration? We must provide the best opportunities for mineral development, yet enhance the basic resources when the mineral extraction is completed.

As you know, the current administration is pushing hard to be sure this country becomes less dependent on foreign energy sources. Consequently, in Colorado and Wyoming, more coal mining, oil and gas drilling, oil shale development activities with their associated impacts are escalating at a rapid pace. On the Thunder Basin National Grassland and associated private lands in Wyoming, there are two active coal mines and one uranium mine. About 200 acres per mine each year are denuded and reclaimed. In addition, four more coal mines are in line for production. We need to get these lands back into production as soon as possible; and also to prevent soil erosion and protect water quality.

Another challenge is the oil shale development, which many of us feel is just around the corner. It too will affect land that will need protective cover reestablished. A study conducted by the Range Science Department of Colorado State University verifies both adverse physical and chemical properties of restored shale. They found that not only is 3 feet of topsoil necessary for vegetative reestablishment and growth, but also a gravel capillary barrier, to prevent upward movement of salts from the shale to the overlying soil, improves vegetative growth. This, again, illustrates the need for all Federal and State entities, working with universities, the industries, and local farmers and ranchers, to develop answers to our mineral development questions by integrating the needs of all resources.

I have mentioned several challenges for us today in examining our missions. Proposition 13, inflation, and our current administration have made all of us more cost conscious. We need to find the most effective way of managing our businesses, whether it's farming, ranching, or public land management. I feel there is more need to emphasize cost efficiency in the methods and techniques of vegetative rehabilitation. Let this be another challenge for this Workshop.

A changing world challenges us to change too. We've made changes in the past, as I've pointed out earlier. Today, I challenge the Workgroups to examine their missions and see if their integration management of all resource needs are representative of the cross section here of industries, universities, State and Federal agencies. This challenge today will provide the change for tomorrow—the basis for innovative equipment development and land rehabilitation methods for the future.

Have a good Workshop!

Panel Examining VREW's Mission

Ted Russell, *VREW Chairman, Panel Chairman*

To examine the mission of VREW, we first need to know a mission is defined as, "The basic reason for the existence of the organization."

A meeting in Portland, Oreg., in December 1945, of western Forest Service personnel concerned with range seeding, marked the beginning of VREW. It was then known as the Reseeding Equipment Development Committee, and later (1958) as the Range Seeding Equipment Committee. During that meeting, the "functions" of the committee were outlined. "It was decided that the committee should consider, evaluate, and assign priorities to the equipment problems that were suggested for attention by several Forest Service Regions. Each year they should draw up a program of work for the Equipment Laboratory (U.S. Forest Service at Portland, Oreg.) to follow.

"In addition, the committee could perform a very essential function by drawing up specifications for the most desirable makes and models of equipment to be used in range reseeding . . . ."[1]

In 1949, the purpose of the committee was enlarged. The current mission of VREW is:

1. Keep abreast of the field of commercially developed equipment and make such modifications as required for wildland use.

2. Develop equipment, if not commercially available, with priority dependent upon the urgency of needs.

One additional task we do in fulfilling this mission is to periodically analyze and evaluate the purpose of our Workshop. A panel was selected to examine the current mission of VREW, with each panel member examining a specific area—Federal role, private industry role, marketing VREW products, and economics.

After the panel reports are received, the Exploratory Workgroup (steering committee members plus workgroup chairmen) will examine our current mission in view of thoughts and suggestions received, in addition to the panel reports, and report to the membership by the annual report or during next year's Workshop.

[1]Reseeding equipment development committee report, March 4, 1947, by Joseph F. Pechanec.

Federal Role in VREW for the Future

Bill Davis, *Forest Service, Ogden, Utah*

VREW, as we now call this group, had its beginning in 1945 and held its first annual meeting in 1946. By 1949, the Bureau of Land Management and Soil Conservation Service had joined the group, then called the Range Reseeding Committee. The committee was primarily interested in range seeding techniques and equipment used to do the job. It outlined four statements of purpose:

1. Evaluate available equipment suitability for range seeding (and brush control) and, if lacking, design, construct, and test appropriate equipment.

2. Prescribe specifications and standards for purchase, maintenance, and use of equipment and materials.

3. Function as a clearinghouse for the interchange of information (technology transfer).

4. Act in an advisory capacity in range seeding and undesirable plant control policies and procedures.

In 1958, the committee adopted the formal name of "Range Seeding Equipment Committee," reinforced the original four objectives, and included allied revegetation measures such as cultural soil treatments, strengthened undesirable plant control, and added some elements of structural range improvement.

Although the name has since changed and restoration of disturbed land has been added as an allied revegetation measure, the objectives of the group have not changed.

A quick glance at the 35th annual attendance report shows 218 individuals actually registered. Of these, only 26 percent were Federal employees, 16 percent were affiliated with States, 51 percent private (mostly from industry), and 7 percent from other countries.

The average number of Federal employee attendance has not changed significantly since 1953. However, Federal participants have declined in percentage from 75 percent to about 25 percent of the total, with the large increase in participants being from State agencies, universities, industry, and individuals.

To obtain a broader view on the future Federal role in VREW, I contacted several Federal agency representatives who have either been active in VREW workgroups or had knowledge of past activities. All expressed concern with the potential of little, if any, budget to operate with. Even the authority to publish an annual report is questionable.

One viewpoint was that VREW, as presently structured, has a low priority. Units with this view would rather invest their share of the financial contribution in a process of obtaining technology tailored to their specific needs, such as localized demonstrations or to seek assistance from known sources.

The predominant view expressed was for the VREW Workgroup concept to continue to function with modification as additional study may dictate. This view further included that perhaps additional new equipment is not as high priority for special funding as technology transfer. It is believed that new equipment and techniques will continue to evolve as they are needed and will be financed by interested groups, whether governmental or private. A good example of this is the Dixon rangeland imprinter pioneered by Robert Dixon, USDA-ARS. This machine is now being adopted, with modifications, by ranchers from Texas to Utah. Other examples are the large number of equipment items evolving from industry that are specifically oriented toward use on nonagronomic land.

No one visualized complete abandonment of State and Federal specialists serving as catalysts to stimulate and help coordinate development of new equipment and techniques. All emphasized a need for the best method possible for effective technology transfer, to avoid duplication of effort, and for the spread of ideas. "Best Management Practices" in one form or another was mentioned several times.

A review of Bill Leavell's introductory remarks at VREW's 34th annual meeting in San Diego described the job ahead very well. Although Bill did not specifically try to address the "Future of the Federal Role in VREW," he did an excellent job of defining the job ahead in five major points of discussion. Bill zeroed in on the need for combined cooperative effort for the development, collection, and dissemination of technology. I would like to include Bill's comments, by reference, as a part of my discussion here today.

Having been directly involved with this volunteer group for the past 11 years, and indirectly involved in field work for several previous years, there is no doubt in my mind that there is a definite need for continued Federal participation along with other copartners in VREW. The annual get-together, usually on weekends, with worldwide specialists of the rangeland improvement game and the receiving of copies of each workgroup's reports have been of great value to me in accomplishing my job of looking after the Intermountain Region's rangeland improvement program. This program amounted to slightly over $2.5 million in direct project costs each year. The opportunity to obtain a brief update of new and old ideas, to discuss items face to face with the person who has done it, and to offer suggestions for possible solutions to others' problems or obstacles, and finally obtain a summary report of the transactions, with names and places, has paid dividends for me.

It gets a bit frightening sometimes when one is faced with the necessity of providing planning advice for large projects where the wrong advice could waste several thousand dollars. This situation repeats itself several times each year in the form of rehabilitation of large wildfires and a diverse makeup of range improvement work. Each spring and fall I receive numerous calls from personnel of other agencies, as well as from ranchers, who desire to do some range improvement work and want to know about equipment, methods, or desire some other advice regarding their problem. It is a good feeling to be able to provide them with advice or steer them to some other specialist who is better qualified. Frequently, I can satisfy their needs with copies of selected articles contained in VREW annual reports.

In summary, there is an ever-increasing need for an organization such as VREW to provide a forum for specialists in rangeland improvement, whether they be employed by private industry, some government agency, or private individuals, to meet together on common ground for arriving at solutions to problems or to offer proposals in equipment or technology, and to record results for others to use.

Perhaps the high priority for developing new specialized equipment is now largely being satisfied by private industry. However, there is and will continue to be a need for establishing knowledge of equipment availability and capability to accomplish difficult jobs on wildlands. The use of equipment pool lists as well as assistance from technical services at the equipment development centers could help here.

Priority should be shifted toward effective collection and dissemination of information. There is a need for development of training aids such as audiovisuals and implementation of localized demonstrations, such as the Forest Service, with the assistance of others, conducted at Twin Falls, Idaho, last fall. Perhaps, there should be more effort toward obtaining more participation by the private range manager through assistance from Soil Conservation Districts and cooperative range planning organizations.

The dropping of any membership component from the volunteer VREW organization would be like removing a link from a chain. The Federal government should not rely on other units to get the job done anymore than the other units, State and private, should rely on the Federal government. We have essentially passed through an inhibiting environmental era and are well on our way through an era of land use planning. Let's not create an era of reinvention of the wheel.

Private Industry's Viewpoint of VREW Equipment

Kent A. Crofts, *Range Scientist, Colorado Yampa Coal Co., Steamboat Springs, Colo.*

In recent years, several participants of the Vegetative Rehabilitation and Equipment Workshop (VREW) have voiced concerns about the expanded focus of the VREW in the area of mined land reclamation and the shift away from what might be considered as the more traditional techniques involved in range improvements, which was the reason this group was organized. While some may view this shift in emphasis as a threat, I believe that any range-trained person working in the area of revegetation should view this as an immense opportunity to have new and more cost effective equipment developed for range improvements that could never be justified in terms of increased red meat production. In defense of this shift of direction, I believe that anyone familiar with the mission of VREW should welcome this change; not as a force that diminishes the role of VREW but as a force that complements and strengthens the role of VREW in the area of range improvements. Simply stated, mined land reclamation probably constitutes the most intensive, yet basic, kind of range improvement practice currently known.

To obtain a feel for the private sector dealing with VREW, I conducted a telephone poll of the reclamation representatives from 21 coal mines (which produce approximately 71 million tons of coal) in the Western States of North Dakota, Montana, Wyoming, Utah, Colorado, and New Mexico.

The questionnaire used in this survey is outlined below:

1. What types of revegetation equipment do you commonly use?

2. Do you think any improvements are needed in any of these machines?

3. What outstanding revegetation equipment needs do you currently have?

4. There is an informal group that meets every year known as the Vegetative Rehabilitation and Equipment Workshop (VREW) that is involved in the development of new revegetation equipment. Are you familiar with this group?
   a. If yes, how did you hear about VREW?
   b. If no, would you like to know more?

5. The following pieces of equipment have either been developed by or presented at previous VREW meetings. (See equipment listed in table 1.)

For each piece of equipment, the following questions were asked:

6. Are you familiar with this piece of equipment?
   Yes or No
   a. If no, would you like to learn more?
      Yes or No
      I. If yes, what would be a good forum to learn of this machine?
   b. If yes, how did you learn about this machine?

7. Have you used or seen this machine in operation?
   a. If yes, were you satisfied with its result?

8. Is there a place in you reclamation operation for the routine use of this machine?

9. On a scale of 0 to 10 (best), how well do you think this machine fulfills the need it was designed for?

10. Are there any suggestions you would make to improve the efficiency of this machine?

While it is evident that there are weaknesses inherent with this straw poll due to the diversity of conditions found on the various mine sites evaluated, it is nevertheless valuable as a starting point because it represents a preliminary means of quantifying the viewpoint of industry with respect to their feelings on VREW equipment.

The responses of the industry reclamation specialists polled are presented on tables 1, 2, and 3. According to table 1, the most commonly used pieces of revegetation equipment are the standard agricultural implements. Of the equipment presented in connection with VREW, only 4 of the 19 most commonly used pieces of revegetation equipment have been formally discussed in VREW meetings. They are the rangeland drill, Truax grass drill, contour furrower, and rotogrind tub mulcher. Of these four, only the rangeland drill was found on a majority of the mines. Seventy-five percent of the mining reclamation specialists polled used a rangeland drill; but of this group, all of them were of the opinion that the seed feeding mechanism was totally inadequate for the complex seed mixtures required to satisfy today's reseeding standards. Noticeably absent from this list are the pieces of reclamation equipment developed in connection with VREW. (The rangeland drill is a development of VREW but was developed for range seeding before VREW became interested in mine reclamation equipment.)

Outstanding equipment needs identified by the industry representatives are found in table 2. As can be observed therein, 11 areas were identified as needing better equipment. The most common need identified was to develop a transporter system larger than the sod mover or tree transplant buckets currently being tested. Among the responses found in table 2 are several references to equipment already developed in connection with VREW.

Of the people polled, 88 percent were knowledgeable of the activities of VREW. All of those who were unfamiliar with VREW expressed a willingness to learn more. When polled about how they had originally learned about VREW, 71 percent said they initially learned about VREW in connection with the Society for Range Management. The other 29 percent said they learned about VREW through a technical publication.

When asked about the specific equipment developed by, or in connection with, VREW, 67 percent of those polled stated they were familiar with the 14 pieces of equipment selected for this poll. Of the group that reported that they were familiar with this equipment, only 32 percent of those sampled reported they had personally used or seen this VREW equipment in operation. As a general rule, the reclamation people polled were more knowledgeable of the seven pieces of equipment developed in connection with the BLM-funded Energy Mineral Rehabilitation Inventory and Analysis (EMRIA) Program than the seven nonmining related pieces of reclamation equipment.

Upon evaluating the effectiveness of various types of reclamation equipment, some interesting trends appeared with respect to how satisfied the reclamation people were with the performance of VREW equipment. Of the reclamation people who had used or seen the mining reclamation equipment in operation, 49 percent were satisfied with the result obtained. The satisfaction level of the nonmining reclamation equipment was somewhat higher at 58 percent.

More importantly than the degree of satisfaction, was the opinion rendered by the reclamation specialists wherein they were asked to determine whether or not they felt they would have a place in their routine reclamation program to utilize a specific machine or the concept upon which a machine was designed. As a general rule, the industry reclamation people felt that the equipment developed for mining reclamation was somewhat less suited for routine reclamation use as compared to those pieces of reclamation equipment developed for nonmining reclamation purposes. Of those polled, 46 percent felt they would be able to use the equipment developed for mining reclamation on a routine basis, while 72 percent of the industry reclamation specialists polled felt like they would be able to routinely use the nonmining reclamation equipment in their reclamation programs.

Table 1.—*Types of revegetation equipment most commonly used and suggestions for improvements*

Type of Equipment	Percent Usage	Suggestions for Improvements
Farm disk	88	No response
Rangeland drill	75	Poor seed feeding mechanism for fluffy seed
Straw mulch blower	63	Very ineffective—hard to feed
Chisel plow	63	Weed cleaning mechanism would help
Farm grain drill	50	OK on agricultural soils
Disk-type straw crimper	50	Too light. Breaks in rocks.
Farm harrow	38	OK on agricultural soils
Cultipacker	38	OK on agricultural soils
Hydroseeder	38	No response
Truax grass drill	25	Frame is too light
Weed mower	25	Won't work in rock
Brillon seeder	25	No response
Contour furrower	25	Too big and too heavy
Broadcast seeder	25	No response
Rotogrind tub mulcher	13	No response
Sheeps foot roller	13	No response
Manure spreader	13	No response
Rock windrower	13	No response
Cultivator	13	No response

Table 2.—*Outstanding equipment needs identified*

Equipment	Percent Response
Sod-tree-bucket transporter	38
Machine to harvest native vegetation as mulch	12
Machine to conserve moisture on arid sites	12
Three-point hookup seeder-chisel plow-harrow	12
Better rock picker	12
Better clod buster	12
Machine to remove woody vegetation	12
Smaller, more versatile, contour furrower	12
Acceptable tubeling transplanter	12
Three-point hookup-mounted tree spade	12
Improved machine for steep slope stabilization in lieu of the Klodbuster	12

The familiarity of the reclamation specialists with a particular piece of equipment seemed to have no correlation as to whether or not they felt they would use a particular piece of equipment in their reclamation program. For example, the land imprinter, basin blade, modified Hodder gouger, and tree spade transplant system are reclamation systems well understood by these reclamation people; however, only a relative few of this group felt that they had any utility for their operations. On the other hand, the rangeland interseeder, sprigger for native shrubs, and vertical axis tiller were systems that were not as well known but which were rated as having a relatively high utility for their routine use in the reclamation of mined lands.

In almost every instance, the industry reclamation specialists expressed a certain amount of frustration with respect to the development of new pieces of reclamation equipment. This frustration often centered around the lack of input as to what was needed in the development of new reclamation equipment. Many felt that in too many instances, the development of new equipment was being conducted by researchers, engineers, and agency representatives who were often somewhat unfamiliar with the day-to-day limitations of mining and reclamation equipment and the regulations governing these activities. One feeling expressed was that in many instances, the most recent developments dealing with reclamation equipment were designed from the top down by researchers and administrators, while the older, more accepted pieces of reclamation equipment were designed with considerably more input from the user, or bottom up.

The subtleties found in tables 1 and 3 are very obvious in that the reclamation equipment developed in recent years has not been accepted by the mining reclamation specialists nearly as well as one would expect. One the other hand, equipment developed for other types of reclamation seems to be accepted much more readily. Although there are undoubtedly several reasons why the recently designed equipment is not being used, the industry people I talked to express two common concerns regarding this problem. The most common concern was the fact that they were being encouraged to use equipment that was designed without their input and often did not address their problems or needs and, secondly, that the newly developed reclamation equipment has, in several instances, been developed to fulfill a need for a new piece of equipment when the actual problem was the lack of experience of the equipment operator or reclamation specialist dealing with that piece of equipment.

In summary, there were some rather surprising findings discovered in this straw poll. The first, I believe, deals with the relationship of VREW and the Society of Range Management (SRM). Approximately three-fourths of those polled initially learned about VREW from the SRM. Coupled with the fact that in recent years there have been more representatives from the private sector than from the traditional Federal sector attending VREW meetings, it might seem appropriate to strengthen the ties between VREW and the SRM and broaden the foundation upon which VREW has evolved. In any event, such an alternative deserves to be explored.

The second surprising finding, I believe, that was identified by this straw poll, deals with the reluctance on the part of the industry reclamation specialists to utilize most of the recently developed pieces of reclamation equipment. This situation is most unfortunate; however, I believe that it identifies two interesting points. There is certainly a need for new reclamation equipment; however, any future development of any new equipment is going to have to have more input from the user group if it is ever going to be accepted by those responsible for using this equipment.

Table 3.—*Response of industry representatives to VREW equipment*

Developed for Mining Reclamation	Percent Positive Responses: Familiar	Seen/Used	Satisfied	Routine Use	Rating 0-10(best)
Sod mover bucket	63	50	100	100	7.7
Basin blade	75	75	50	12	4.3
Mulching-tilling system	63	37	0	12	5.0
Tree spade transplant system	88	63	12	12	4.3
Modified Hodder gouger	88	75	83	38	6.6
Dryland tubeling planter	88	0	0	50	–
Sprigger for native shrubs	50	0	0	100	0
Developed for Nonmining Reclamation					
Land Imprinter	100	50	50	38	5.3
Vertical axis tiller	50	12	100	88	6.0
Rangeland interseeder	38	12	100	88	7.0
Mechanized nursery transplant system	50	25	0	63	–
Backpack seed harvester	88	25	0	88	4.0
Steep slope seeder scarifier	50	0	0	50	–
Madge Rotoclear	50	25	100	63	10.0

How Do We Market the Products of VREW? *(from manufacturer's viewpoint)*

John Laird, *Laird Welding and Manufacturing Works, Merced, Calif.*
(Presented by Dan W. McKenzie, Forest Service, San Dimas, Calif.)

The manufacturing and marketing of rangeland vegetation and disturbed land reclamation equipment is a varied and diversified endeavor. One important step in the manufacturing and marketing of a product is to evaluate the product to determine if it can be manufactured efficiently and profitably with your firm's production equipment and methods. It also should be determined if the product will function reliably in the intended environment (in this case, rangeland). Most of the equipment developed by the Vegetative Rehabilitation and Equipment Workshop (VREW) has been designed and/or field tested by the Forest Service Equipment Development Centers at San Dimas, Calif., and Missoula, Mont.

Special-use equipment creates problems for the manufacturer due to the low volume of sales. The ability of a manufacturer to produce a product at a reasonable price, with a low unsure volume, is difficult to accomplish. An example of this difficulty is the fact that parts manufacturers require minimum orders of $500 to $1,000. With only $10 or $20 worth of a single part used on one machine, the resulting investment in bearings, castings, wheels, tires, steel, bolts, etc., quickly becomes a large liability for the small manufacturer.

Certain employee problems are inherent in a small manufacturing operation. For example, each worker has to be skilled in a variety of jobs. Also, because of the low rate of production, often employees must work independently, requiring that they display good workmanship and high productivity with little or no supervision. Craftsmen skilled at doing many different jobs are necessary, and this type of craftsman is almost nonexistent.

I have experienced these employee problems directly myself, for I have had to fill in for the bookkeeper when he was sick, as well as do the managerially related jobs. Also, I have to do engineering, fabrication, and assembly, for the expense of hiring draftsmen and engineers required for research and development would easily consume our profit. These expenses cannot be recovered by the low volume of the equipment we produce.

We, as a small manufacturer, have to rely on, and make use of, the Forest Service Equipment Development Centers' technical output, and guidance in research and development. The necessity for the Equipment Development Centers to perform this function is vital to VREW and the small manufacturer. Without it specialized revegetation equipment would be too expensive for the users, and the small manufacturer would not make this type of equipment.

Technical literature and advertising is essential and is part of the equipment cost. This is especially expensive for color literature, which costs approximately $2,000 per piece of equipment. If we recover the cost over 10 units, this literature cost will increase the cost per unit by $200. Therefore, we have limited advertising, primarily to the VREW meeting. Also, air travel and hotel costs during the VREW meeting are other expenses that have to be recovered by equipment sales. At the VREW meetings we see old friends and customers from all parts of the country. Through these contacts they learn about the type of implements we manufacture, and we learn of problems they are having with equipment we have produced and their solutions to them. Often we are able to incorporate their solutions into our future production, eliminating the problem.

We are still manufacturing the rangeland drill, seed dribbler, and Dixon land imprinter, which can usually be purchased directly from stock, with limitations, depending on the options ordered. We will build the brushland plow and contour furrower only on a bonified order as there has not been a demand for them the last several years.

We have shipped some of the implements overseas with success. The greatest problems are quoting CIF (cost, insurance, and freight) prices, for we are in the manufacturing business and not the freight business. By the time the negotiations, fabrication, and the delivery takes place, the freight prices have increased, and we have to pay the new higher freight price out of our profit.

We also have had difficulty with letters of credit from an issuing bank. Merchandise has been shipped on time but, because of delays in mail delivery, shipping documents were late arriving at the issuing bank resulting in nonpayment; then further negotiations are required that take time before payment, and time is your profit. We are making a living, but certainly not getting rich. One thing to remember, if profit is taken out of business (small business included), business could not exist.

VREW and the Forest Service Equipment Development Centers have certainly been a help to our business, and we feel we have been a help to VREW by providing a commercial source for needed rangeland revegetation and disturbed land reclamation equipment. This relationship, which as been developed largely by the efforts of VREW, is an excellent example of private enterprise and Government working together to achieve the rehabilitation of rangeland and disturbed lands at the lowest costs. Also, our exports of VREW-developed equipment, while not very large, do help with the problem of the "balance of international payments." We hope this relationship of private enterprise and Government, fostered by VREW, will continue.

How Does Economics Play a Role in VREW's Future?

Ray Dalen, *Forest Service, Albuquerque, N.Mex.*

Our Chairman, Ted Russell, has asked me to discuss the role of economics in VREW's future. First, I am not an economist by academic training. However, I have worked during the last 12 years on economic and cost-effectiveness analysis procedures at the program and project level. This past year I was part of a small workgroup assigned to develop a range allotment project cost-effectiveness analysis procedure handbook for use by range personnel in the National Forest System.

I believe we have always recognized economics in our range improvement programs. Up until now they have been based on intuitive knowledge and experience. We used equipment and techniques that were available and had been tried. In reviewing some of the early Range Seeding Equipment Committee reports, economic efficiency was implied. Our economic analysis procedures were crude and very informal. In recent years, economic analysis procedures have become more formalized and serve as a decision record. From the information I have seen, the current administration is placing greater emphasis on productivity and economic efficiency in all of our programs. This means the economic and cost-effectiveness analysis will continue to become more formalized.

We are all trying to get a fair share of the budget dollar for our range improvement programs and related support activities such as equipment development so that project work may be done more efficiently and with greater probability of success. Economics must be recognized and practiced in program and project development. This is so the program or project that is more cost-efficient and gets the "biggest bang for dollar" will be identified and this advantage should be recognized and considered in the selection.

Funds are available but limited. The Federal Land Policy and Management Act of 1976 provides that 50 percent of the grazing fees collected on National Forests and lands administered by the Bureau of Land Management in the West may be appropriated by Congress to be used for on-the-ground range rehabilitation, protection, and improvement. In FY 1982 this fund amounts to about $7 million for the National Forests and a similar or somewhat larger amount for lands administered by the Bureau of Land Management.

To assure these range improvement funds are used in a cost-effective manner requires the most efficient type of equipment available should be used and where necessary efforts should be continued to improve efficiency.

We have been developing specialized equipment for rangeland improvement for 35 years. You might ask what is there left to do. There is a demonstrated need to continue equipment development just to meet specialized situations. An example is the rangeland imprinter developed by the Agricultural Research Service in Tucson, Ariz. This equipment is designed for seeding at reduced cost under arid conditions and also increasing the probability of seeding success. This increased probability of seeding success and reduced cost of seeding combined may just make the difference in benefits compared to costs. According to the 1981 workgroup report, development of this equipment is continuing with new and different designs.

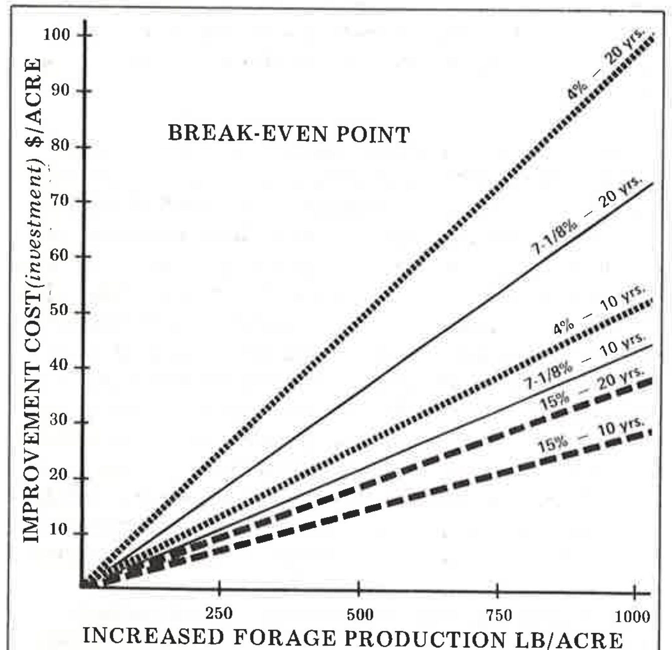
The range rehabilitation job is not completed. Much more needs to be accomplished. We have a great variety of equipment available now as one can see from the Revegetation Equipment Catalog prepared by VREW in 1980. Equipment is never perfect and can always be improved. Conditions are always changing and new ways are being found to use existing equipment more effectively, which may require equipment modification to make it cost effective or more cost effective.

To get some idea of the range rehabilitation job yet to be accomplished, the RPA assessment provides some information. According to a recent publication on the 1985 Resources Planning Act Program and Alternative Goals, more than one-half of the rangeland in the contiguous 48 States is in unsatisfactory condition which means that it is producing less than 40 percent of its natural potential productivity. Forage production can be substantially increased on rangelands by improving range condition and increasing the level or intensity of management. A much higher proportion of forage increases is expected to be produced from private holdings, as opposed to Federal range according to the RPA document mentioned above. This is because forage production potential of private rangeland is generally higher and these lands respond more favorably to cost-effective vegetation improvement practices.

In some cases, opportunities for restoration of range in unsatisfactory condition may be limited because on some ranges costs would exceed benefits. Let's use an example to illustrate the cost efficiency of a range rehabilitation project. Using an interest rate of 4, 7-1/8, and 15 percent, the break-even point can be plotted using the following assumptions: (1) One AUM (animal unit month) benefit value is $10; (2) forage intake of 600 pounds per AUM or 2 percent of body weight per day; (3) allowable use of 50 percent; (4) the improvement or practice cost is invested the first year; (5) minor maintenance costs are few or none during the project life; (6) a project life of 10 or 20 years with no forage benefits occurring the first 2 years; and (7) the primary benefit is increased forage production that is converted to AUM's and discounted to present value.

The break-even point is equivalent to a benefit-cost ratio of 1:1 or a net present value of zero. The break-even cost in dollars per acre compared to increased forage is illustrated in figure 1. When the projected increase in forage production is

250 pounds per acre over a 20-year project life, the cost of installing the improvement should not exceed $18 per acre at a 7-1/8 percent interest rate. If the production increases to 500 pounds per acre, the improvement cost can increase to, but not, exceed $36 per acre. At 750 and 1,000 pounds per acre of increased forage production, the improvement costs can reach $54 and $72 per acre. This means that at a 7-1/8 percent interest rate the cost of the range practice for the restoration of unsatisfactory rangeland generally must be in the range of $18 to $54 per acre (250 to 750 pounds per acre) to meet the break-even point.



Assumptions:

Cost: All cost occurs the first year. None or minor maintenance costs over project life.

Benefits: AUM value—$10.00
Forage intake—600 lb/AUM
Allowable use—50%
Project life—10 and 20 years; no forage benefits the first 2 years

Figure 1.—Range improvement cost compared to present value of increased forage production discounted at 4, 7-1/8, and 15 percent interest rate.

Let's take an example in the Southwest where forage production following a range improvement practice may increase somewhere between 250 and 500 pounds per acre. Using an interest rate of 7-1/8 percent and a 20-year project life, the cost per acre should not exceed $18 to $36 to break even, assuming the above assumptions and AUM forage values are valid. Equipment costs generally account for at least 60 percent of the costs. Practices vary. Some of our practices cost $40 per acre and even higher. We probably need to evaluate our practices more closely but a reduction in costs with more efficient equipment of only $5 to $10 per acre may make the difference between a good or marginal project. Regions that have higher forage production rates have greater latitude in selecting range improvement techniques but reduced costs still lead to more cost efficient practices.

The terms cost-effectiveness and cost-efficiency are used frequently and may have several meanings depending upon the user. Generally, cost efficiency refers to economic values where both the benefits and costs can be quantified and are based on market value or dollars. Cost effectiveness generally means that other considerations such as environmental and social impacts where costs and benefits are evaluated on non-market values. In managing public land all three: economic, environmental, and social impacts are evaluated in the decisionmaking process.

In the private sector the decision may be based solely on economic values. Where ranchers operate on borrowed capital with current interest rates, the cost of range improvement practice compared to expected benefits should be cost-efficient. For example, at a 15 percent discount rate and a projected forage increase of 500 to 1,000 pounds per acre over a 20-year project life, the break-even point is at about $20 to $38 per acre, using the assumptions described above.

Since the early 1970's many of the reports presented to this workshop concern mine reclamation activities that involve higher costs per acre for investments than on rangeland. According to a presentation by Michael J. Cwik on mine reclamation costs and systems at the 1980 meeting in San Diego, Calif., mine reclamation costs range from $500 to almost $5,000 per acre, with a large variable being earth movement. In his paper, it is pointed out that this treatment is done to comply with environmental degradation. The decision is still economic. It is not whether to do or not to do the reclamation treatment but to develop and implement an effective plan for the least cost to assure the desired results will be attained.

Equipment must continue to be improved to reduce operational costs. In addition, more information is needed on the operational costs of new or modified rehabilitation equipment. Equipment operational costs are difficult to separate between the efficiency of the equipment and user efficiency. Costs are

dependent on experience and efficiency of the user, site conditions, type of project, etc., but better information could be supplied. For example, only four papers at the 1979 and 1980 and three papers at the 1981 workshop provided information on equipment operations costs.

Where do we go from here to meet the economic constraints of the future? We should give consideration to the following:

1. The current effort of the Vegetative Rehabilitation and Equipment Workshop in equipment development should be continued.

2. Emphasize economic considerations in the development and modification of equipment. Is there potential for widespread or limited use? Public, private land, or both? Rangeland improvement, disturbed land reclamation, or both?

3. One of the main reasons our workshop exists is development of specialized equipment. This group must continue to operate as a clearinghouse for the dissemination of information on development, modification, and use of specialized equipment.

4. The continued efforts of this group will cost time and money. The ultimate benefits will be more cost-efficient operations on-the-ground.

Workgroup Reports

Information and Publications

Dan W. McKenzie, *Chairman*

Activities

- *Catalog—Revegetation Equipment* is no longer available from the U.S. Government Printing Office. Copies may be obtained from the Forest Service Missoula Equipment Development Center, Fort Missoula, Missoula, MT 59801.

- The VREW 35th annual report on the Tulsa, Okla., meeting was prepared and 2,000 copies printed and distributed. This report has been placed in the National Technical Information Service (NTIS). The NTIS accession number is PB82 189879; cost is $10.50 for paper copy and $4.00 for microfiche. Address requests to: National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

- The agenda for the 36th annual meeting, held at Denver, Colo., was prepared and distributed.

- The Plant Materials Workgroup prepared and Missoula Equipment Development Center published and distributed a pamphlet titled, *Sources of Seed and Planting Stock.* Additional copies are available from MEDC.

- The VREW history manuscript is almost complete with photos being obtained from various agencies and companies to replace those from the original booklet which were lost along with the camera copy of the *Catalog—Revegetation Equipment.*

- The Chemical Plant Control Workgroup is nearing completion of an aerial herbicide application handbook. See Chemical Plant Control Workgroup report by Ray Dalen for more information.

- Missoula Equipment Development Center supported a workshop for range and wildlife habitat improvement sponsored by the Intermountain Forest and Range Experiment Station, Northern Region, and the Intermountain Region of the Forest Service, and the Burley District of BLM near Twin Falls, Idaho, on the Burley District in September 1981. MEDC shot a video tape, covering the workshop, some of which will be incorporated into the Range Habitat Improvement Video Tape.

- A draft role statement for the Information and Publications Workgroup has been prepared and revised by workgroup members.

Projects

Two VREW funded projects come under the Information and Publications Workgroup. They are:

1. Range Habitat Improvement Video Tape, ED&T E22D19 at MEDC.

2. Problem Area Investigation and Definition, ED&T 1E11D42 at SDEDC.

In the Range Habitat Improvement Video Tape project, the shooting script has been reviewed, recommended changes incorporated, and about 70 percent of the video tape has been obtained or shot. MEDC plans to record the final narration, shoot the remaining tape sequences, and assemble and edit the final version. The tape should be available by mid FY 1983.

The goal of the Problem Area Investigation and Definition project is to investigate and prepare a separate prospectus or report on each problem area. A number of range equipment problem areas have been suggested, prioritized, and work on the first six prospecti has begun. They are, in order of priority:

1. Arid land seeder—being prepared by SDEDC and Jornada Experimental Range, ARS, Las Cruces, N.Mex.
2. Range fencing systems—being prepared by Colorado State University, Fort Collins, Colo., and SDEDC.
3. Disk-chain implement—being prepared by Texas A&M University, Agricultural Research and Extension Center, Vernon, Tex., and SDEDC.
4. Punch seeder—being prepared by University of Idaho, Moscow, Idaho, and SDEDC.
5. Mulch spreading equipment—being prepared by Colorado State University, Fort Collins, Colo., and SDEDC.
6. Backhoe containerized shrub injection planter attachment—being prepared by University of Idaho, Moscow, Idaho, and SDEDC.

Work not yet started on the following:

7. Reclamation of mine spoil by vertical mulching.
8. Investigation of self-leveling tractors.
9. Mineland trencher.
10. Mulch gathering equipment.
11. Bandoleer grass transplanter.
12. Backpack seed collector.

Plans

1. Complete range habitat improvement video tape.
2. Complete and publish updated VREW history.
3. Prepare, publish, and distribute VREW 36th annual report.
4. Prepare and distribute 45 days in advance of meeting agenda for 37th annual meeting to be in Albuquerque, N.Mex., February 13 and 14, 1983.
5. In FY 1982, complete four prospecti in the problem area investigation and definition project, ED&T 1E11D42.

Publications of Interest to VREW

The American Association for Vocational Instructional Materials (AAVIM) is an interstate organization of universities and colleges dedicated to improving teaching through better information and teaching aids. This organization has some very good instructional publications. Their publication list was reviewed and following are three publications from their list that may be of interest to VREW.

- *Planning for an Individual Water System* (No. 600), $6.95
- *Building Fences* (No. 405), $4.25
- *Planning Fences* (No. 404), $4.25

These publications can be ordered from:

AAVIM
Engineering Center
Athens, GA 30602
(404) 542-2586

For orders less than $10, add $1 for postage and handling. For orders over $10, add 8 percent for postage and handling.

Publications from the American Association for Vocational Instructional Materials that may be of interest to VREW.

Seeding and Planting

Bill McGinnies, *Chairman*

Lely Vertical Axis Tiller

Tests of the Lely vertical axis tiller have continued in Colorado and Wyoming. James L. Smith, University of Wyoming, has attached ripping teeth ahead of the tiller and found that this improves efficiency considerably, particularly in hard ground. In Colorado, W. J. McGinnies has been using the Lely vertical axis tiller to incorporate mulch. For effective mulch incorporation, it was found that the front of the tiller must be raised to give the tilling tines a down-and-into-the-soil action. The tiller will incorporate 1,000 pounds per acre of straw or hay mulch in one pass, but for 3,000 pounds per acre, two passes were required. Shear pin breakage was encountered when buried logs (left by a Rotoclear tree shredder) jammed the tines. Lely manufactures an automatic shear pin replacer and one of these has been obtained for testing.

The vertical axis tiller produced better seedbeds than the more conventional horizontal axis tillers or seedbeds prepared by the plow-disk-harrow procedure. The effects of these treatments on weediness during the seedling year are to be evaluated during 1982.

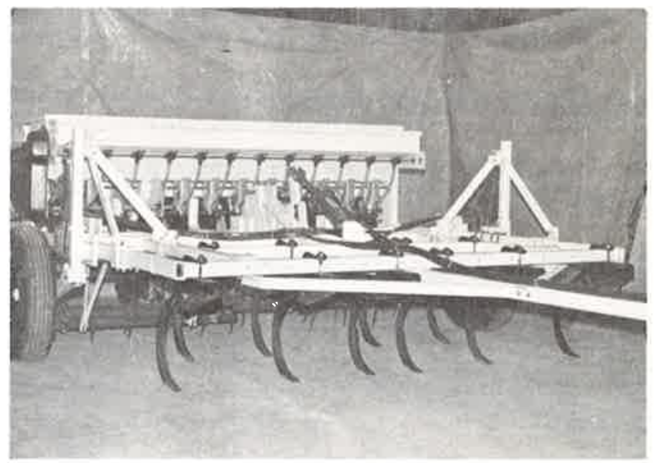
Lely vertical axis tiller.

Development of an Articulating Planter for Seeding Rough Lands

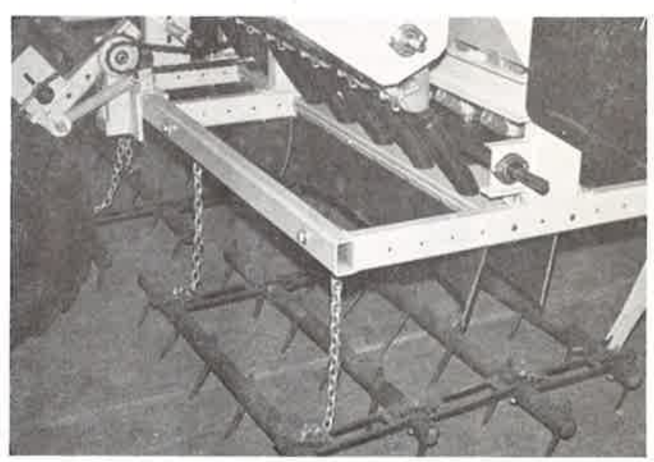
By Jim Truax, Truax Co., Minneapolis, Minn.

The double-disk opener drill or seeder has been proven to be one of the most reliable tools to plant native prairie grasses, legumes, and cereal grains on fairly well-prepared seedbeds. This is due mainly to its ability to accurately meter the seed and properly plant them in the ground. However, the double-disk drill is limited to fairly well-prepared seedbeds and, therefore, is not suited for all sites and locations.

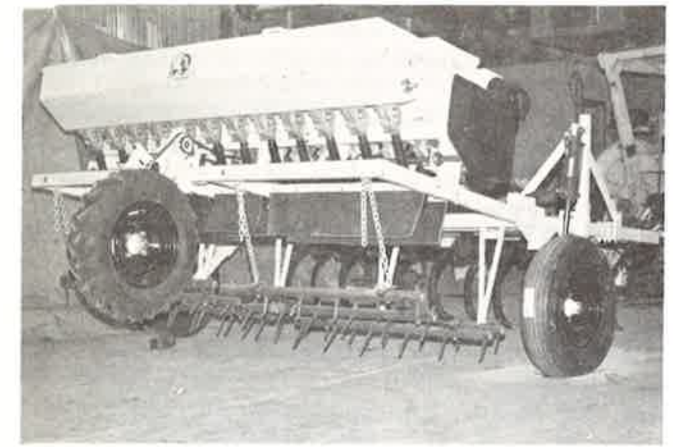
To achieve proper planting on the typical disturbed, contoured site laddened with rocks and other debris, the Truax Co. has under development an articulating planter that folds and bends with the contour as it is pulled across the site. The seedboxes, seedbox agitators, and seed-metering devices are the same as on the standard Truax drill. Field cultivators or chisel plows replace the double-disk openers.



Production prototype model of Truax Co. articulating planter showing chisel plows serving as openers.



Rubber belting used as seed guides and rolling harrow for covering the seed on the Truax articulating planter.



Seedbox, seedbox drive wheel, seed guides, and rolling harrow of the Truax articulating planter.

In place of the seed tubes, rubber belting is used to guide the seed to the ground from the seedbox. A rolling harrow or drag is used to cover the seed. The seedboxes, chisel plows, rubber belting, and rolling harrow are all carried by an articulating frame.

Chisel plows are used for openers because they are better suited to loosening the rocky soil surface and are not as subject to breaking as the disk used on double-disk openers. The rubber seed guide belting will not be damaged if the rolling harrow is lifted and contacts the belting. However, the most important feature of the new seeder is the articulating frame that bends and folds as the drill goes over uneven ground. This results in uniform depth control, constant ground contact of the seedbox drive wheel, and elimination of "bottoming out" when crossing swales and other sharp contours.

Development is not complete and field testing is still required, but it is expected that the articulating planter will provide an improved means of seeding rough, rocky, debris-laddened lands.

High Rate Mulch Spreading Equipment

By Bob Anderson, Lo-Co Equipment Co., Windsor, Colo.

The Lo-Co Equipment Co. now has available two models of high-rate mulch spreading equipment. This equipment is for sale, lease, or Lo-Co will do custom mulch spreading.

The first and most versatile is the Mulch-Master. The Mulch-Master is a modified farm tub grinder weighing 3,000 pounds. It will spread any type of mulch or mulch bale and also loose material such as bark and wood chips. This mulch spreading machine is power takeoff (PTO) powered from the towing tractor and requires a tractor of at least 100 horsepower.

Mulch-Master mulch spreader.

The second high-rate mulch spreader is the Big Bale Buster, weighing 2,800 pounds. It is operated by attaching to a farm tractor's three-point hitch and powered by the tractor PTO. This is a self-loading machine and should be used with large round bales. Small square bales do not work well and are not recommended. PTO-driven flails unroll the bale and blow the material 30 to 40 feet out. The Big Bale Buster mulch spreader requires about 30 percent less power than the Mulch-Master. Also, there is less mulch reduction with the Big Bale Buster than with the Mulch-Master.

Big Bale Buster mulch spreader.

Both machines can dispense wet moldy hay without plugging. Field production rates depend on the efficiency of handling and loading the mulch material. The Mulch-Master is usually loaded by a front-end loader tractor and will accept one or two large round bales at a time. The Big Bale Buster is self-loading but can carry and spread only one bale. When using the Big Bale Buster, the big round bales should be evenly distributed over the area to be mulched before starting mulch spreading. This increases production by reducing travel time. With either machine, strings or wires do not need to be cut or removed, which also increases production. Either machine will spread large round bales of 1,000 to 1,500 pounds at the rate of one every 3 or 4 minutes.

In Lo-Co's contract or custom mulch spreading, the Mulch-Master is generally used because of the problems and cost of obtaining large round bales. For the large round bales cost more to haul than the large square or conventional bales. In a mulch spreading project, transportation of the mulch can become a considerable cost factor when the mulch has to be hauled a long distance.

Cost of the mulch spreading equipment is $10,500 for the Mulch-Master and $4,500 for the Big Bale Buster. To obtain more information on the mulching system, contact Lo-Co Equipment Co., Windsor, CO (303) 686-2110.

Rangeland Imprinting in Utah

By Thane J. Johnson, Bureau of Land Management, Utah State Office, Salt Lake City, Utah

Many of the Great Basin rangelands in Utah are characterized by a variety of soils varying in depth, texture, and salinity, but usually limited in production by low precipitation. The moisture-collecting capability resulting from imprinting appears to be very feasible for revegetating these rangelands following fire or other land disturbances such as pipeline construction. Considerable acreage is burned each year and without rehabilitation treatment, much of this disturbed area is reverting to cheat grass and other annuals.

Jerold Hall of Levan, Utah, became interested in rangeland imprinting from reading reports of its effectiveness, both in cost and results. His interest was also stimulated by correspondence with Dr. Robert Dixon, ARS, Tucson, Ariz., who developed the imprinting concept.

Dr. Dixon provided the basic design configuration for Mr. Hall, who constructed the imprinter using discarded 5-foot asphalt rollers. Eight-inch angle iron was welded symmetrically around the cylinders. The cylinders were coupled together by a steel frame with a tongue for pulling. The combined width of the two cylinders is 10 feet with a height of almost 6 feet.

Each unit has an access so water or other liquid (such as fuel oil—used in cold climates) can be added to increase weight.

A grain drill seedbox was mounted in front of the rollers to broadcast seed ahead of imprinting. The seedbox is driven by a 10-inch rubber tire mounted on one side of a roller and driven directly by the roller. Hand-levers on the side of the seedbox control seeding rate. This rangeland imprinter, without added water for weight, weighs about 8 tons.

Interest in applying this nontillage practice to Utah's rangelands increased with the construction of the imprinter. The Little Oak Creek Burn, 10 miles southwest of Levan, during July 1981, provided a well-prepared site for a field trial of the usefulness of the rangeland imprinter compared to the rangeland drill. This wildfire covered much of the Oak Creek Mountain range evaluation area administered under a cooperative agreement between the Forest Service, Soil Conservation Service, Bureau of Land Management, Agriculture Stabilization Conservation Service, Utah State, County Soil Conservation Districts, and Utah State University.

A study site was established on the burn area and designed with two replications each of imprinting, drilling, and control. Plots were 500 feet wide and 1 mile long, containing more than 60 acres and generally oriented east to west, conforming to the general lay of the landscape.

Objectives were to:

1. Impose and evaluate several revegetation treatments at sites selected to be representative of the rangeland resources within the Great Basin.

2. Monitor over a long period and in detail, soil and vegetal responses to treatments with time following treatment.

3. Determine relative cost effectiveness of the revegetation treatments.

4. Develop new and improved revegetation systems from research results.

Seeding started on October 19 and was completed October 24, 1981. Rainfall just before the treatments provided good soil moisture and soil stability. The weather during the week of treatment consisted of sunny, comfortable working days with frosty mornings and very little wind. A grass-legume mixture of Fairway crested wheatgrass, Luna pubescent wheatgrass, Russian wildrye, and Ladak alfalfa was seeded on each treatment at a rate of 8 pounds per acre. Seeding success will be monitored and reported.

Because total depth imprints were achieved without added weight, no additional liquid weight was used. A John Deere 5020 (135-horsepower) diesel rubber-tired tractor pulled the rangeland imprinter at 5 to 6 mph. This tractor was generally adequate for the area. However, slight slopes did cause some traction difficulties. Therefore, it is recommended that the rangeland imprinter be pulled with a crawler tractor to maintain a constant travel rate.

Rangeland imprinter, constructed by Jerold Hall of Levan, Utah, for land imprinting in the Great Basin.

Pattern of imprinted area.

Arid Land Seeding

Harold T. Wiedemann, *Chairman*

A rubber-tired loader grubber (920 Caterpillar) with foam-filled tires, currently under study by the Texas Agricultural Experiment Station, Vernon, Tex., appears to hold excellent promise for a practical method to control sparse stands of small trees such as mesquite on rangeland that has become reinvaded after rootplowing. Test data indicate the wheel-loader grubber can average 9.7 acres per hour in an infestation of 22 trees per acre ± 7.

In comparing the rubber-tired loader production rate to the production rate of an equal size crawler tractor (D-4 Caterpillar), the production rates were equal at 11.5 acres per hour in an infestation of 18.6 trees per acre. In a 140 trees per acre infestation, the production rate of the rubber-tired loader was 42 percent less than the crawler tractor. However, average fuel consumption of the rubber-tired loader was 43 percent less than the crawler tractor for equal size areas worked. Soil disturbance, a drawback of grubbing with a crawler tractor, was 38 percent less in the area worked by the rubber-tired loader as compared to the crawler tractor grubbed area.

This testing indicates a rubber-tired loader grubber has the potential to maintain over 7,000 acres a year of rough rangeland. Additional detailed information on this study of the use of a rubber-tired loader for grubbing can be obtained from the Texas A&M University, Agricultural Research and Extension Center, P.O. Box 1658, Vernon, TX 76384, (817) 552-9941.

Rubber-tired loader grubber under study by Texas Agricultural Experiment Station appears practical for controlling small trees, such as mesquite, on rangeland that has been root-plowed and is being reinvaded.

Establishing Range Seedings By Irrigation

By Brice E. Boesch, Bishop Associates, Denver, Colo. (formerly with Soil Conservation Service, Denver)

It has been suggested that supplemental moisture could be applied during the first growing season to enhance the emergence and survival of seeded grasses in areas of low annual rainfall. From a technical standpoint, irrigation may overcome, or help overcome, the problem of having to reseed rangeland two or more times to get a satisfactory stand of grass. However, it is not cost-effective as it is estimated irrigation of rangeland one time to help establish a grass stand would cost $80 to $140 per acre.

To irrigate a grassland seeding, a water supply must first be found or developed and legal water rights acquired. Because the grass seeding initially would be shallow rooted, it cannot use, so would not require, deep watering. Also, many range soils are shallow and excessive watering would only emerge as seeps in other locations. An initial, and possible only, total irrigation of 1 to 3 inches for new plantings would generally be adequate. The seeding could be irrigated a second time, if desired; but this should wait until the new grass planting has used up most of the available moisture. A 3- to 6-week waiting period would normally be required before irrigating a second time.

Hand-moved solid-set sprinkler systems would be best for rangeland irrigation. Aluminum lateral lines could be used with sprinklers spaced every 40 feet on the lines. The lateral lines could be spaced 50 to 60 feet apart. Surface irrigation systems, such as graded border, would not work on the rolling topography normally encountered on rangeland. Center pivot and side roll sprinkler systems would be more costly to install and harder to move on the rolling topography of rangeland than hand-moved solid-set sprinklers.

The water could be supplied from an existing well or from a surface water source. Drilling new wells would be costly. The least expensive areas to irrigate would be within a quarter mile of the water supply, but it would be possible to pump irrigation water for distances of a mile or more. There are several drawbacks to pumping long distances, including:

1. Added mainline pipe with additional capital cost.
2. More friction loss in the extra mainline pipe, which causes higher pumping heads and thus more energy use.
3. Possible increases in elevation from the water supply resulting in higher pumping heads requiring larger pumps and more energy resulting in higher pumping costs.

The hand-moved solid-set sprinkler system could be designed to cover 600 acres a year with a 3 inch total application of water. A 2-month grass seeding establishment time in the spring is normal for most rangeland because the soil needs to warm up before seeds germinate. Plantings started too late in the season will die under the hot, summer sun.

The irrigation system could be designed to irrigate once every 4 days for 7 or 8 hours. The hand-moved pipe and sprinklers would be moved onto the area to be irrigated and set up. After the irrigation is completed, the system should be left in place for about 2 days. This allows the soil to dry out enough so the irrigation system can be moved without excessive damage to the soil and seeding.

Using one irrigation set every 4 days during a 60-day establishment period allows 15 irrigation sets per season (60 days divided by 4 = 15 sets). Covering 600 acres in one spring would require 40 acres to be irrigated at one time (600 acres divided by 15 sets = 40 acres per set).

A hand-moved solid-set irrigation system would cost approximately $400 per acre for the aluminum lateral pipelines and sprinklers. The pump and mainline costs would run from $4,000 to $6,000 if located next to the water source, and from $25,000 to $35,000 if the irrigated area were a mile away from the water source. Water well development, if required, would be expected to cost $5,000 to $15,000.

Thirty minutes to 1½ hours of labor are required per acre to move a hand-moved solid-set sprinkler system. Using an average labor requirement of 1 hour per acre, 600 hours of labor would be required to irrigate 600 acres one time.

The cost of energy to pump varies from a low of $3 to $4 per acre-inch of water for areas next to the water source, to $4 to $5 per acre-inch of water for areas a mile from the water source.

Equipment is assumed to have a 10-year life. Based on this 10-year life, equipment costs, plus energy and labor costs to irrigate rangelands to enhance the establishment of grass stands, would vary from $80 to $140 per acre.

From the above information, and from the fact that center pivot operators are not now making a profit growing corn, the only possible conclusion that can be reached is that it would not be profitable to establish range seedings by irrigation.

Revegetation of Pipeline-Disturbed Land

By Harry Somme, Tye Co., Lockney, Tex.

The pipeline construction industry has increased enormously in recent years and indicates a steady growth in the future. Until just a few years ago, the pipeline was complete when the line was laid and covered. Today, the area disturbed by the line, as well as the adjacent work areas, must be revegetated to the natural vegetative growth which existed prior to installing the pipeline. Extensive environmental impact studies determining the population and species of the native grasses along the proposed rights-of-way must be done prior to receiving permits to begin construction. Upon laying the pipeline, the disturbed area must be reseeded with the specific species and population determined by the environmental studies. This is no easy task for population and species often changing every few miles.

Special equipment often is needed for the seeding due to the terrain and the difficulty in metering the many different species of native grasses. Where terrain permits, drilling is a preferred method. A drill manufactured by the Tye Co. seeded portions of the Alaskan Natural Gas Pipeline. This unit was chosen because it has three seedboxes that can seed three different and unlike seeds (medium heavy, small dense, and light fluffy) and also dispense fertilizer all in one pass when equipped with fertilizer attachment. The unit was also equipped with opening coulters that insure a seedbed in areas of poor seedbed preparation.

Tye drill seeding on the Alaskan Natural Gas Pipeline. This drill has three seedboxes to seed three different types of seed. The drill also dispenses fertilizer at the same time when equipped with optional fertilizer attachment (not shown).

Procedures for revegetation of land disturbed by strip mining differs from those of pipeline revegetation in that topsoil is usually added and prepared into a loose, well-prepared seed-bed. Drill seeding of these areas is preferred where terrain permits, but requires a machine to meter many different types of seeds at a shallow depth. A machine manufactured by the Tye Co. is designed for shallow planting of three different and unlike seeds (medium, small dense, light fluffy) at the same time in one pass while also dispensing fertilizer.

A tye drill seeds land disturbed by strip mining near Farmington, N. Mex. This drill can seed three different types of seed and dispense fertilizer at the same time.

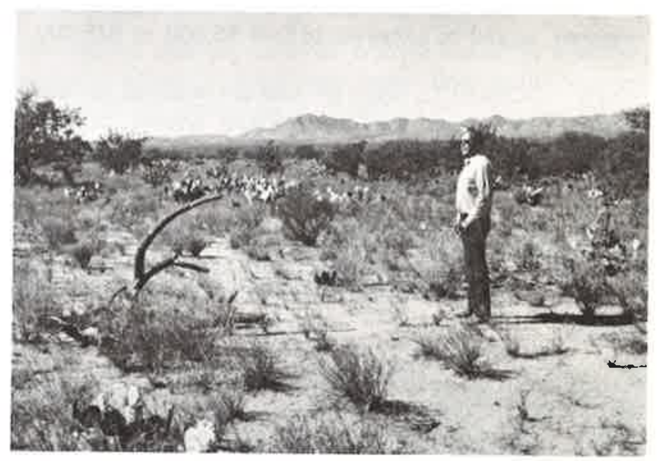
Land Imprinting Activities

By Robert M. Dixon, Agricultural Research Service, Tucson, Ariz.

Land imprinting is a spinoff of the infiltration/desertification control research that was initiated at Madison, Wis., in the early sixties and is currently being conducted at Tucson. Reduced to its fundamentals this research has shown that:

- Rainwater infiltration can be controlled by manipulating surface macroporosity and microroughness.
- These two properties interact to funnel rainwater into the soil and to funnel displaced air out of the soil.
- The collapse of these naturally occurring fluid exchange funnels is both cause and effect of man-induced land degradation or desertification, such as resulting from overgrazing, overcropping, and other land disturbances.
- To reverse desertification these funnels have to be rebuilt.
- Land imprinting is a cost-effective mechanical method for artificially rebuilding these funnels.
- Imprinter-formed funnels not only provide a good surface configuration for infiltrating rainwater, but also provide excellent seedbeds and seedling cradles for revegetating barren desertified land.
- Vegetation established in the imprints then maintains the fluid exchange funnels through natural processes in the absence of overgrazing and overcropping.

Numerous requests are being received for construction plans for the rangeland imprinter primarily in response to an article that has appeared in six different editions of John Deere's *Furrow* magazine. These requests come from farmers and ranchers in Southeastern and Western United States, Northern Mexico, Southern Canada, and Western Australia. Local rancher, Ralph Wilson, has already been successful in converting shrub-infested Upper Sonoran Desert rangeland back into grassland again using a homemade land imprinter. The new grass stand was knee high in just 6 weeks after a heavy rain that germinated the imprinter-seeded Lehmann lovegrass.



Untreated rangeland in upper Sonoran Desert.

A box-type land imprinter is being developed that is inherently more versatile in design than the conventional cylindrical types and thus should be of greater utility in reversing land denudation and desertification. The standard design consists of eight steel boxes (1 meter square and ¼ meter deep) filled with reinforced concrete and clamped together on a common axle with an axle pulling clamp. An infinite number of pattern variations are possible to better fit a given land situation and management objective.

Sonoran rangeland imprinter-seeded with Lehmann lovegrass.

Several types of hand-operated imprinters were designed, one of which has been fabricated and tested. Several interchangeable steel-faced plastic teeth were also fabricated. These hand imprinters are being developed for experimental use in small plot studies, however, they may also be useful in small-scale landscaping, gardening, and range interseeding projects.

With the successful adaptation of a commercial broadcast seeder, the rangeland imprinter has been elevated to an Imprinting Revegetation System (IRS). To improve performance and increase land treatment reproducibility, the following IRS standard testing procedure has been established for southern Arizona:

- Select imprinting roller with interconnected water-shedding and water-absorbing patterns.
- Weight roller for full tooth penetration.
- Operate roller on the contour.
- Imprint in the middle of the spring and fall dry seasons.
- Prepare adapted mix of seeds including both shrubs and grasses.
- Broadcast seed directly in front of imprinting roller to effect implanting.
- Seed at a rate half-way between broadcast and drill seeding recommendations.

Research plans are being developed for comparative analyses of IRS and the rangeland drill. Treatment effects to be contrasted will include the categories: mechanical, microhydrological, microclimatological, and biological.

Seed Coating "Hard to Drill" Seeds

By Wendall R. Oaks, Soil Conservation Service, Los Lunas Plant Materials Center, Los Lunas, N.Mex.

Most fluffy or trashy seeds are difficult to plant accurately. This is due principally to physical characteristics such as shape, size, and seed appendages. Many range seedings may have failed as a result of poor seed dispersal. Often these failures have been falsely blamed on poor weather conditions.

The objective of the project activities at the USDA, Soil Conservation Service Los Lunas Plant Materials Center (PMC) is to reevaluate the feasibility of coating trashy seed. Previous work was done in the 1950's when seed costs were very low. When seed cost 50 cents per pound, seed coating cost was uneconomical. Today, when the cost of some seed is $30 per pound (galleta), a 50 cents per pound coating cost is minimal. Economics is only one factor that might support recommending seed coating. Other advantages include:

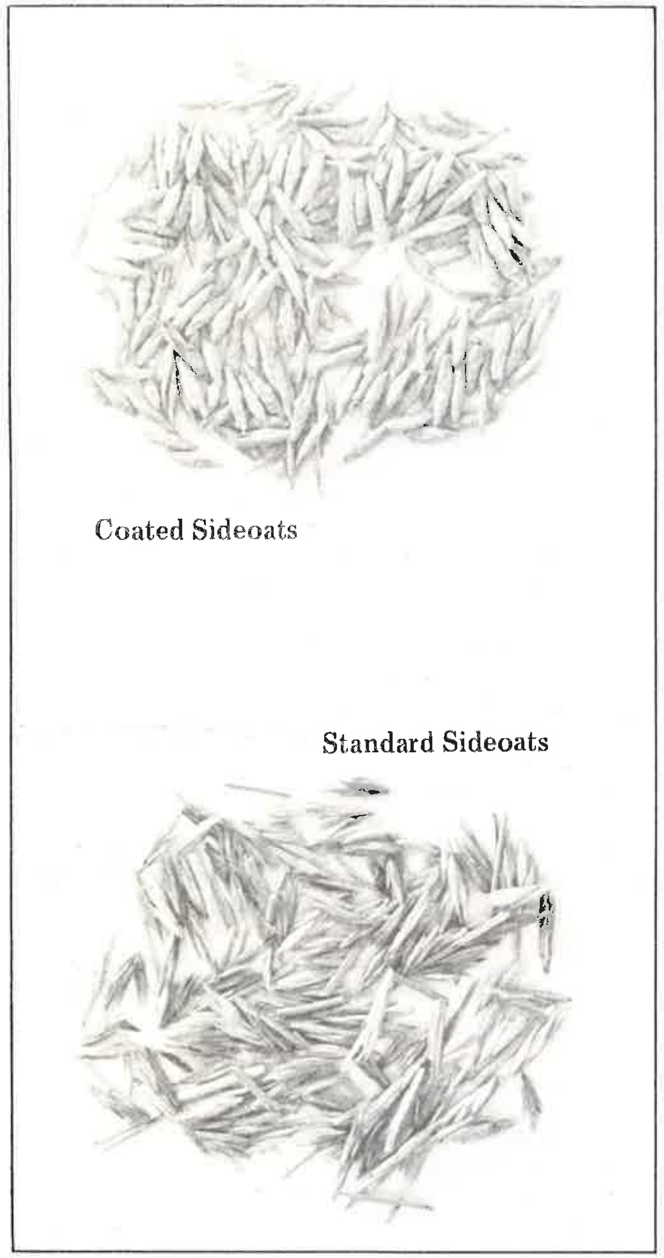
- More accurate seed placement.
- Better seed mixing.
- Use of conventional equipment.
- Inclusion of nutrients, fungicides, or herbicides in the coatings.
- Reduced seeding rates.

To date, only preliminary work has been done. However, this work has shown it is possible to coat the most trashy seed, but coating costs are higher for such seed.

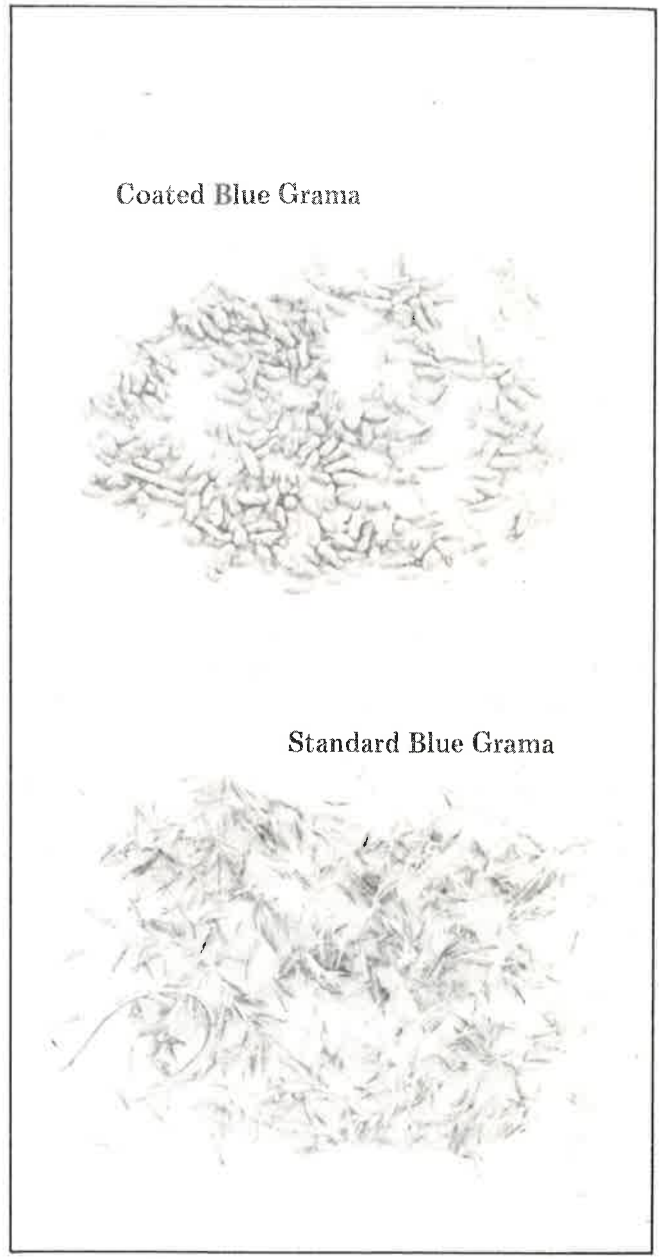
The following pictures show how the seed looked before and after treatment. All seeds were very flowable after treating. The following seeds have been successfully treated:

- Blue grama (*Bouteloua gracilis*)
- Black grama (*Bouteloua eriopoda*)
- Yellow bluestem (*Bothriochloa ischaemum*)
- Galleta (*Hilaria jamesii*)
- Sideoats (*Bouteloua curtipendula*)
- Rocky Mountain penstemon (*Penstemon strictus*)
- Indian ricegrass (*Oryzopsis hymenoides*)

More extensive studies will be carried out in 1982 to evaluate effects on germination, seed rates, nutrients, flowability, coating rates, and costs. These results will be reported at next year's VREW workshop.



Bouteloua curtipendula



Bouteloua gracilis

Plant Materials

Wendall Oaks, *Chairman*

The Plant Materials Workgroup objectives include:

1. Identification and recommendation of needed research on species, techniques, and equipment for reseeding, harvesting, and processing plant materials.

2. Dissemination of new information on adapted species, production and establishment techniques, and processing plant materials.

3. Stimulation of interaction between and among private, local, State, and Federal groups concerned with development, production, and use of new plant materials and techniques for their application.

Examples of planned projects and/or activities include:

1. Development of a listing of cultivars for reclamation.

2. Development of a slide set and narrative of new cultivars for range, pasture, and critical area stabilization, etc.

3. Development of a national source list of cultivars for use in critical area stabilization, etc.

In 1981 the workgroup concentrated its efforts on objective 2, dissemination of information on plant materials. The Plant Materials Workgroup completed a major objective toward this goal by preparing, publishing, and distributing a pamphlet titled, *Sources of Seed and Planting Stock*. The publication is available by writting the USDA Forest Service, Missoula Equipment Development Center, Bldg. 1, Fort Missoula, Missoula, MT 59801. The publication is on magnetic cards and can be easily updated. With the help of the Ecological Sciences Staff, USDA Soil Conservation Service, Washington, D.C., the workgroup plans to update this publication on an annual or biannual basis.

Other publications reviewed in 1981 and of interest to plant materials producers and users include:

Improved Plant Materials Cooperatively Released by SCS Through December 1981. Copies available from Plant Materials Workgroup chairman.

Commercial Production of SCS Released Plant Varieties 1980 Data. Copies available from Plant Materials Workgroup chairman.

Plant Materials Released in 1981

Scientific name	Cultivar	Common name	PI or other No.	Source	Date released	Agency Participation		PMC
						Primary	*Others*	
Dactylis glomerata	Berber	orchardgrass	421010	Australia	1981	SCS	AES, CA	Lockeford
Dichanthium app	T-587	old world bluestem	421783		1981	SCS	TAES	Knox City
Leucaena retuna	Yellowpuff	littleleaf leadtree	321631	TX	1981	SCS	TAES, Abilene State School	Knox City
Lupinus albicaulis	Hederma	sickle-keel lupine	P-15659	OR	1981	SCS	OR, WN, AES	Corvallis
Panicum amarum v. amarulum	Atlantic	coastal panicgrass	421136	Princess Ann, VA	1981	SCS	NJ, AES	Cape May
Panicum coloratum	Verde	kleingrass		S. Africa	1981	TX, AES	SCS	Knox City
Prunus app	Rainbow	wild plum	434240	TX	1981	SCS	TAES, TX Forest Service	Knox City
Sanguisorba minor	Delar	small burnet	464584		1981	SCS	ID, AES	Aberdeen
Secale cereale	Aroostook	cereal rye	464583	NY	1981	SCS	ME, NY, AES	Big Flats
Sorghastrum nutans	Lometa	Indiangrass	434362	TX	1981	SCS	TX, AES	Knox City
Sporobolus airoides	Saltalk	alkali sacaton	434445	OK	1981	SCS	OK, TX, AES	Knox City

The National List of Scientific Plant Names, January 1982. This two-volume publication of plants that occur in the United States mainland and Hawaii, Canada, and the Caribbean will be of value to many who continually use scientific plant names. It contains a list of correct names and synonymy of incorrect names and is available on a computer tape from the USDA Soil Conservation Service. It is also available to interactive computer terminals.

Plant Materials for Use on Surface Mined Lands in Arid and Semiarid Lands, by Ashley A. Thornburg, SCS TP 157, available from U.S. Government Printing Office or Soil Conservation Service offices.

Wayne Everett has been transferred to a new position and Wendall Oaks has become the new chairman of the Plant Materials Workgroup of VREW.

A list of plant materials released in 1981 by SCS plant materials centers is included in this report.

Disturbed Land Reclamation (Western Subgroup)

Ron Younger, *Chairman*

(Reported by Thane Johnson, Bureau of Land Management, Salt Lake City, Utah)

Following the general workshop meeting, the Disturbed Land Reclamation Workgroup (Western Subgroup) and the Arid Land Seeding Workgroup met together. One proposal made was for improving seed metering capability as there is a growing need for seeding small (expensive) seed and seeding at lower rates per acre. At present, the rangeland drill can be equipped with a front-mounted small-seed attachment and the seeding rate of the large seedbox can be reduced by changing the gear ratio driving the feed shaft. However, the workgroup members will investigate seed metering technology other than mechanical seed metering for disturbed lands reclamation.

Western Subgroup representatives gave two reports:

- Transplanting Attachment for Front-End Loader for Use in Mine Reclamation, Kenneth Carlson, Colorado State University.
- Western Reclamation Group Progress Report, Wayne E. Sowards, Utah International, Inc.

Transplanting Attachment for Front-End Loader for Use in Mine Reclamation

By Kenneth E. Carlson, Colorado State University, Fort Collins, Colo.; James L. Smith, University of Wyoming, Laramie, Wyo.; Kent A. Crofts, Colorado Yampa Coal, Steamboat Springs, Colo.; Earl Frizzell, Bureau of Mines, Spokane, Wash.
(Presented by Kenneth E. Carlson)

Introduction
Transplanting mature, native vegetation is a new and much needed development in mined land reclamation. However, design and utilization of equipment to transplant mature vegetation has not kept pace with the development of equipment capable of creating disturbed mined lands. This paper describes a research program on the design and use of a front-end loader attachment that removes, transports, and places mature, native vegetation on graded mine spoil. This research was sponsored in part by the Bureau of Mines and was a cooperative effort between Colorado State University, Fort Collins, Colo.; Colorado Yampa Coal (fomerly Energy Fuels Corp.), Steamboat Springs, Colo.; and Asbury Industries, Inc., Murrysville, Pa. The attachment was designed for a Terex 72071A front-end loader, but can be adapted to most large front-end loaders used in surface mining operations.

Transplanting native vegetation has many advantages in reclamation work that cannot be matched by other methods of tree and shrub establishment. Transplanting trees and other species not only provides growing plants and cover immediately to a disturbed site, but it also provides a nucleus for seeds and other organisms by which to repopulate the area.

In addition to developing the transplanting attachment, research was conducted in two additional areas. The first, equipment evaluation consisting of operation procedure, productivity, and attachment's effectiveness over an extended operating period; and second, the survival of the transplanted plant material.

Attachment Description
The transplant attachment is shown in figure 1. The bottom is 15 feet wide by 5 feet long (75 square feet), which is 50 percent larger than the conventional coal bucket used to transplant native vegetation before delivery of the transplant attachment. The back is 4 feet high. The rectangular box shape maximizes the square feet of material that can be moved and minimizes the damage to the plants and root systems. In the conventional bucket, the volume is maximized and as a result, when used to transport native plant material, the plants are frequently damaged or bent over due to the position and shape of the back of the bucket. The flat bottom of the bucket minimizes pad bending, which can result in severe root damage while unloading the pad at the receiving site.

Figure 1.—Transplant attachment mounted on Terex 72-71A front-end loader.

Figure 2 shows the attachment transporting a single serviceberry. This plant was over 20 feet tall and included more than 75 stems. Using a conventional bucket, this plant could not have been moved without severe damage. Aspen, ranging in height to 30 feet, were also moved successfully and stood erect when placed on the leveled spoil at the receiving site.

Figure 2.—Transporting pads.

Backfilling around a completed clump is illustrated in figure 3. This was done to cover exposed roots and reduce soil water losses. The modified bucket also has been found useful for several tasks: it is preferred to other equipment for road building, cleaning mine pits, snow removal, and for removing coal from overloaded coal train cars.

Figure 3.—Backfilling around clump.

Operating Procedure
A series of recommended steps for equipment operation are detailed below.

1. A vertical bank, or step, approximately 36 inches high is cut around the source of trees and shrubs. This is done with the front-end loader and transplant attachment.

2. With attachment bottom level to the ground and from 18 to 36 inches below the top of the vertical bank, the attachment is pushed into the bank.

3. When the attachment is full or driven to refusal, it is rolled back and/or lifted vertically, removing a pad of trees, shrubs, and soil.

4. The attachment is tilted back (towards the loader) 10 to 30 degrees and the pad is transported by the loader to the new planting or receiving site.

5. The pads are placed in areas of water and/or snow accumulation, or in drainage swales to enhance plant available water.

6. At the receiving site, the attachment is tilted forward (30 to 45 degrees), placing the front edge of the pad in contact with the ground and the loader is backed, resulting in laying the pad on the ground.

7. The loader returns to the donor area and the cycle is repeated. If necessary, any access roads are constructed or surface leveling accomplished for transplanting before picking up the next pad.

8. After completion of the clump, backfilling around the clump with spoil or topsoil is advised.

Productivity
The productivity of the front-end loader method of revegetation is greatly dependent on the distance and the type of terrain over which the pads must be moved. For moving 160 pads approximately 1 mile, travel time averaged 82 percent of the total transplanting time. The average time required for preparation and cleanup of the donor area was 1.25 minutes per pad; loading, 0.5 minutes per pad; unloading, 0.75 minutes per pad; and backfilling, 0.75 minutes per pad. These operations total 3.25 minutes of an average total round trip time of 18.2 minutes. The remainder, 14.95 minutes, was travel time.

Transplanting Costs
The present cost of operating the front-end loader at Colorado Yampa Coal is $1,600 per day, based on operator costs of $20 per hour and equipment costs of $180 per hour. For an 8-hour day average transplanting was 26 pads with an average of 9 trees and shrubs on each 75-square-foot pad. This resulted in 234 trees and shrubs being moved per day. Using these costs, transplanting per square foot costs $.82 and for each tree or shrub $6.84. Utilizing the overall survival rate of the four target species of 70 percent experienced when using the transplant attachment (table 1), a cost of $9.76 per surviving tree and shrub is calculated. As a comparison, the Vermeer tree spade was able to move 24 trees per day in tests conducted in 1977. Using 1982 operating costs of $720 per day for the Vermeer tree spade and operator, the current cost per planting each tree would be $30. Further, using survival rate experienced with the Vermeer tree spade of 25 percent will result in a cost of $120 per surviving tree.

Table 1.—*Survival percent by year*

	Aspen		Oak		Serviceberry		Chokecherry	
Year of transplant	*No. of plants*	*Percent alive*	*No. of plants*	*Percent alive*	*No. of plants*	*Percent alive*	*No. of plants*	*Percent alive*
1976[1]	138	11.6	0		12	100.	20	100.
1977[1]	1,911	25.9	227	55.1	199	95.0	275	98.2
1978[1]	2,911	18.4	37	27.0	97	90.7	146	88.4
1979[1]	2,891	21.1	48	72.9	55	89.1	171	90.6
1980[1]	72	66.7	88	2.3	57	94.7	43	86.1
Subtotal	7,923	21.5	400	42.3	420	93.3	655	94.5
1980[2]	515	47.4	421	32.8	839	80.6	1,274	84.9

[1]Conventional coal bucket transplants.
[2]Modified transplant attachment.

Costs only reflect the cost of moving larger plants. Grasses, forbs, and small shrubs, which exhibit virtually 100 percent survival, are not included. Also, no value was placed on the immediate availability of pads for wildlife cover and habitat. Wildlife use, in the author's opinion, is of sufficient value alone to justify the cost of transplanting.

Survival Results
Transplanting mature vegetation with a front-end loader was initiated at Energy Fuels (now Colorado Yampa Coal) in January 1976. A conventional coal bucket on a Terex front loader was used to dig, transport, and place the plant material from 1976 through the spring of 1980. In July 1980, the transplanting attachment was mounted on the front-end loader. From July 1 to November 1, 1980, 70 clumps of vegetation, composed of 11 or 12 pads per clump, were established. The total area of vegetation moved in 1980 was 57,000 square feet. Estimated 1981 area planted is 100,000 square feet of vegetation.

In the summer of 1980, survival data were taken on the 1976 through 1979 transplants in which the conventional coal bucket was used. The survival data for the 1980 transplants, utilizing the transplanting attachment, were taken during the summer of 1981. The survival data were collected on aspen, oak, serviceberry, and chokecherry. Table 1 summarizes the survival data.

The data indicates a substantial increase in aspen survival with the transplanting attachment. The authors attribute this increase in survival primarily to less root and plant damage as a result of using the transplanting attachment. The survival of oak, serviceberry, and chokecherry decreased. It is believed this is due to weather conditions for the summer and fall of 1980 and the winter of 1980-81, was one of the warmest and dryest on record. Continued monitoring of each year's transplants will help prove the usefulness of this equipment.

Summary
The results of this study suggest that transplanting of mature native trees and shrubs is a viable and cost-effective addition to accepted reclamation practices.

Western Reclamation Group Progress Report

By Wayne E. Sowards, Utah International, Inc., Craig, Colo.

The Western Reclamation Group was formed this past year because of concerns over current regulatory approaches to setting revegetation success standards for mined lands. Ken Brakken of Environmental Research and Technology, Inc., in Fort Collins announced the intent to form the group at the 1981 workshop. At that time, the proposed group was called the Committee to Develop Alternative Methods to Judge Success of the Revegetation of Coal Mined Lands.

The group as it exists today is comprised of mining, government, university, and consulting industry personnel with technical backgrounds. A statement of purpose and objectives of the Western Reclamation Group has been adopted as follows:

> To promote the cautious and deliberate development, revision, and application of technical reclamation standards in the western United States, the Western Reclamation Group is formed. This group will work independently to evaluate reclamation techniques and regulatory requirements. It will strive to coordinate its activities with appropriate associations and entities sharing a common concern in reclamation evaluation.
>
> Specific objectives include:
> 1. Promoting a cautious and deliberate approach to establishing reclamation standards.
> 2. Promoting flexibility for use of a variety of reclamation standards.
> 3. Promoting new concepts for evaluating reclamation.
> 4. Evaluating the validity and applicability of current concepts for determining reclamation success.
> 5. Promoting the use of economical indices of reclamation success.
> 6. Promoting the use of reclamation standards that are relevant to the end land use.
> 7. Promoting reclamation standards that support multiple land uses.
> 8. Providing a forum for the interstate exchange of reclamation information.
>
> The purposes and objectives will be achieved by:
> 1. Providing forums for interested technical people of diverse but related interests to discuss problems and needs and to recommend solutions.
> 2. Encouraging relevant literature searches and research.
> 3. Providing technical input to relevant regulatory bodies.

The group is represented by a steering committee and four working subgroups. The steering committee is made up of people from those organizations that helped form the group. They include: Sunedco; Colowyo Coal Co.; Kiewit Mining and Engineering; ARCO Coal Co.; North American Coal Co.; Shell Oil Co.; Utah International, Inc.; Camp, Dresser, and McKee, Inc.; Colorado Yampa Coal Co.; Environmental Research and Technology; Gibbs and Hill, Inc.; and AMAX Coal Co.

Four working subgroups were established last October when the Western Reclamation Group sponsored a 1-day workshop in Denver. The subgroups are now working to prepare an assessment of four major topics: (1) land use determinations and classification; (2) management of reclaimed lands; (3) quantitative evaluations procedures; (4) concepts of reclamation standards.

The subgroups have selected their own leaders and have been meeting and working together for the last 4 months. A 2-day workshop will be held April 28-29 in Denver where the subgroups will present their progress reports. The workshop will be structured to maximize exchange between the subgroups and the audience.

A final workshop will be presented in late 1982. The proceedings of this workshop will be published and will be used to try to persuade changes in regulations and guidelines. The papers should also provide information on needed research and literature search.

The Federal Office of Surface Mining is beginning to allow States greater flexibility to develop their own programs. Several Western States are developing their own guidelines to address revegetation standards. It is an appropriate time for a group such as the Western Reclamation Group to make input to these processes. At present, the subgroups are including the States of Colorado, New Mexico, Utah, Wyoming, North Dakota, and Montana in their scope of efforts.

The Western Reclamation Group is intended to provide opportunity for all technical persons with an interest in mined land revegetation standards to participate. Interested persons should contact Wayne E. Sowards by phone at (303) 824-4401 or by letter mailed to: Utah International, Inc., P.O. Box 187, Craig, CO 81626.

Disturbed Land Reclamation (Eastern Subgroup)

Willis Vogel, *Chairman*

Controlling dust on haul roads is one of the environmental problems that confronts the surface mining industry. Water sprinkling is the most commonly used method of dust control. But, when humidity decreases and temperature, wind velocity, and vehicular traffic increase, the effects of sprinkling are short-lived and more frequent passes by the water trucks are required.

A few years ago, the project engineer at the Forest Service reclamation research project in Berea, Ky., experimented with wood chips as an alternative method for controlling dust on a coal haul road in eastern Kentucky. The results strongly suggested that wood chips could significantly reduce the day-to-day use of water sprinkler trucks for controlling dust. In comparison to sprinkling, the duration of dust control was increased tenfold during a 6-hour test period by covering the road with a layer of wood chips. The blanket of chips prevented existing dust-size particles from being kicked up and swept into plumes by passing truck traffic, reduced evaporation of moisture from the road surface, and protected it from the pounding and abrasion of truck tires.

The long-term effectiveness of the wood chips was not determined. There was, however, noticeable deterioration in the chips themselves and in the continuity of the chip blanket after 6 hours of traffic-imposed stress. The mean chip width decreased by 25 percent and there was a tendency for the traffic to windrow the chips. A motor grader could respread the chip blanket to eliminate windrows and bare areas, but chip deterioration would continue under traffic stress. Moreover, each time the blanket is respread the chips will be adulterated with more fine particles from the road surface. Thus, over an extended period the day-to-day advantage of the chips is unlikely to be as great as the tenfold advantage noted during the period of the experiment.

Dust plumes stirred by coal truck as it passes from untreated segment of haul road onto section treated with wood chips.

Lack of dust plume on woodchip segment of coal truck haul road.

On the other hand, where chips are used on temporary spur roads the chip deterioration and contamination with road surface material might be beneficial when it comes time to abandon, plow under, and revegetate the roadway. The pulverized chips would be a source of organic matter to be incorporated into the organic-deficient minesoil.

The experiment does not answer some questions, such as what kind of road conditions would occur in winter where wood chips had been used, and what are the economics of wood chips compared to sprinkling? But, it does suggest that, if converted to chips, the trees that currently are waste materials on coal surface mines might be valuable for dust control during the mining operation and possible later for reclamation work. Obviously, some additional experimentation is needed.

A report on this dust control experiment can be obtained from Northeastern Forest Experiment Station, Route 2, Highway 21 East, Berea, KY 40403. Ask for Research Note NE-277, *Wood Chips for Dust Control on Surface-Mine Haul Roads.* Also available from the same address is the recently printed 190-page General Technical Report NE-68, *A Guide for Revegetating Coal Minesoils in the Eastern United States.*

In the 1981 report I discussed the need for modifying or developing equipment for direct seeding of tree species on surface-mined lands in the Eastern States. In a separate paper on page 39, experimental work with a modified row crop planter for direct seeding of tree species will be discussed by Dr. Tom Richards, Forestry Department, University of Kentucky.

Seed Harvesting

Stephen B. Monsen, *Chairman*

(Reported by Richard Stevens, Utah Division of Wildlife Resources, Ephraim, Utah)

Two backpack seed collectors have been designed, built, and tested. It is felt that a backpack seed harvester should not be built incorporating the desirable features from each unit.

Workgroup efforts have centered on locating commercially available equipment that may have some potential for collecting wildland seed. The Echo PB-400 power blower shows some promise. This unit performs either as a blower or vacuum by moving an internal baffle. Seed can be vacuumed into a bag without going through the fan. Sufficient air velocity (6,500 to 7,000 feet per minute) is produced in the 2½-inch inlet to pick up and harvest many types of seed. A representative of Echo showed the PB-400 with the PBAV-400 (vacuum attachment) at the VREW meeting. The Echo PB-400 with vacuum attachment incorporates many desirable features of a backpack seed collector—lightweight (22½ pounds), sufficient inlet velocity, no seed damage (seed does not pass through the fan), fair amount of seed storage, and easy to operate. Two of these machines have been purchased for evaluation as backpack seed collectors.

Echo PB-400 power blower with vacuum attachment that can be used as a backpack seed collector.

Woodward Flail-Vac Seed Stripper

By C. L. Dewald, Agricultural Research Service, Woodward, Okla.; and V. A. Beisel, Aarons Engineering, Fargo, Okla.

(Presented by Harold T. Wiedemann, Texas Agricultural Experiment Station, Texas A&M University, Vernon, Tex.)

A mechanical seed stripper has been developed and tested in Woodward County, Okla., which proved to be an effective seed harvester for chaffy seeded grasses such as plains, caucasian, and ganada bluestem. The effectiveness of this new mechanical seed harvester results from a revolutionary design combining the following principles:

1. A flail-action stripper brush rotating upward on its exposed and leading edge.

2. A curved shroud positioned above the brush to create a high velocity, low-pressure airflow above and behind the rotating stripper brush resulting in a vacuum near the leading edge of the rotating stripper brush.

3. A unique triangular shaped seed bin which retains the seed and turns the airflow 180 degrees where it escapes above the shroud.

Airflow pulls the seed heads into the rotating brush were seeds are removed by the flailing action of the brush. Seeds are lifted into the airstream as they are removed and propelled into the seed bin. This new seed harvester is simple, effective, and versatile. Ten 7-foot machines are being built on order, and they will cover 2 to 3 acres per hour, collecting 200 pounds of seed per acre. Cost of these 7-foot units is $4,700 each.

For more information on this seed stripper, contact C. L. Dewald, USDA-ARS, Southern Plains Range Research Station, 2000 South 18th St., Woodward, OK 73801, (405) 256-7449.

Mechanical seed stripper employing a rotating brush and airflow to collect chaffy seeded grasses in Woodward County, Okla.

Steep Slope Stabilization

Bob Hamner, *Chairman*

(Reported by Billy Hardman, Forest Service, Missoula, Mont.)

Activity of the workgroup has continued at a low level. Evaluation of the steep slope seeder is continuing on a number of revegetation sites. Results have been good to excellent as original testing indicated. It is anticipated that as word of its utility and success becomes more widespread, additional seeders will be constructed and put into use. Steve Monsen, of the Forest Service Intermountain Forest and Range Experiment Station, Boise, Idaho, has been particularly effective in providing information on the seeder and demonstrating it to various groups working on reclamation throughout the Intermountain West.

The workgroup has answered a large number of inquiries concerning revegetation related to mineral and energy fuel development. Need for revegetation of disturbed slopes has never been more apparent nor the challenge greater.

The workgroup will continue to search for new opportunities to use its collective expertise in assisting private, State, and Federal land managers in "healing over" disturbed sites. If anyone in the workshop has an idea or situation that they feel the Steep Slope Stabilization Workgroup can assist with, don't hesitate to contact us.

Mechanical Plant Control

Loren Brazell, *Chairman*

Mechanical Plant Control Equipment

By Stan Brown, Roscoe-Brown Equipment Corp., Lenox, Iowa

The Roscoe-Brown Equipment Corp. has developed a versatile, all-terrain rubber tired tractor capable of operating a variety of brush control and rehabilitation equipment. This tractor, the Brown Bear Cub, competes favorably with any track-mounted tractor on the worksite, yet has a 22 mph road speed to move between jobs.

Brown Bear Cub tractor with Morbark Eeger Beever chipper mounted on front.

Some of the desirable features of the Bear Cub tractor include: hydrostatically driven four-speed transmission; 22 mph road speed; planetary axles, rear axle with no-spin differential; hydrostatic implement (chipper) drive; ROPS and FOPS canopy with cab enclosure option with or without pressurization and heater; front only, crab, or coordinated four-wheel steering; and turbocharged engine for operation at high altitudes. The machine is powered and geared such that, theoretically, it can climb a vertical wall at ½ mph. Practically, it is limited by the engine crankcase oil sump and pump to 52 percent slope continuously and 78 percent slope intermittently in any direction (contour, downhill, or uphill).

The various interchangeable front- and rear-mounted attachments include: Eager Beever chipper, trencher, auger, back filler, backhoe, brush cutter, brush rake, brush shredder, dozer blade, snow blower, drop hammer, and forklift.

The advantages of the brush shredder were shown in an earlier publication of VREW. Now a new addition to the rehabilitation field is the Eeger Beever front-mounted chipper for large trees and clean up of areas that have large amounts of slash.

The Eeger Beever front-mounted chipper will chip material up to 1 foot in diameter and is not limited by material length.

Production rates range from 50 to 75 tons per day, depending upon material, terrain, and the rate at which the chipper can be loaded. For working with even moderately heavy loads, a man can only physically handle around 10 tons of material a day. To overcome this limitation, a knuckle boom loader for the tractor chipper combination is available that allows the operator of the tractor to handle bigger and heavier loads than a man could possibly lift. Also, in pine plantations, the Eeger Beever with a knuckle boom loader can load bulky, limby trees with ease that a man would have difficulty loading. In other applications, the knuckle boom loader makes it possible to reach trees and limbs over obstacles or obstructions such as snowbanks or ditches and feeds them to the chipper.

The chipper can be mounted or unmounted from the tractor in about 15 minutes or less and features curbside feeding and automatic feed wheel system—doesn't jerk material from operator's hands, no wood kick-back, reverse control bar—instantly reverses material flow direction, knives changed in 10 to 15 minutes, large capacity (chips chain saw trimming and chips Christmas trees without wrapping or delimbing).

For more information on this combination of tractor and chipping unit, contact Roscoe-Brown Corp., P.O. Box 48, Lennox, Iowa 50851, (515) 333-4551.

Chemical Plant Control

Ray Dalen, *Chairman*

Work is continuing on the aerial herbicide application handbook. This past year Dr. Norman B. Akesson, University of California at Davis, reviewed the draft of the handbook and made several revisions, including adding some new material. These proposed revisions are now being reviewed at the Missoula Equipment Development Center. Publication is expected in FY 1983.

Structural Range Improvements

Billy H. Hardman, *Chairman*

Three of the invited speakers at this meeting are here as an outgrowth of the Structural Range Improvements Workgroup activities. Two deal with water pumping systems and one with electric fencing. They are:

- Federal Photovoltaic Utilization Program by Albert Lawson, Jet Propulsion Laboratory.
- Solar Water Pumping Systems by Ron Matlin, TriSolarCorp.
- Electric Fencing—A State-of-the-Art Review by R. Garth Taylor, Colorado State University.

There has been progress in the project Range Water Systems Improvements concerning solar and wind as an energy source for pumping livestock water and preventing livestock drinking water from freezing. Dan McKenzie, San Dimas Equipment Development Center, is the project leader and will give use a progress report on each task.

During 1981, the report *State-of-the-Art Review of Rangeland Fencing Systems,* which is being prepared under the "Problem Area Investigation and Definition" project, was reviewed by the workgroup. In this review, the workgroup also reviewed three publications on fencing that may be helpful in planning and constructing rangeland fences. They are:

Building Fences, No. 405, $4.25
Planning Fences, No. 404, $4.25

Available from:

American Association for Vocational Instructional Materials
Engineering Center
Athens, GA 30602

(For orders of less than $10, add $1 for postage and handling; for orders over $10, add 8 percent for postage and handling.)

How to Build Fences with Max-Ten 200 High-Tensile Fence Wire, $5

Available from:

United States Steel Corp.
Pittsburgh, PA 15230

The first publication is on basic fence building; the second is on advanced fence-building and fence layout; and the third is on the use of high-tensile smooth wire for fencing and also contains a very good chapter on electric fencing.

The workgroup also met while at Denver to discuss new initiatives for the workgroup.

Range Water Systems Improvements Project ED&T 0E01D40

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

The goals of this project are to improve range water supplies and systems for pumping and handling range water. The objectives, as determined by the Structural Range Improvements Workgroup, are to: (1) Investigate and develop systems for inhibiting or preventing stock watering tanks from freezing and, (2) investigate and develop solar water pumping systems as alternatives to the conventional windmill.

The Range Water Improvements Systems project is very appropriate at this time because of the large amount of development work currently being done in the area of solar water pumping. Some of the developments, under some circumstances, have the potential to produce pumping systems that could replace the conventional windmill.

The long-range plan for this project is to produce a handbook on rangeland water pumping systems.

Preventing Stock Water Tanks from Freezing

The San Dimas Equipment Development Center is investigating methods to keep stock water tanks from icing over and preventing livestock from drinking. This investigation includes contacting stockmen, universities, and U.S. and foreign patent offices. Also included are a computer search of Department of Energy publication files and a review of livestock journals, equipment publications, and livestock supply catalogs.

So far, this investigation has revealed a number of ways to inhibit or prevent stock water tanks from freezing, but most are not well known nor widely used. The Center is preparing a report detailing current methods of inhibiting or preventing stock water tanks from freezing (for more details on some of these methods, see VREW, 35th annual report, Tulsa, Okla., February 8 and 9, 1981) along with proposed systems for development.

Solar Water Pumping Systems

Three categories of equipment may offer alternatives to the conventional windmill: (1) photovoltaic powered pumping systems, (2) solar-thermal pumping systems, and (3) improved or new windmills. In the photovoltaic and improved and new windmill categories, considerable research and development is underway with promising new units being developed. In the solar-thermal category, demonstration equipment is still being operated, but few if any new units are being produced.

Photovoltaic Pumping Systems
Federal agencies have purchased a number of photovoltaic water pumping systems with "Federal Photovoltaic Utilization Program" funds. This program is managed for the Department of Energy by the Jet Propulsion Laboratory (JPL), Pasadena, Calif. These applications are described in detail in the JPL report *Federal Photovoltaic Utilization Program, Water Pump Application*. Copies are available from JPL.

The World Bank project, "Testing and Demonstration of Small-Scale Solar-Powered Pumping Systems," has completed and published two reports in the last year:

> *Small-Scale Solar-Powered Irrigation Pumping Systems—Phase 1 Project Report*, July 1981
>
> *Small-Scale Solar-Powered Irrigation Pumping Systems, Technical and Economic Review*, September 1981

The World Bank project to date has considered only low lifts (15 feet). Most range applications are much greater than 15 feet, but the reports contain much useful information on photovoltaic systems. One conclusion from the World Bank reports was ". . . that the choice of pump can be perhaps the single most influential factor in a small-scale solar photovoltaic pumping system design." This is true because pump efficiency can vary greatly, resulting in considerable cost differences in a solar pumping system with the current cost of $9 to $12 per peak watt for photovoltaic modules.

The World Bank solar water-pumping project is continuing and will include water pumping lifts of over 65 feet. This will result in test and evaluation of water-pumping systems that are closer to range water-pumping systems.

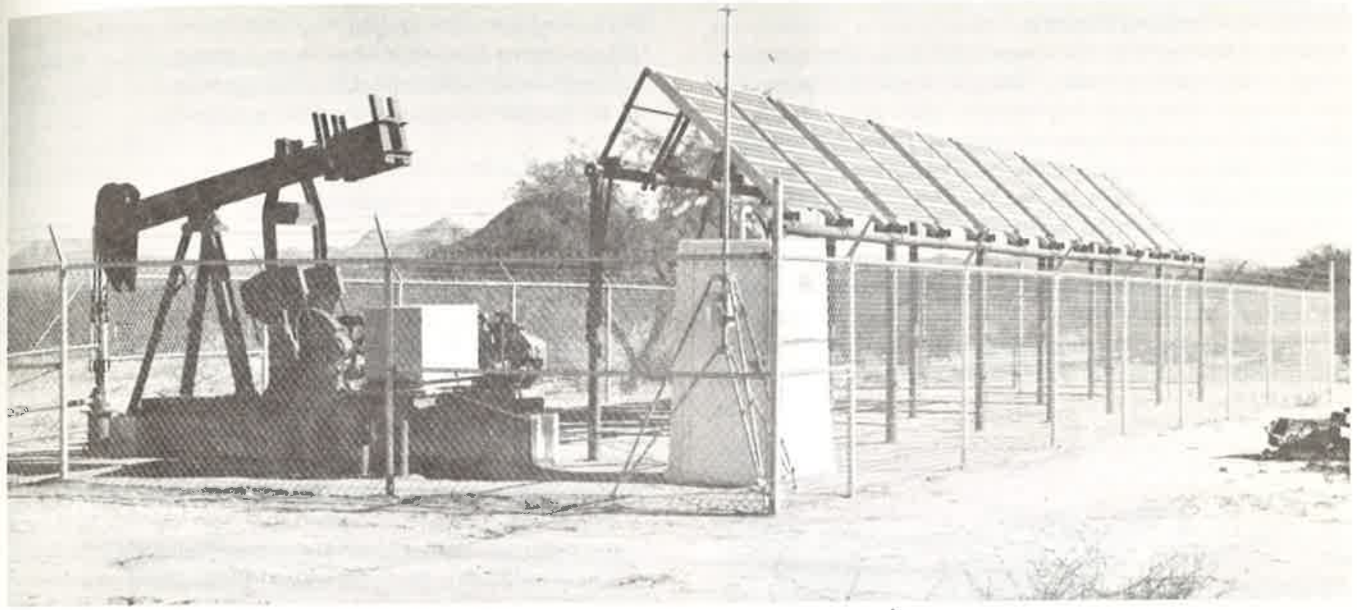
A very good starting point on stand-alone power systems with batteries is the book *How to Design An Independent Power System* by Terrance Paul. It is available for $4.95 from Best Energy Systems for Tomorrow, Inc., P.O. Box 280, Necedah, WI 54646, (605) 565-7200. This book points out: "Batteries are a major cost component in any independent power system. Indeed in typical wind, photovoltaic or hydro systems, over the long haul, they are *the most* expensive component. For batteries not only cost a lot initially, they wear out." Therefore, it would be desirable not to have batteries in water-pumping systems if possible.

Photovoltaic-powered conventional rod and well-cylinder pumps have been designed and operated without batteries. Three systems that power photovoltaic pumping systems without batteries are: (1) Maximum power controller systems, (2) series-parallel photovoltaic panel switching, and (3) large or oversized solar arrays.

To understand how positive displacement photovoltaic-powered pumping systems can be operated without batteries, the following information is necessary:

> Conventional rod and well-cylinder pumps are positive displacement type pumps that require a starting torque approximately equal to running torque. Torque of a dc electric motor is approximately proportional to current or amperage. The speed of a dc motor, when adequate amperage is available, is approximately proportional to voltage. The output power (horsepower) of a dc electric is directly proportional to speed (rpm) times torque. Because speed is approximately proportional to voltage, and torque is approximately proportional to amperage, power output of a dc electric motor will be approximately proportional to voltage times amperage. Therefore, changing voltage and/or amperage will result in changes in rpm, torque, and output power. The amperage output of a photovoltaic module is approximately proportional to solar radiation intensity. The voltage ouput of photovoltaic modules is almost constant with only a small increase as solar radiation increases. Therefore, to operate a positive displacement type pump, a system must be used that supplies adequate amperage to the motor to overcome the approximately constant torque of the pump, both starting and running. The three methods listed above are designed to do this.

Maximum Power Controller System
A maximum power controller system will take the low amperage and constant voltage output of photovoltaic modules just after sunrise and convert it to high amperage (enough to start and run the pump) and lower voltage (pump will run slow). As the day progresses, the photovoltaic modules will produce higher amperage and the constant voltage. Then, the maximum power controller will convert this to a little higher amperage and a little lower voltage, resulting in faster motor speed and more water pumped. On large photovoltaic-powered systems, at the current cost of $9 to $12 per watt for photovoltaic power, the maximum power controller system has a cost advantage. If the cost of photovoltaic power drops markedly, the maximum power controller will lose some of its advantage. The maximum power controller is designed and marketed by TriSolarCorp, 10 De Angelo Dr., Bedford, MA 01730; (617) 275-1200.



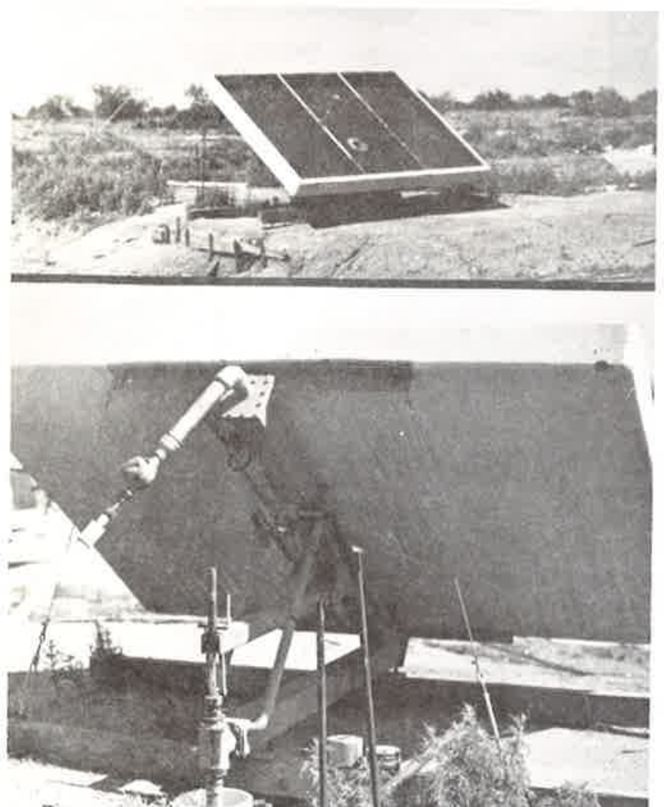
Photovoltaic-powered water-pumping system using a maximum power control and no batteries powering a 3-horsepower motor, located at Queens Well on the Papago Indian Reservation near Tucson, Ariz.

Series-Parallel Photovoltaic Panel Switching
In a series-parallel photovoltaic panel switching system, panels are divided into two equal sets. Within each set, the panels are connected in series and then each set is connected to a switching unit that will either connect the two series-wired sets of panels in parallel for combined amperage output or in series for combined voltage output. During times of low solar radiation, such as early morning or during cloud cover, the switching unit will connect the sets of panels in parallel, resulting in a high amperage and low voltage output that will start or keep the motor running, but at half speed. Series-parallel photovoltaic panel switching devices for operating water pump units are being marketed by GPL Industries, 4528 El Camino Corto, La Canada, CA 91011, (213) 790-0762.

New type pump jack powered by series-parallel photovoltaic panel switching.

Large or Oversized Solar Arrays
For a large or oversized solar array system, the power rating at solar noon of the panels, or array, is much larger than the power required to run the pump motor. This method of operating water-pumping systems without batteries is very simple to hook up. All that is required are the photovoltaic panels and the dc motor. Because at solar noon considerable available power that cannot be used by the dc motor driving the water pump is lost in this method, it would not be desirable for installations powering large motors. However, because of its simplicity, this method may be a very desirable method to use for powering a relatively low-power pumping system. Photovoltaic water-pumping systems using this method are marketed by the William Lamb Co., 10615 Chandler Blvd., North Hollywood, CA 91601, (213) 980-6248.

Solar-Thermal Pumping Systems
That part of the World Bank's report that deals with solar-thermal power systems states, "Despite the long history [solar-thermal water-pumping systems were operating in 1903] of solar-thermal powered systems, there are still no manufacturers producing systems on a commercial basis in the world market. In the consultant's opinion [Sir William Halcrow and Partners/Intermediate Technology Power, Ltd.], none of the systems currently available are as yet sufficiently developed to be viable in comparison with many other energy conversion systems under free market conditions. Nevertheless, there are a number of prototype devices that could possibly offer prospects for development into viable pumping systems."



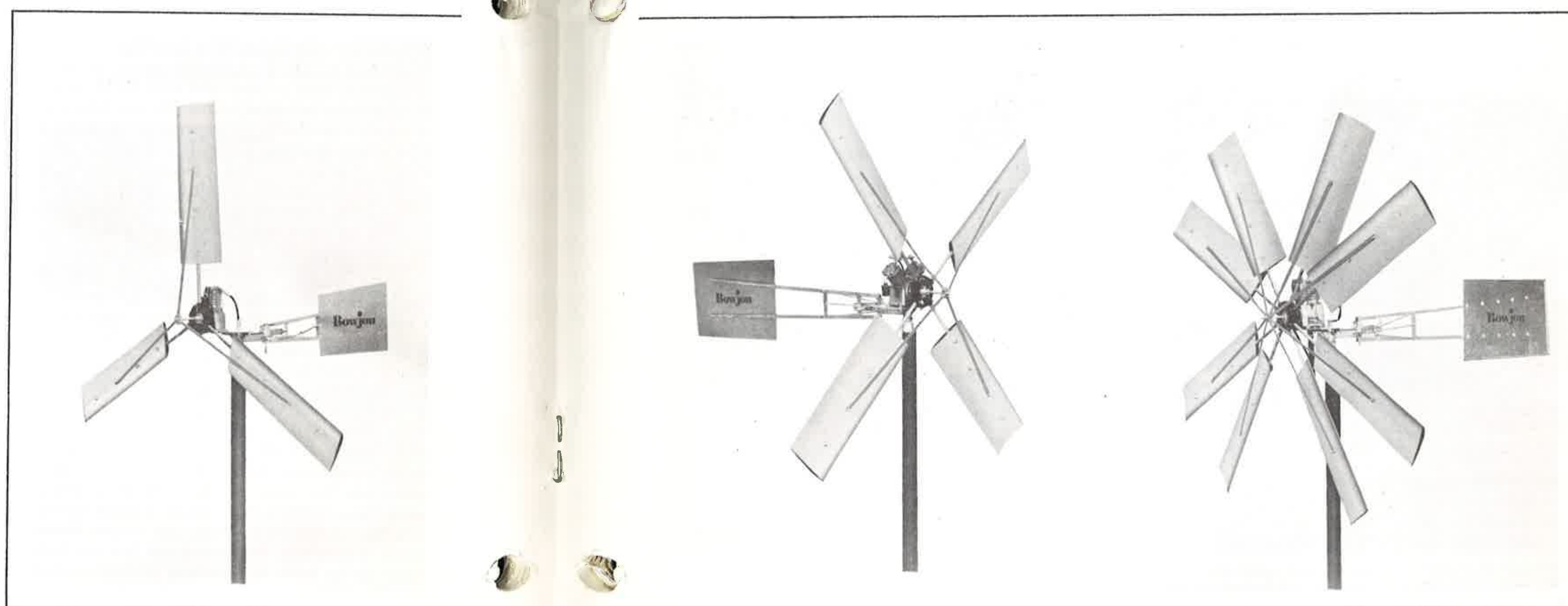
Solar-thermal water pumping system operating near Tucson, Ariz.

Improved or New Windmills
Improvements are being made to the new design windmill that produces compressed air. This was reported on last year. The compressed air is used to lift water directly by an airlift or bubble pump, or by a compressed air-operated pump. This windmill is now available with from three to eight blades. The eight-bladed unit is for light wind areas. This windmill is available from Bowjon International, Inc., 2829 Burton Ave., Burbank, CA 91504, (213) 846-2620.

Work continues on improving conventional windmills. Improvements learned of last year include: (1) A fully counterbalanced windmill, (2) a cam-operated windmill, and (3) an automatic stroke control for windmills.

Also, USDA ARS is developing and testing an ac submersible pump driven by an ac wind generator.

A windmill is now being produced that can be fully counterbalanced so one half of the pumping work is done on the upstroke and one half on the downstroke. Fully counterbalancing a windmill allows the windmill to start and pump water at lower windspeeds than a windmill that is not counterbalanced. When fully counterbalanced, the required starting torque is reduced to half that required of a conventional windmill. (It is not good practice to attempt to fully counterbalance a conventional windmill.) Through extensive testing on the Navajo Indian Reservation near Window Rock, Ariz., it was determined that the fully counterbalanced windmill will pump substantially more water (13.46 times) at windspeeds below 10 mph than a conventional windmill, and at windspeeds above 10 mph, 32 percent more water was pumped. This windmill, which can be fully counterbalanced, is available in a 16-foot size only, from the Wind Baron Corp., 3702 West Lower Buckeye Rd., Phoenix, AZ 85009, (602) 269-6900.



Compressed air producing windmills. Eight-bladed model is for areas with light winds.

A private individual is developing a cam-operated windmill. It uses three quarters of the pumping cycle for lifting, and only one quarter for return. The cam mechanism reduces the starting torque required to less than half that of a conventional windmill. This allows the windmill to start and pump water at lower windspeeds than a conventional windmill. Limited production models have been produced.

Another individual is developing an automatic stroke-control for conventional windmills. This stroke-control device automatically changes the pump stroke to match the pumping-load to the power that can be produced by the windmill at the speed the wind is blowing. The results are that the windmill will start pumping at lower windspeeds. At high windspeeds, much more water will be pumped than with a conventional windmill without the automatic stroke control. A demonstration model of the automatic stroke control has been designed, fabricated, and tested. Test results were good.

USDA ARS at the Conservation and Production Laboratory, Bushland, Tex., is investigating coupling an ac submersible centrifugal pump directly to an ac wind generator. The load of a centrifugal pump increases in the same way as the power that can be produced by a wind generator, with increased windspeed. Therefore; an increased output of an ac wind generator will be automatically absorbed by a centrifugal pump resulting in a system where the components are well and easily matched.

Federal Photovoltaic Utilization Program

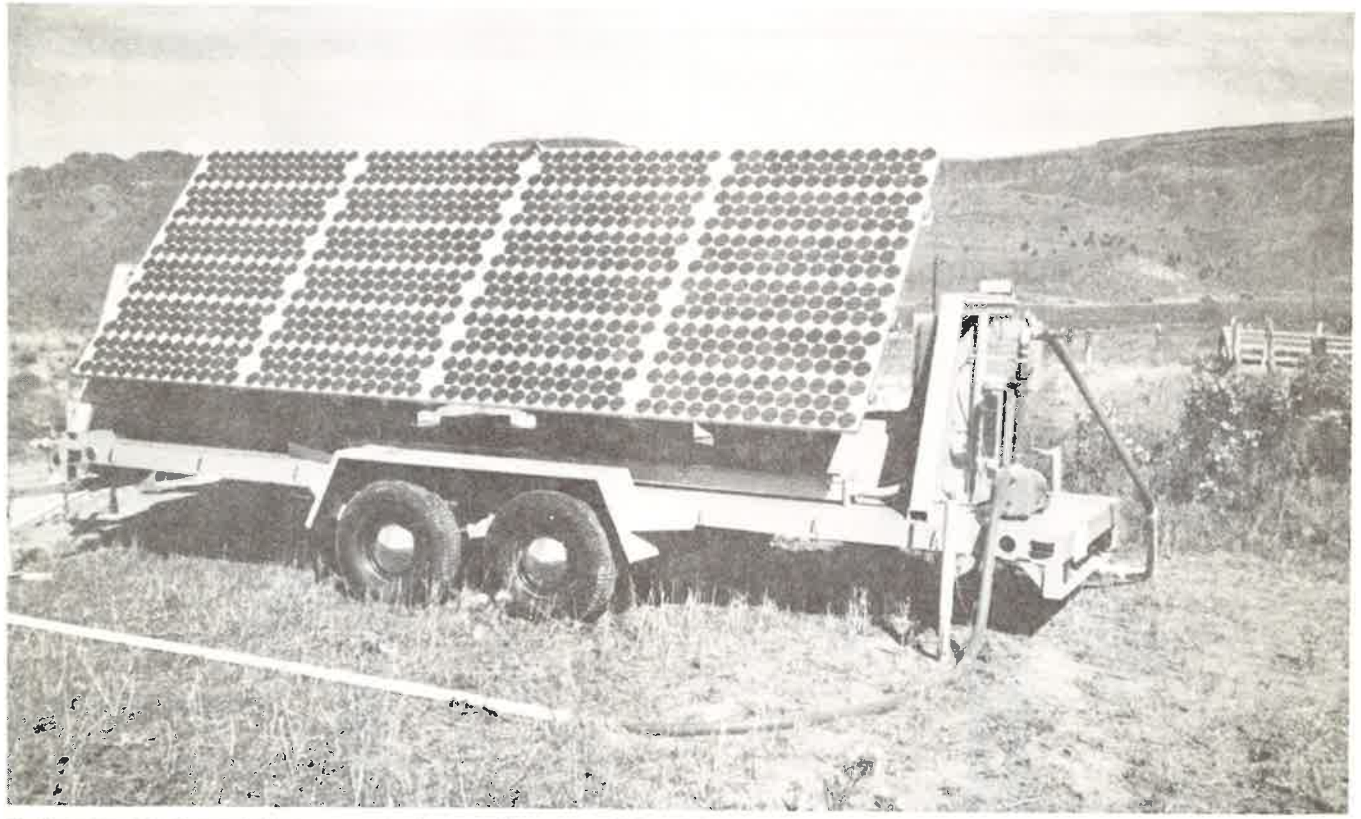
Albert C. Lawson, *Federal Photovoltaic Utilization Program, Jet Propulsion Laboratory, Pasadena, Calif.*

The Federal Photovoltaic Utilization Program (FPUP) is part of the continuing Federal support to the development of solar energy, specifically, photovoltaics technology. FPUP is a $22.5 million effort with the Jet Propulsion Laboratory serving as manager of the program for the Department of Energy (DOE). DOE expects FPUP to assist in accelerating the market development of photovoltaic technology and reduce the cost of photovoltaic applications. DOE anticipates that experience in using this technology will provide important feedback for continuing research and development efforts, which will result in even more improved products, at reduced costs.

The total number of applications funded under FPUP now stands at 2,781, representing a total estimated power of over 650 kW_p. Forty-four States are represented by applications; 24 Federal organizations within the various government departments submitted applications that have been approved for funding by the Federal Photovoltaic Utilization Program. Represented are: Departments of Agriculture, Commerce, Defense, Energy, Interior, State, Transportation, and Treasury, as well as the Environmental Protection Agency, General Services Administration, Tennessee Valley Authority, and National Aeronautics and Space Administration.

The Department of Agriculture, Forest Service, Department of the Interior, National Park Service, Department of Health and Human Services, Indian Health Service range of approved applications consists of lighting, water pumping, venting systems, repeaters, instrumentation, and communications. These applications are located in 51 different National Forests, National Monuments, and National Parks, and five different Indian reservations.

Most of the Forest Service applications provide power for venting systems and lighting. These photovoltaic systems provide power for sanitary facilities and for Forest lookout towers. There are also some water pumping systems. The National Park Service photovoltaic power systems consist of repeaters and communications instrumentation in remote areas. The Indian Health Service applications are, for the most part, in the area of domestic water pumping and lighting.



Trailer-mounted photovoltaic power and water pumping system. This unit has a 1-horsepower centrifugal pump and can provide power in 12- and 24-volt dc and 115-volt ac. This unit was funded by the Federal Photovoltaic Utilization Program.

Industry response to the program has been very good. There has been a steady increase in the number of companies that have developed capabilities and are seeking to provide photovoltaic systems (from 12 to 34 in the past year). In addition, "the complete systems procurement" concept for contracting for photovoltaic-powered systems is gaining acceptance. In this concept, the contractor is responsible for the design and installation of the complete system, including, of course, solar modules and all other system components. They are also agreeing to provide full 2-year warranties on their systems after installation. Battery manufacturers are also giving increased attention to photovoltaic applications.

Benefits of Federal Photovoltaic Utilization Program are:

1. Federal agencies are gaining experience in RFP's (Request for Proposals), in evaluating proposals, contracting, and operating photovoltaic systems.

2. System suppliers are learning how to design, install, operate, and warranty photovoltaic systems, plus learning how to respond to RFP's.

3. Federal agencies are starting to procure photovoltaic systems with their own funding.

4. Battery suppliers are placing increasing attention on development and application of batteries for the photovoltaic systems.

5. A marked increase in the number of suppliers of photovoltaic systems has been observed.

Feasibility of Direct Seeding Trees on Surface Mines in Kentucky[1]

T. W. Richards, R. F. Wittwer, and D. H. Graves, *Department of Forestry, University of Kentucky, Lexington, Ky.*

Abstract
Successful direct-seeding trials on mine soils have renewed interest in this reforestation method. Application of direct-seeding to large-scale plantings requires the development of a planting machine capable of planting large seeds on variable topography and in rocky soils. Adaptation of an existing agricultural planter was investigated. Modifications met with reasonable success. Mine soils present no major problem for mechanical planting. Seed size limitations can be extended to plant most large-seeded species. Modifications to plant variable slopes are the most difficult. Redesign and further development are needed to supply the mining industry with a dependable planting machine suited to the variable site characteristics encountered on mined land.

Introduction
Alternatives for reforestation of surface-mined land include planting seeds, bareroot or containerized seedlings, and stemwood or rooted cuttings (Wittwer 1980). Bareroot seedlings are most commonly used. Steep rough slopes, rocky terrain, and other difficult planting conditions often encountered on surface-mined lands in the Appalachian coal fields make direct-seeding an attractive alternative to planting bareroot seedlings.

Successful reforestation by broadcast seeding has been confined largely to black locust (*Robinia pseudoacacia* L.). Some promising results have also been reported for several pines, especially shortleaf (*Pinus echinata* Mill.), loblolly (*P. taeda* L.), and Virginia (*P. virginiana* Mill.) (Brown 1973, Plass 1974, Thor and Kring 1964). The inherent ease of broadcast seeding has led researchers and reclamation personnel to try broadcast seeding with other species, usually without success (Davidson 1980). Spot planting on prepared sites has been more successful (Smith 1962).

Reforestation trials with direct-seeding were attempted on Midwestern surface-mined lands during the 1930's (Schavilje 1941). Results were mixed and led Limstron (1960) to discourage the use of direct-seeding. He attributed failures to the drying out of germinating seedlings, rodent depredation, erosion and siltation. Until recently direct-seeding of species other than black locust has received little attention.

[1]The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published with the approval of the Director.

Provisions in the Surface Mining Control and Reclamation Act of 1977 have renewed interest in reforestation of mined land. Strict enforcement of regulations requiring return to the premining land use and establishment of a "diverse cover of native species" could result in extensive tree planting efforts in the heavily forested regions of the Appalachian coal fields. Potential economic benefits and increased species diversity have again renewed interest in direct-seeding.

In response to this interest, the University of Kentucky Department of Forestry is conducting reforestation research on surface-mines in Kentucky. Survival varies with planting technique, species, cultural treatment, and the presence of herbaceous vegetation (table 1). Results indicate that for several species, notably the oaks, which are an important component of the native forest, spot-seeding is a reasonable alternative to planting bare rooted seedlings.

Table 1.—*First year survival of reforestation trials on mined lands in Kentucky as related to planting technique, cultural treatment and presence of a herbaceous cover*

Year	Technique	Species	*Control*	Treatment[1] *Herbaceous cover*	*Mulch*	*Fertilizer*	*Mulch and fertilizer*	References
				survival percentage				
1977	seedlings	red oak (*Quercus rubra*)	64	40	70	—	65	Ringe 1979
		Virginia pine (*Pinus virginiana*)	64	50	63		73	
		European alder (*Alnus glutinosa*)	72	31	80	—	76	
1977	seedlings	European alder	10	21	23	—	—	Albers and Carpenter 1979
1978	seed	red oak	52	—	71	44	60	Wittwer et al 1979
		chestnut oak (*Quercus prinus*)	31	—	36	35	32	
		pin oak (*Quercus palustris*)	27	—	29	31	48	
		Virginia pine	14	—	41	40	70	
1978	seed	bur oak (*Quercus macrocarpa*)	—	46	46	46	52	Tackett 1979
		red oak	—	31	34	34	39	
		pin oak	—	46	46	46	52	
1979	seed	black walnut (*Juglans nigra*)	—	3[2]	8	—	9	Cunningham 1981
		white oak (*Quercus alba*)	—	47[2]	97	—	81	
		bur oak		99[2]	88	—	96	
		chestnut oak		77[2]	78	—	80	
		pin oak		54[2]	76	—	80	
1980	seedlings	eastern cottonwood (*Populus deltoides*)	74	—	—	75	—	Zimmerman and Wittwer 1981
		yellow popular (*Liriodendron tulipifera*)	53	—	—	53	—	
		sycamore (*Platanus occidentalis*)	90	—	—	85	—	
1980	seed	sawtooth oak (*Quercus acutissima*)	63	—	73	40	71	McComb et al 1981

[1]Mulch, fertilizer, and mulch and fertilizer treatments did not include herbaceous cover.
[2]Mulched; herbacious species and seeding rate were designed to minimize competition.

Mechanized Planting

Desired stocking rates can be obtained by spot-seeding if a good estimate of survival is available and the proper number of seeds are planted to account for loss. Direct-seeding is a useful method for reforestation, but hand planting seeds is not practical for large-scale plantings. A mechanized planting system is needed to apply direct-seeding techniques to the reclamation of surface-mined land.

Row-planting type tree seeders were developed during the 1960's. Designs, such as the H-C furrow seeder and the Auburn seeder, were developed to prepare a seedbed and plant pine seeds on natural sites (Croker 1964, Richardson 1965). Investigations for development of a similar machine for surface-mined land were begun by the University of Kentucky Department of Forestry in the fall of 1979 (Richards 1981). Some necessary requirements were the ability of the planter to plant on steep slopes and on rocky ground. Such a machine must also be able to plant a range of seed sizes, including very large seeds such as walnuts. As an added consideration it was decided that the planter should be an adaptation of a commercially available planter rather than a totally new design requiring custom construction.

Just as the builders of the H-C furrow seeder and the Auburn seeder borrowed parts from available agricultural row planters, corn and soybean planters were again considered for adaptation. The first criterion considered was the adaptability of a planter to plant large seed. Most planters are designed to meter and plant small seed usually no larger than a peanut. Metering designs and crossectional areas of the drop tube restrict adaptation of most planting units. The Cole Manufacturing Co.[2] of Charlotte, N.C., produces a planter that was originally designed to plant onion sets as well as smaller seeds. Alterations in new models have decreased this upper size limit, but minor modification can produce a planter capable of accurately metering and planting a variety of large-seeded tree species.

A Cole multiflex unit planter was obtained for study (fig. 1). Its general design is typical of row planters. It has a grooving device that opens the soil into which seeds are automatically metered. A compaction wheel completes the planting process by firming the soil around the seed. The Cole multiflex planter comes with a double disk grooving mechanism. It is designed to pivot independently of the planter frame and is pressed into the soil by a pair of compressed springs. This design allows the disk to ride over obstacles in the row (fig. 2), and was viewed as an asset because of the amount of rock in mine soils that could damage a rigidly constructed unit.

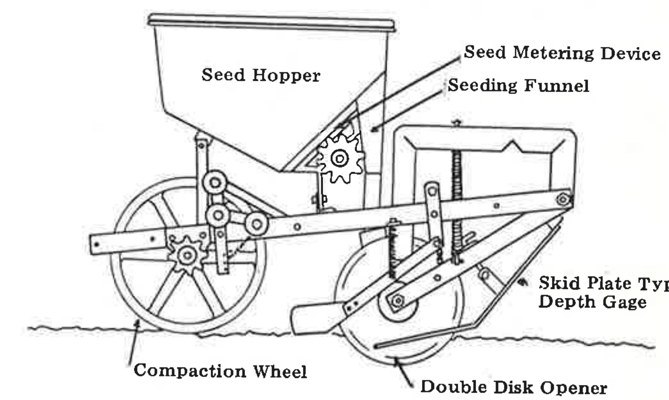


Figure 1.—Basic design of the Cole multiflex unit planter with a double bin seed hopper.

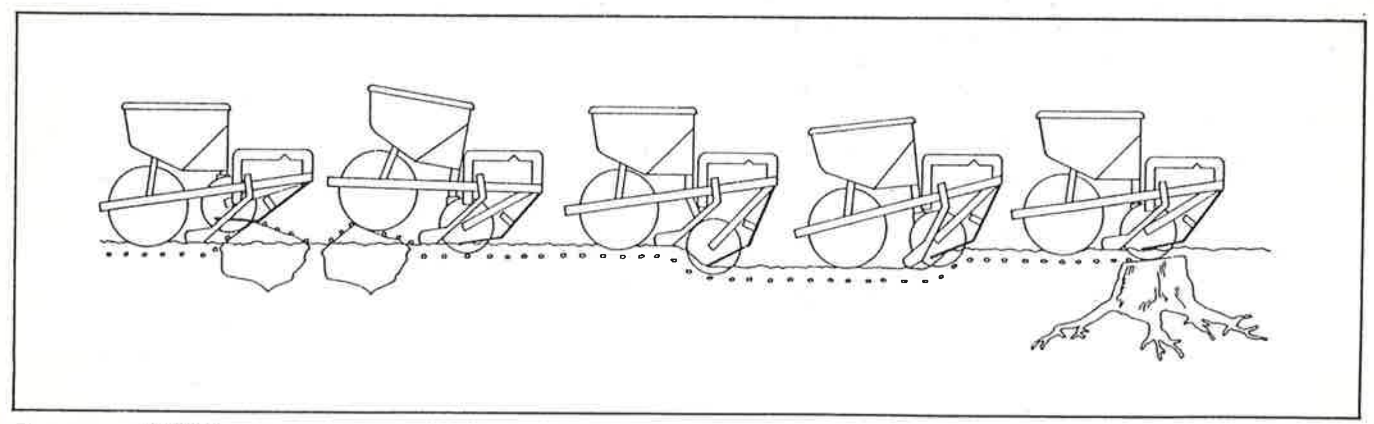


Figure 2.—Illustration of the flexing design of the Cole planter that allows for obstacles and irregularities in the row without damage to the planter.

[2]Mention of product names does not imply endorsement by the Kentucky Agricultural Experiment Station.

Cole uses a disk metering system for this planter. The metering disk is set at an angle in the seed hopper so that only the lower edge moves through the seed reservoir. Cups on the disk pick up seeds and lift them to a drop hole at the top. Excess seeds fall from the cups as they revolve toward the drop hole. At the drop hole the single seed still in the cup falls into the seeding funnel where it is channeled into the soil groove behind the double disk.

The planter has slope limitations because it is critical that the metering disk be kept at the correct angle. When the angle is more horizontal, as when the unit is going down a slope, seeds will ride too far up the disk, resulting in an almost continuous flow of seeds on to the ground. If the angle is too close to the vertical all of the seeds will fall from the disk and no seeds will reach the drop hole and be planted. Proper angles are maintained as long as the top line of the seed bin is horizontal. The rigid attachment of the seed bin to the planter frame does not allow for uphill and downhill use of the Cole planter.

Cole has some attractive options available on its planters. A double bin is available that has the potential to plant two different seed sizes, species, or mixtures. It also seemed possible to plant 9-gram fertilizer tablets at the same time seeds are planted.

Modification
The manufacturer made some slight modifications before the planter was shipped. The drop hole was enlarged and the onion set disk had half of the cups removed in order to extend the possible spacing within the row to 3 feet. When it arrived the Cole planter could accurately plant seeds up to the size of northern red oak (*Quercus rubra*) acorns.

An attempt was made to adapt the existing seed metering system by hinging and hydraulically leveling the seed bin. This modification also required changing the design of the seed drop funnel. The original one-piece funnel was cut short and remained attached to the seed bin. A lower enlarged funnel was added between the double disks to channel the seed to the soil. Redesigning the funnel allows the seed bin to pivot properly, but it also increases the seed size limitation by enlarging the crossectional area of the drop tube and opens the planting operations to the operator's view. Before, the planting operation was completely enclosed so that the operator could not visually check for interruptions in seed metering.

Discussion
The modified Cole planter had no difficulty planting large tree seeds in loose mine soils (fig. 3). Rocks and other obstacles did not damage the planter or interfere with planting. This may be due to the pivoting design of its double disk soil opener. This design may also be a drawback for while force on the disks is not high enough to damage them, there is not enough force to properly cut a seeding groove in unprepared soil. Early considerations for the use of this machine were directed toward planting in loose soils during the final grading operation on mine sites. Evolution of later ideas suggested the need to plant in existing cover or on hard packed material. Possible options may include attaching a cultivator ahead of the planter. Without some type of soil preparation this planter will not plant seed properly.

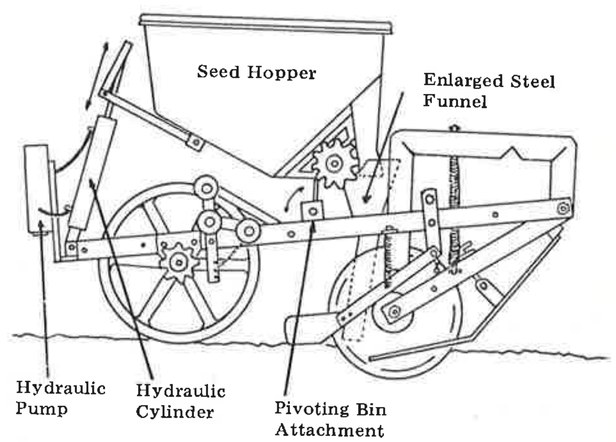


Figure 3.—Modifications added to allow planting on steep slopes.

Seed planting depth is controlled by a skid plate attached to the grooving mechanism. It worked well to uniformly control the depth of grooving and therefore seed placement. The plate performed an additional function by breaking clods. This smoothed the seedbed and produced more loose soil to cover the seeds.

Hinging the seed bin and adding hydraulic leveling to the planter increased slope capabilities. The control switch was placed in the tractor cab for easy access, but it is difficult for the operator to estimate when the bin is level. Leveling is only applicable to uphill planting so the planter cannot plant while the tractor returns to the bottom of the hill.

The redesigned drop funnel that was necessary to allow the seed bin to pivot was enlarged to accommodate larger seeds. This adjustment did not affect proper seed placement, but it increased the sloppiness of the seed drop and varied the time between metering and planting. Metering accuracy was maintained, but spacing accuracy in the row was reduced. Spacing accuracy within the row is not important for planting seeds, but it eliminates the possibility of planting seeds and fertilizer tablets in a one-step operation.

Contour planting is a marginal operation with the Cole planter. Tilting the seed bin disrupts the metering operation in the lower bin. Seeds will meter properly in the upper bin but the operator must remember that half as many seeds are planted per row. The decreased seeding rate can be corrected by doubling the number of rows, but this also doubles the time.

Crawler tractors are commonly used for mining and reclamation of the land. One objective of this study was to incorporate mechanized tree seeding into final grading, thus, adding tree seeding to an existing operation. This requires the attachment of a planter to a dozer. Considerations for such an attachment include the ability to lift the planter out of the ground to allow the dozer to work in reverse. No steps were taken to design or construct this attachment, but such a mechanism is necessary to make mechanized seeding practical on steep mine slopes.

Conclusion
The Cole multiflex unit planter is capable of planting large seeded tree species in loose mine soils, but the planter is limited in its ability to plant steep slopes. It is only a fair solution to the objective of mechanically planting tree seeds on surface-mined areas. It has the advantage of being commercially available and relatively cheap, but a machine specifically designed for the task is needed.

Although this planter was not damaged during experimental testing, a larger scale, more heavily reinforced planter would be more desirable to withstand the long-term effects of harsh planting conditions on mine sites and the abusive treatment that could result from the planter being pulled by a dozer. Replacement of the disk type metering with a pneumatic seed metering device may also be beneficial by eliminating the difficulty a gravity system has with variable topography.

A tree seeding machine has a niche to fill in reforesting mined land. It adds new possibilities for species diversity and requires less time and labor than planting seedlings. Investigations have begun, but further development is needed.

Acknowledgments
This study was supported in part by the Institute for Mining and Minerals Research, the McIntire-Stennis Cooperative Forestry Research Program, the Mountain Drive Coal Co., and the Cole Manufacturing Co. The authors are indebted in particular to Glen Johnson of the Cole Manufacturing Co., Charles Grace and John Surber of Mountain Drive Coal Co., Tom Richards of Brinley-Hardy Co., and Don Estes of Estes Equipment for their assistance.

References

Alberts, D.J. and S.B. Carpenter. 1979. Influence of site environmental conditions, mulching, and herbacious ground cover on survival, growth, and water relations of European alder seedlings planted on surface mine spoil. p. 23-32. *In*: Proceedings Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation. Univ. Kentucky Coll. Engr. Bull. UKY Bull. 9.

Brown, J.H. 1973. Site factors and seeding methods affecting germination and survival of tree species direct seeded on surfaced-mined areas. W. Virginia Univ. Agric. Exp. Stn. Bull. 620. 25p.

Croker, T.C., Jr. 1964. Two H-C Furrow Seeders. USDA For. Serv. Southern For. Exp. Stn. Research Note SO-5.

Cunningham, T.R. 1981. Direct seeding oaks and black walnut on mine soils in eastern Kentucky. M.S. thesis, Univ. of Kentucky, Coll. of Agric. 116p.

Davidson, W.H. 1980. Direct seeding for forestation. P.93-97. *In*: Proceedings—Trees for Reclamation. Gen. Tech. Rep. NE-61. North. For. Exp. Stn. Upper Darby, Pa.

Limstrom, G.A. 1960. Forestation of strip-mined land in the Central States. USDA Agriculture Handbook No. 166. 74pp.

McComb, W.C., S.B. Carpenter, and R.S. Caldwell. 1981. Direct seeding sawtooth oak on surface mine spoil. p.497-500. *In*: Proceedings of Symposium on Surface Mining Hydrology, Sedimentology and Reclamation. Univ. Kentucky Coll. Engr. Bull. UKY BU 126.

Plass, W. 1974. Factors affecting the establishment of direct-seeded pine on surface-mine spoils. USDA For. Serv. Res. Pap. NE-290. 5p.

Richards, T.W. 1981. Mechanically seeding trees on surface-mined land. M.S. thesis, Univ. of Kentucky, Coll. of Agric. 68p.

Richardson, B.Y. 1965. New tools for direct seeding. Southern Lumberman, Christmas Issue. No. 2632. pp.150-151.

Ringe, J.M. 1979. Effects of bark mulch, fertilization and herbaceous cover on survival and growth of three tree species on eastern Kentucky mine spoil. M.S. thesis, University of Kentucky, College of Agric. 74p.

Schavilje, J.P. 1941. Reclaiming Illinois strip mined coal lands with trees. J. For. 39:714-719.

Smith, D.M. 1962. The Practice of Silviculture, 7th ed. John Wiley and Sons, Inc., New York. 578p.

Tackett, E.M. 1979. Direct-seeding commercial forest species on eastern Kentucky surface mines. M.S. thesis, Univ. of Kentucky, Coll. of Agric. 107p.

Thor, E. and J.S. Kring. 1964. Planting and seeding of loblolly pine on steep spoil banks. J. For. 62:575-576.

Wittwer, R.F. 1980. Reclamation systems for returning surface mine lands to a forest land use. p.222-226. *In*: Proceedings 1980 National Convention - Society of American Foresters. Spokane, Wash.

Wittwer, R.F., D.H. Graves and S.B. Carpenter. 1979. Establishing oaks and Virginia pine on Appalachian surface mine spoils by direct seeding. Reclamation Rev. 2:63-66.

Zimmerman, L.J. and R.F. Wittwer. 1981. Use of slow release fertilizers when planting sycamore, yellow poplar cottonwood seedlings on surface mined land. p.477-480. *In*: Proceedings of Symposium on Surface Mining Hydrology, Sedimentology and Reclamation. Univ. Kentucky Coll. Engr. Bull. UKY BU 126.

Solar Water Pumping Systems

Ronald W. Matlin, *TriSolarCorp, Bedford, Mass.*

Water pumping applications are projected to provide the largest potential market for photovoltaic (PV) systems in the 1980's. The most significant applications in this market are expected to be potable/livestock water systems for communal use and microirrigation water pumps used by small farmers.

Rough estimates of the value of water are 2 - 6 cents/m^3 (m^3 = 264.2 gal U.S.) for irrigation water, 10 - 20 cents/m^3 for livestock water and 30 - 60 cents/m^3 for potable water for humans. Thus, water for human use and livestock can be worth up to 10 times the worth of water for irrigation. Because of this, photovoltaic water-pumping systems for human use and livestock are now cost-effective applications in many locations.

Over the past several years, a number of different photovoltaic powered waterpumping systems have been installed around the world. Surveys by the World Bank showed 60 such systems in use in the fall of 1979 and over 250 by the spring of 1981. Projections indicate more than 500 will be installed by the end of 1982. In general, these systems have performed quite well. They range in size from small 150 watt units to 28 kW systems.

Several systems are described below to give an indication of the different sizes and uses. Figures 1 and 2 show a 1.3 kW centrifugal pump system installation in Yemen near Taiz for the United Nations Food and Agriculture Organization. It uses a 26-stage vertical turbine pump sized to produce 59 m^3/day (15,500 gal U.S./day) with a lift of 20 m (66 feet). At maximum insolation, it will pump at 12 m^3/hour (52 gal U.S./min). Nearly half of the photovoltaic pumps in the world are similar to this.

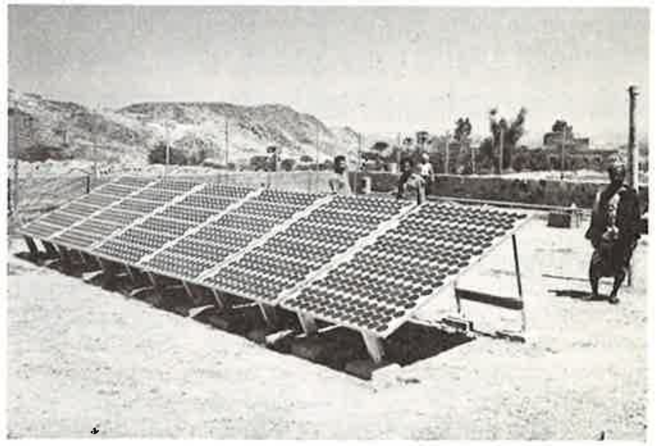


Figure 1.—Photovoltaic array for vertical turbine pump in Yemen.

Figure 2.—Vertical turbine pump in Yemen.

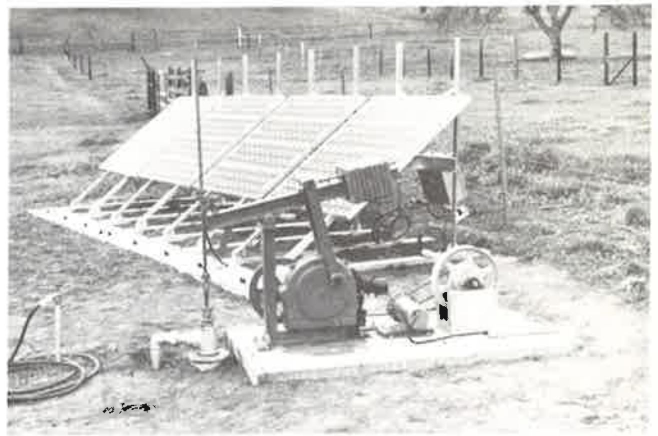


Figure 3.—"Jack" pump at Cortina Rancheria, Calif.

The world's largest PV water-pumping system is a 28 kW vertical turbine system installed in Mead, Neb. The system will pump 225 m^3/hr (1000 gal U.S./min) from the 5.5m (18 feet) deep reservoir. The water irrigates 80 acres of corn in the summer. During the winter, the harvested corn is dried in crop drying bins.

The large fans of these crop drying bins are powered by the PV array of the water pumping system. In the spring, the power from the PV array is used to manufacture nitrogen fertilizer using nitrogen from the atmosphere and a high-voltage electric arc technique. Thus, the power is used year round. In addition to being the largest of its type, this installation also demonstrated the high reliability that can be achieved with PV pumping systems. Data taken during its first year of operation (1977) showed that the PV system achieved a higher reliability than the commercial grid power system. This PV system had fewer unscheduled outages and a lower amount of downtime than the local electric utility service.

Figures 3 and 4 show installations using the volumetric type "jack" pump. This type of pump has higher efficiency than centrifugal pumps in the lower flow ranges of below 1 liter/sec (16 gal U.S./min) and can operate easily to depths of hundreds of feet. They are especially useful for village drinking water or for livestock water pumping systems where high lifts are required.

Figure 3 shows such a pump installed in California. It produces 6 m^3/day (1,600 gal U.S./day) from 50 meters (160 feet). Figure 4 shows another larger system installed by TriSolarCorp, at a site in Arizona. This unit pumps 12 m^3/day (3,200 gal U.S./day) from 160m (525 feet) and supplies drinking water for a Papago Indian village. Both systems represent "jack" pumps operating without batteries. They use electronic impedance matching devices and small flywheels for energy storage.

Figure 4.—"Jack" pump at Queens Well, Ariz.

The design of a photovoltaic water pumping system and the selection of components depend on many factors. The most important of these are desired daily flow, total dynamic head, local solar insolation, and local temperature. Many other factors must also be considered, including storage requirements, well type, well capacity and drawdown characteristics, water quality, etc.

The selection of the pump and motor greatly affects the system design. Centrifugal pumps have reasonable efficiencies down to the 20 to 25 gallons per minute pumping range. Below this, their efficiency drops off rapidly. Volumetric pumps maintain good efficiencies at low pumping rates, especially at high heads, and therefore allow PV water pumping systems to be cost-effective over a wider range than centrifugal pumps alone would allow.

Centrifugal and volumetric pumps have very different load characteristics and hence present the PV design engineer with different problems. Centrifugal pumps are the easiest to power with PV. For in their operating range, centrifugal pumps to the first order have a nearly constant voltage characteristic (actually the power varies with the cube of the voltage) which matches reasonably with a PV array that is also to the first order a constant voltage device (at maximum power). Volumetric pumps, which to the first order are constant current devices, require special engineering and matching to enable them to be operated by a PV array. The performance of PV powered volumetric pumping systems can be greatly enhanced by electronic impedance matching and some systems are so provided.

In water pumping systems of less than 10 kW, dc motors are more efficient and cost-effective than ac motors. Therefore, because most PV water-pumping systems are below 10 kW, they are in general designed to be dc systems. Experience has shown that when energy storage is required, it is more cost-effective to store water in tanks than chemical energy in batteries. Batteries are costly to purchase initially, require attention and maintenance, and their life is often much shorter than advertised, resulting in a large replacement cost.

Therefore, it is very desirable to configure PV water-pumping systems without batteries, for systems using water storage will result in a lower life cycle cost. It is also desirable to use high voltage systems because the efficiency of control electronics is considerably lower when low voltage systems are used.

It is also important to select proper plumbing configurations to minimize frictional losses in pipes and bends.

Forest Service Equipment Development Center Activities

Ken Dykeman, *Forest Service, San Dimas, Calif.*

The USDA Forest Service, San Dimas Equipment Development Center (SDEDC) is located in San Dimas, Calif., which is east of the greater Los Angeles area in the center of one of the greatest technology areas in the world. About 55 people are employed at the Center, including 15 engineers and about the same number of other professionals. Center personnel are working on about 60 different, but often related, projects. Some projects of interest to workshop participants and not reported elsewhere during the workshop, are described here.

Mountain Climbing Backhoe

The mountain climbing backhoe is a unique new answer to the problem of using mechanical equipment effectively and efficiently on rugged, steep, rocky difficult-to-reach worksites. The key to the machine's ability is a unique design that allows individual control of each leg and wheel. Each may be raised or lowered, extended or retracted, and/or moved in or spread out to accommodate radical changes in ground surface and terrain.

This machine can carry and operate attachments besides a backhoe, including grapple, swivel grapple, feller-buncher, air drill/hammer, rotary cutter (possibly for fireline construction where tractors cannot go), and many shapes of buckets.

Two versions of the climbing backhoe are manufactured, both by firms in Europe. The Menzi Muck is made in Switzerland and the Kaiser in Liechtenstein. They cost between $80,000 and $100,000, depending on accessory equipment. SDEDC has conducted tests on both machines over the past 3 years to determine their adaptability to do Forest Service work. The Center now owns a Menzi Muck.

Mountain climbing backhoe that is able to climb steep mountain slopes like a five-legged spider and position itself to perform work.

Each wheel or leg may be raised or lowered, extended or retracted, and/or moved in or spread [illegible] to accommodate radical changes in terrain.

The Center has tested the machine on four National Forests and found it to be a versatile, productive piece of equipment for working at sites in mountainous terrain that are inaccessible to other equipment. Work done during the tests included: Digging test holes to find subsurface materials to aid in cost analysis and design of forest road structures; placing large boulders to improve fish habitat in a remote canyon bottom; excavating a wildlife watering hole in a remote area; bunching, piling, and loading slash into a chipper from steep clearcuts; constructing cross-drains in a road fill; locating and cleaning out large culverts; and preparing sites for tree planting.

On-Site Chipper/Conveyor for Fire Hazard Reduction and Residues Reduction

Over 5 billion tons of wood is rotting on U.S. forestlands today. More than enough wood is going to waste every year to equal all the crude oil consumed in the United States each year. This wood residue converted to biotherm energy can be available at less than half the cost of coal or oil and it is the largest *continuous energy reserve in the world.*

Reducing slash material to a uniform chip at the site has many advantages from a material handling standpoint. If all slash smaller than YUM (yarded unmerchantable material) can be reduced to a uniform bulk material by an onsite chipper, it could be conveyed to a landing and transported or scattered on the slope to recover the nutrients. According to the Forest Service Pacific Northwest Forest and Range Experiment Station, most of the nutrients are in the fines, twigs and branches, and of course most of the chip volume is in the chunks left onsite and the YUM decks on landings.

Onsite chipper for fire hazard reduction and residues reduction.

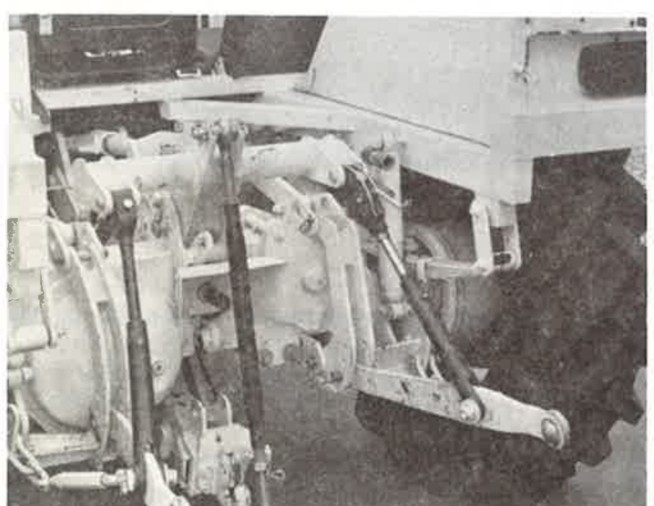
Cable chip conveyor dumping chips.

SDEDC development an onsite chipper and conveyor in 1980 to test the concept of chipping and conveying chipped slash to reduce the fire hazard. The concept proved feasible so the Center built a demonstration model chipper and conveyor.

This equipment was used on two National Forests in Oregon and Washington. The Center is now building, for testing this year, a self-propelled chipper, powered with a diesel air-cooled engine for chipping slash on steep slopes.

High Road Speed Tractor (50 mph)
The Center was shown a unique new concept of a farm type tractor that can perform all the functions of an ordinary farm tractor, yet travels 50 mph on the highway. This is made possible by the tractor's special suspension (springs on rear and torsion bar on front), gearing and brakes. The tractor, built by an English firm, is equipped with a standard three-point hitch and power take-off (PTO) that will carry and operate most implements, including plows, disks, cultivators, drills, mowers, and interseeders. The tractor would be especially versatile in ranching and range work where travel distances can be great. It is not necessary to load and haul the tractor to the job because it can move to the site on its own wheels at high speed.

High road speed tractor (50mph).



High speed tractor's three-point hitch, PTO, rear springs, and brakes.

Magnesium Chloride for Dust Control
The Center has been investigating dust abatement techniques and monitoring tests conducted by others. Dust abatement has always been a problem on forest roads and it is especially important to find a less expensive means of dust control with the rising cost of crude oil.

Magnesium chloride ($MgCl_2$) is used as a dust suppressant because of its hygroscopic and deliquescent properties. When applied to unpaved roads, magnesium chloride reduces evaporation of soil moisture while absorbing moisture from the air during favorable humidity periods. Magnesium chloride, which is only available in a 28 to 35 percent strength aqueous solution, can be applied with a water truck or, better yet, a spreader truck after the road has been properly prepared—rut free, correct side slope, and good water penetration. One-half gallon per square yard is the recommended application rate. With good penetration of 2 to 3 inches, the magnesium chloride will last 3 to 6 months, depending on local conditions of traffic, vegetation, and humidity. $MgCl_2$ costs $35 to $40 per ton fob Utah, the primary source. One ton would be enough to treat about 400 square yards or a road 9 feet wide and 400 feet long.

The abatement of dust on roads used for management of rangelands may be economically feasible with magnesium chloride.

Before treatment with magnesium chloride for dust control.

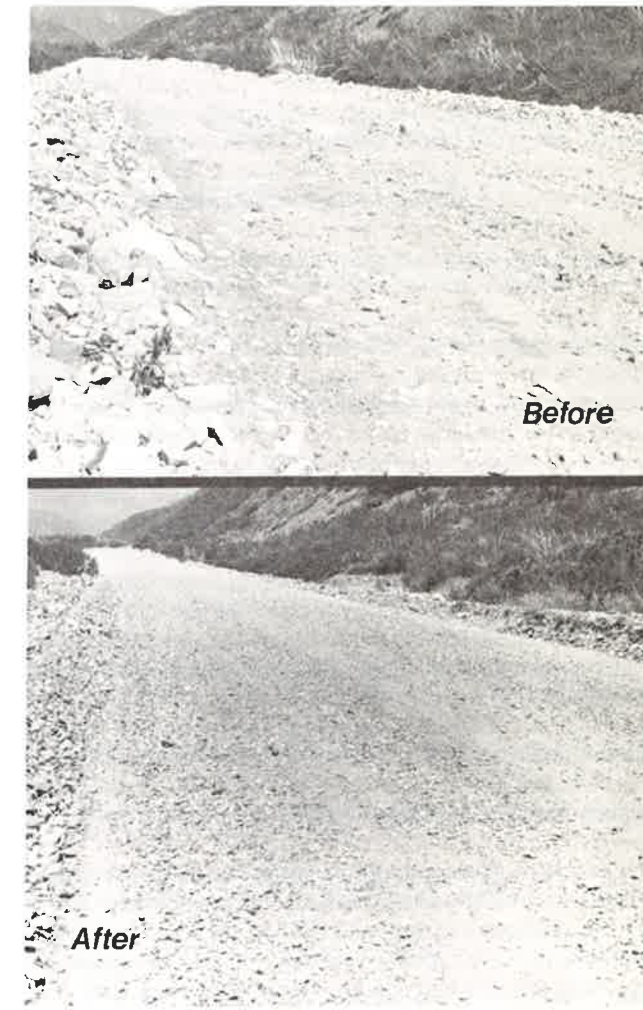
After treatment.

Mobile Hammermill
The Center has been testing and evaluating a mobile hammermill that can efficiently reduce in place, unwanted oversize rock 6 to 12 inches diameter, into a useful wearing course for an existing road. Oversize rock can occur in ditches—as a result of bank sloughing; in berms—formed at the side of the road by blading or raking; and in roadways—exposed by erosion or traffic.

The oversized rock is first windrowed and watered, then crushed as the mobile hammermill is towed over the windrow. Next, a wearing course is formed by spreading, shaping, and compacting the resulting crushed rock.

Other applications for the hammermill are in new construction to reduce the excavated oversize material into a base course and in asphalt recycling work to break the ripped asphalt and concrete pieces into usable size material.

Mobile hammermill for treating oversized rock for use as road base.



Road before and after treatment by mobile hammermill.

Improvements to the Modified Hodder Gouger

Randall Chappel, *R.W. Chappel Planning and Management, Calgary, Alberta, Canada*
Bernie Jensen, *Western Reclamation, Bozeman, Mont.*

Over the past year the Alaska Project Division of NOVA, an Alberta corporation, has been redesigning and building a modified Hodder gouger for its reclamation program on a major international pipeline. The Alaska Highway Pipeline Project will carry gas from reserves in Alaska through 4,800 miles of large-diameter pipeline to consumers in the southern United States. A portion of its route crosses the Great Sand Hills in eastern Alberta and southwestern Saskatchewan.

Even minor natural and man-made disturbances in the Great Sand Hills were found to be poorly stabilized and revegetated; often they resulted in the creation of slow moving, but persistant sand dunes that could reach tens of acres in size, with heights on the leading edge of several hundred feet. In the interests of disclosing cost-effective methods of controlling wind erosion and establishing permanent vegetative cover on areas to be disturbed by pipeline construction, NOVA began revegetation trials[1] in the Saskatchewan Sand Hills.

On plots created with earth movers and dozers to simulate post-disturbance right-of-way conditions, six triplicated trials, employing various materials, techniques, and treatments, were laid out. Full-scale simulations were used on each of three surface preparations. Results of this research indicated that "gouging" was the most effective of the methods to establish a native seed mix.

The modified Hodder gouger creates basins surrounded by ridges that collect and concentrate the small amount of moisture common to the Sand Hills. It therefore provides a desirable micro-climate for vegetation as well as a rough surface resistent to wind erosion. Gouging involves only one tractor-drawn machine, which both manipulates the surface and applies seed in a single operation. Other successful techniques, such as straw-crimping, require two or three passes with different equipment, increasing labor, time, and materials. While such intensive techniques were not eliminated from use in specific restricted areas, the effectiveness and efficiency of gouging made it the choice for larger sections of right-of-way that required treatment.

Once the modified Hodder gouger was chosen for the project, NOVA and its consultant, Western Reclamation, reviewed machine production, control systems and other limits of the design. NOVA personnel felt that at least two major changes had to be made:

[1]The first and second years results of these trials are presented in the proceedings from the 1982 Society for Range Management conference.

1. Gouging and seeding control had to be linked to the ground speed of the machine instead of being under control of the tractor operator (as effected by engine rpm).
2. Basin size and shape had to be adjusted for use in sand.

Several years of research and development led to the machine now referred to as the modified Hodder gouger, designed and built by the Forest Service Missoula Equipment Development Center. Although the modified gouger represents a significant improvement over the prototype, the hydraulic control system and seedbox drive mechanisms were judged inadequate for the high-production requirements of a pipeline revegetation contractor.

To make the gouger more suitable for high-production use, Western Reclamation designed an independent ground wheel that would drive the seedboxes and regulate a redesigned depression excavation control system.

The seed mixes to be employed required both small and large seedboxes; to apply fertilizer at the time of seeding, a second large seedbox was added. Minor modifications were made to the original frame to add the small seedbox on the back of the machine; a separate frame was designed and built to solidly support the second large box. Seedboxes and fertilizer distribution box are powered with roller chains and sprockets driven by the ground wheel via a sprocket connected to the cam.

Overall machine operation control is achieved with a second small-diameter short-stroke hydraulic cylinder connected to a trailing wheel elevating arm, which can lift the wheel off the ground. Activation of this cylinder simultaneously forces the large cylinder to fully extend and thus lift the gouging blades out of the ground and turn off all systems.

The blade arms and blades were redesigned to achieve greater clearance and a more effective basin shape for seed holding. The redesign reduced the angle of the basin sides providing a larger surface for holding seed and insuring that the sides did not collapse as completely.

One further change of note was that the hitch was replaced with one from the rangeland drill; minor changes were made to the frame and supports at the point of attachment to accommodate the new hitch.

Results
The new machine was field tested in Alberta in the summer of 1981. In mid-September the gouger was given to the first of two specialty revegetation contractors working on reclamation of the 260 miles of Alaska Highway Pipeline constructed in Canada that summer. In approximately 14 days the contractor gouged 72 acres of right-of-way; one out of every 4 hours was downtime for routine maintenance (i.e., greasing, tightening bolts), repairs, and recalibration of seeding rates.

Upon completion of the Saskatchewan section, the gouger was taken into a machine shop for a more intensive overhaul. The majority of this work had to do with reinforcing new and old seedbox frame parts, upgrading bolt strength, and adding teflon-locking nuts where possible. Repairs to the control mechanism was limited to replacing some springs on the control levers and installing a new horizontal hydraulics control rod and teflon slider.

The machine was then given to the second contractor for use in Alberta. In 9 days they gouged 77 acres of right-of-way. Of the 9 days, 1 in 3 were downtime, spent mostly on repairs to the seedbox drive (sprockets and chains) and the control mechanism resulting from operator-precipitated breakdowns, and resultant recalibration of the basin shape and size.

Conclusions
Overall, the gouger, the new control mechanism, and the other modifications met NOVA's expectations. There were problems, however, related to machine design that became apparent because of the use the machine was put to and the priorities of the user.

1. *Seeding System.* The Truax large seedbox with picker wheels could not be calibrated for any of our seed and was eventually left empty. The seed cups on the fluted-roller large seedbox would continually jam with seed and then spontaneously unclog, resulting in uneven application. The side slot on the seed cups had to be blocked off to prevent a significant loss of seed. Uneven application was a continual problem.

2. *Control System.* The first contractor had few problems with the machine in general and virtually none with the new trailing wheel, cam, control, arms, and hydraulic assemblies. As previously mentioned he devoted 1 hour each morning and afternoon to maintenance; his approach to use of the machine approximated that of an owner-operator. Nevertheless several free-moving and rotating parts began to show wear, indicating a need to reexamine component material quality and certain aspects of control design.

The second contractor had continual problems with the control system. Bearings and bushings wore and had to be replaced, control levers bent, and the adjustment of the horizontal hydraulics control rod ended up jury-rigged with wire. The "O" rings in the hydraulic valve and large cylinder had to be replaced several times before it was discovered that the contractor's tractor had a hydraulic system not meeting specifications.

The majority of the problems the second contractor had with the control system could be traced to a lack of interest in the machine. The gouger was run until it broke down or until the basins no longer met specifications, then it would be repaired. The contractor felt that the machine, and the control system in particular, was too touchy, not built strongly enough and generally not production oriented.

NOVA's conclusion is that the control system is functional, allowing complete adjustment of basin size and shape, and that it achieves the goal of producing consistent, predictable basins that are not directly affected by tractor hydraulics.

NOVA feels, however, that the control system is not contractor-proof.

Recommendations
1. *Seeding System.* Our opinion is that the mechanical seedboxes currently recommended for use with the modified Hodder gouger should be replaced with a reliable "air-seeder." All frame and control parts associated with the current specified seedboxes should be deleted. The seed should be directed against "splash plates" hanging from the main frame and behind the blades to provide a uniform broadcast distribution.

2. *Control System.* Our opinion is that the control system should be strengthened. This applies particularly to the control levers, rods, and associated bushings. A linkage that would transmit instructions from the cam to the hydraulics without so many moving, wearable, and breakable parts would make the control system completely functional and reliable.

Electric Fencing—A State-of-the-Art Review

Ronald Jepson and R. Garth Taylor, *Colorado State University, Fort Collins, Colo.*

(Presented by R. Garth Taylor)

(This review was abstracted from a comprehensive *State-of-the-Art Review of Range Fencing Systems* by Ronald Jepson, R. Garth Taylor, and Dan McKenzie, which is in preparation and will be available from the USDA Forest Service, San Dimas Equipment Development Center.)

Electric fences have historically been used as temporary fencing. With recent innovations, electric fencing has been used as permanent fencing and as a method for upgrading existing fences. The chief advantages of electric fencing are low cost and ease of erection and removal. Like most fences, electric fences employ line posts and wire strands. However, they do not necessarily require corner braces. Disadvantages are the fence must be kept in operation full time to be completely effective, livestock must be trained when first exposed and and frequent inspection and maintenance are required.

Energizers (controllers or fence chargers) are necessary to regulate the amount and frequency of current through the wire. When an animal touches a hot wire and is either standing on moist ground or is in contact with a grounded wire, the electric circuit is completed and the animal receives a shock. To be effective, a shock of at least 1,000 volts must be delivered to cattle and 2,000 volts to sheep.

Standard U.S. manufactured energizers are thermal-breaker-switch and coil-and-breaker point operated. They electrify 4 to 6 miles of wire but do not release sufficient voltage to power through vegetation without a substantial loss of charge. Each intermittent charge emitted by these energizers lasts 1/10 of a second. This duration of an arcing charge has often initiated fires in dry vegetation. Useful life of U.S. energizers ranges from 2 to 4 years.

In the midsixties, new type energizers were developed in New Zealand. These units, and others based on them, are of solid-state electronic construction. Their useful life has yet to be precisely determined as they are relatively new on the market but many have lasted 10 to 15 years. This type of charger can release at least 5,000 volts under no load conditions and can effectively charge 30 to 75 miles of fence, depending on the type of energizer and number of wires charged. These modern energizers produce a pulse rate of 35 to 65 per minute and last 3/10,000 of a second. The very brief, high intensity pulses spark through vegetation rather than shorting out.

New Zealand-developed chargers have circuit panel modules that can easily be removed from protective casings and be either replaced or repaired. Ninety percent of problems with energizers occur within the module panel. The dependability of these energizers has reduced total fence failures from one per week to one every 3 months. The average cost of these energizers is $200 to $300, and replacement panels cost $30 to $50.

All fences should be grounded to reduce both injury to animals and fence damage caused by lightning strikes. Although energizers are required by Underwriters' Laboratory to contain lightning resistors, they cannot be totally protected from damage if lightning strikes a live wire. The energizer may be provided additional protection by attaching lead wires to the charged fence wires and running them to a lightning arrestor attached to a post near the energizer. Ground wires along the fence line should be connected to ground posts every 3,000 to 4,000 feet in wet conditions, and every 1,600 feet in dry conditions.

Insulators which are most effective in preventing current leakage are those that:

- Are strong and durable.
- Hold wire clear of the post.
- Have a smooth and impervious surface that drains water and dries rapidly.

Recently developed fiberglass posts are themselves particularly effective insulators. Wood posts that have been pressure-treated with creosote are able to retard water absorption and also are good insulators.

High tensile smooth wire should be used with electric fences because it is easier to handle and will not entangle livestock. This wire is stronger and more elastic than barbed wire and may be stretched over longer distances without an increase in sag. Because it is type III galvanized, it also has a longer expected life (about three times longer).

High tensile wire for permanent electric fences is available in 12½, 14½, and 15½ gages. Careful attention must be devoted to splices to insure both adequate contact and minimum damage to galvanized coating. The "figure 8" knot is recommended and is one of the strongest knots and easiest to tie. Special patented, galvanized connectors are available for splicing high tensile smooth wire. They work very well for they can be installed quickly and hold firmly.

For cattle, three-, four-, and five-wire permanent electric fence systems have been used successfully with the three- and four-wire designs being the most popular. The four-strand designs provide a greater physical barrier, but if animals are properly trained, three-strand designs have proven effective. Top wires are generally charged to prevent animals from crawling over the fence. Height of the top wire from the ground may vary from 30 to 40 inches and the bottom wire, from 6 to 18 inches.

For temporary electric fences, either one-wire or two-wire designs are used for controlling cattle. When a one-wire fence design is used, the wire should be installed at a height of one-half to two-thirds of the average shoulder height of the cattle. If calves are present, a second hot wire should be installed 18 to 24 inches off the ground. For sheep, a two-wire fence should be used with the top wire 24 to 27 inches off the ground and the bottom wire 12 to 15 inches off the ground. The bottom wire should be grounded.

A recent innovation in fencing wire for temporary electric fences is multistrand electroplastic twine. This twine is available as either single strand like a light rope or as a woven matrix mat like woven wire fencing. The intertwining strands are stainless steel wire conductors and bright orange polypropylene cord. This twine has the advantages of being very portable, lightweight (less than 10 percent of 17-gage steel wire weight), versatile, fairly elastic, and easily knotted. The lightweight and elasticity of the twine permits it to be hand tightened, reduces the number of required line posts, and permits the use of only light end braces. Disadvantages of electroplastic twine are that it weathers relatively poorly and should not be used in lengths over 1,000 feet.

Also, when overstressed, the metal conductors may break before the plastic twine. This break in the metal conductor is often very difficult to find.

Line posts for permanent electric fences may be T-shaped fiberglass posts or 2- to 6-inches-diameter by 4-feet-long treated wood posts. The new fiberglass posts are lightweight, strong, and flexible enough to withstand substantial livestock impacts. Post spacing with permanent electric fences is a function of topography, soil type, stays, and wire number. Where stays are not used, wooden posts for three- to five-wire designs should be spaced on 40- to 65-foot centers. Spacing for fiberglass posts is recommended at 20- to 30-feet with a 4- by 4-inch wood stabilizing post every 200 to 300 feet. Where stays are used with three- to five-wire fences, wood and steel posts may be placed every 150 feet with stays every 50 feet.

For temporary electric fences, the same specifications for wooden posts are recommended. Wooden line posts should be spaced every 30 to 50 feet. Steel posts can also be used, but they must be insulated from the wire. When fiberglass rods and posts are used they should be placed every 20 to 34 feet.

High voltage, low impedance energizers have permitted the electrifying of long stretches of permanent or temporary electric fences. Fewer and lighter posts are required which permit a permanent electric fence to be erected faster and cheaper than conventional permanent fences. Savings in labor and material costs range from 25 to 50 percent. The conventional cost of a four-strand barbed wire fence is $2,000 per mile compared to a four-strand high-tensile electric fence at $1,000 per mile.

Grass Establishment: New Directions

Victor L. Hauser, *Agricultural Research Service, Grassland, Soil and Water Laboratory, Temple, Tex.*

Abstract
Current seeding and establishment methods frequently fail to produce adequate stands of grass. Three new grass establishment systems are discussed and available research data on their performance are evaluated. Punch planting is a method that places the seed in the bottom of an open, small-diameter hole. Punch planting places the seed deep in the soil where soil moisture is available longer than with conventional planting. Punch planting established more plants than conventional planting. Punch planting established more plants than conventional planting in both greenhouse and field studies. However, two problems limit the use of punch planting: rainfall fills the holes with soil, and available punch planting machines are too slow and too weak for commercial use. Live grass plants set into the field usually produce vigorous fast-growing plants. A new method for automating all phases of transplanting for grass employs the plastic bandoleer to permit mechanization of all phases of growing and transplanting grass plants. Transplants perform well in the field, but machinery to accomplish all phases of the work is incomplete. Grass seeds that were germinated before planting dramatically improved grass establishment both in the greenhouse and in field trials. Practical field use of germinated grass seeds should be easier to achieve than the other two methods because equipment is available now to plant germinated vegetable seeds. This research demonstrates that substantial improvement in grass establishment technology is possible.

Introduction
Good range and pasture management requires the ability to establish desirable grass plants on the land when needed. This need has been recognized for a long time; however, our ability to establish grass is often not adequate.

Early range managers found that fluffy grass seeds would not flow through their drills, and that the early drills were not strong enough to withstand use on range and pasture land. However, machinery developed by several government agencies and private companies has largely overcome both of these problems.

Current machinery and seeding methods were developed when seed, labor, and land were all relatively less expensive than now. Current recommended seeding rates call for 20 live seeds to be planted for each plant that may be established. About half of the grass seeding attempts fail in the Southern Plains, but the success rate is better in the Northern Plains (Great Plains Council 1966). We are clearly not able to establish desirable grasses when needed. The probability for success in seeding small grains, by contrast, is high. Present corn seeding practice produces about 14 ears of corn for each 20 corn seeds planted (Bateman 1972). Even a modest improvement in grass seeding technology might cut the required seeding rates in half and increase probability for success by 20 to 40 percent.

If the probability of success is low, the grower can afford to spend only a small amount to seed grass; however, costs are not low and they are increasing. If the probability of success is relatively high, then the grower can afford to spend relatively large sums to establish a stand of grass. Therefore, research on new, more effective seeding methods is justified.

This research was undertaken to find seeding practices that are more likely to achieve success than present systems. Most of my research was with hand planted experiments because it is necessary to find what will work, before machines can be designed to do the work. These ideas may form the basis for new, more reliable grass establishment systems. My research is conducted in the Southern Plains, but similar problems are found in many other range and pasture regions.

Most of the grasses seeded in the Southern Plains have relatively small seeds, thus, they must be planted with no more than 2 cm of soil cover. However, the top 2 cm of soil can dry from field capacity to wilting point in as little time as 8 hours. The goal for my research was to find new systems that avoid the rapid drying of the surface soil. I studied three new seeding methods, each of which might achieve the goal: punch planting, transplanting, and planting germinated seed.

Punch Planting
In punch planting, the seeds are placed in the bottom of an open hole that is deeper than normal planting depth (fig. 1). The soil at the punch planting depth remains wet longer than surface layers. I found that the hole depth for some grasses should be about four times the conventional planting depth. The hole diameter should be the smallest possible to receive the seed; about 0.6 cm is a practical size for small seeds.

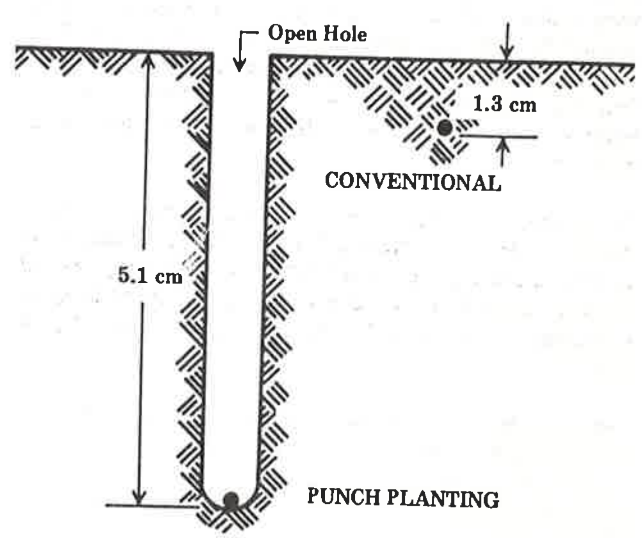


Figure 1.—Comparing seed placement for punch planting and conventional planting.

In greenhouse tests, 30 to 80 percent of seeds placed in punch holes produced plants, but 0 to 5 percent of seeds planted conventionally produced plants, (Hauser, in press). In field studies, 25 percent of the punch planted seeds produced plants, but none emerged from conventional planting. However, intense rainstorms destroyed all seedlings that were established and covered ungerminated seeds too deeply for them to produce plants.

Two major problems limit the present usefulness of punch planting: (1) rainfall may fill the holes with soil and bury the seed too deep, and (2) available punch planting machines are too slow or too weak for commercial use.

Transplanting
Grass breeders have used transplants for a long time to establish grass in the field and to insure survival of their plant selections. Transplants are big enough and vigorous enough to overcome the adversities of dry surface soil, high temperature, wind, insects, rodents, weed competition, etc. However, transplants can be used in large-scale grass establishment, if, and only if, complete and efficient mechanization is achieved.

The Forest Service of USDA, private forestry companies in the U.S., and numerous workers around the world have developed several machines for transplanting trees. Several vegetable transplanters are in use. Most of these machines are hand fed and none are known that can be adapted to transplant grass plants. The system recently developed by Boa (1979) in England for vegetable transplanting appears to be the most complete and most automatic equipment available.

Brewer (1978) conceived the idea of using a plastic bandoleer with grass plants growing in the pockets as the basis for a complete automatic transplanting system. Brewer built equipment to make bandoleers for research purposes, and built a transplanter that used the dibble mechanism developed by Moden et al. (1977) with USDA Forest Service assistance. The transplanter was developed further by Moden and Brewer (1979) and by Moden and Hauser (1980) (fig. 2).

I studied transplants grown in hand-made plastic bandoleer cells of cylindrical shape. They were made with Brewer's equipment, which joined two thin, polyethylene strips by heat welding. Chichester (1981) described the process and equipment used to make the bandoleers. Two bandoleer cell sizes were tested: 0.8 cm diameter by 6 cm long (small) or 3.2 cm diameter by 11.4 cm long (large). The cells were filled with a commercially available potting mix containing peat and vermiculite. Seeds were placed directly in the bandoleer cells; they were germinated under controlled temperature and moisture conditions, and the plants grew in the greenhouse until transplanted to the field. Figure 3 shows grass seedlings growing in a bandoleer unit, and figure 4 shows the root system of one of the plants shown in figure 3.


Figure 2.—Dibble transplanter.

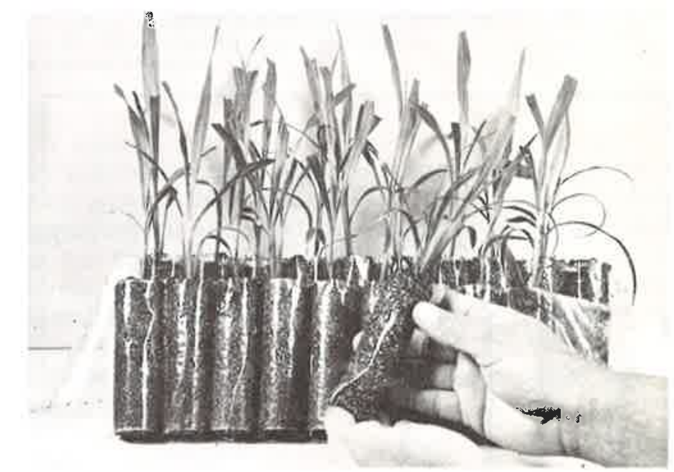


Figure 3.—Eastern gamagrass *(Tripsacum dactyloides)* seedlings growing in large bandoleer cells 1 month after planting.

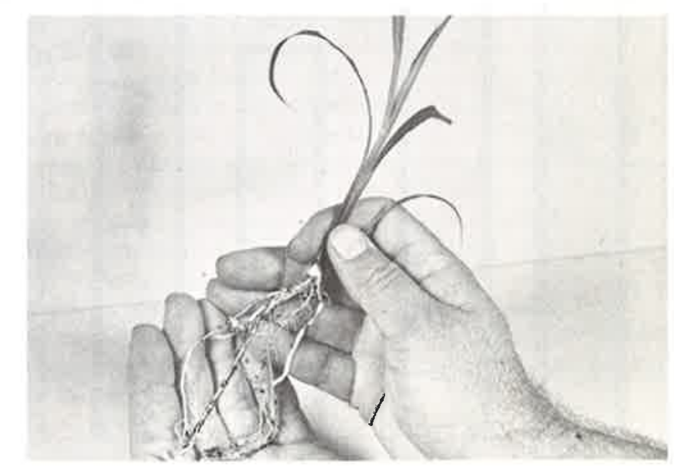


Figure 4.—Root system of an eastern gamagrass *(Tripsacum dactyloides)* transplant shown in figure 3.

Several hand-planted field tests were carried out at Temple and Big Spring, Tex. Holes were made for each plant with a rotating dibble of suitable size for the transplant root plug. Water was poured into each hole before setting the transplant to encourage rapid establishment of the root system in the soil.

The transplants performed well in the field. Between 50 and 90 percent of the transplants commonly survived to the end of the first growing season. Figure 5 shows the survival of kleingrass (*Panicum coloratum*) transplants in a test at Temple where both small and large bandoleer plugs were planted, and the root plug was left covered by plastic or bare. Switchgrass (*Panicum virgatum*) and sideoats grama (*Bouteloua curtipendula*) produced similar results. Significantly fewer plants survived from the small bandoleer plugs than from the large ones. Untreated seed established few plants, but transplants grew vigorously (fig. 6).

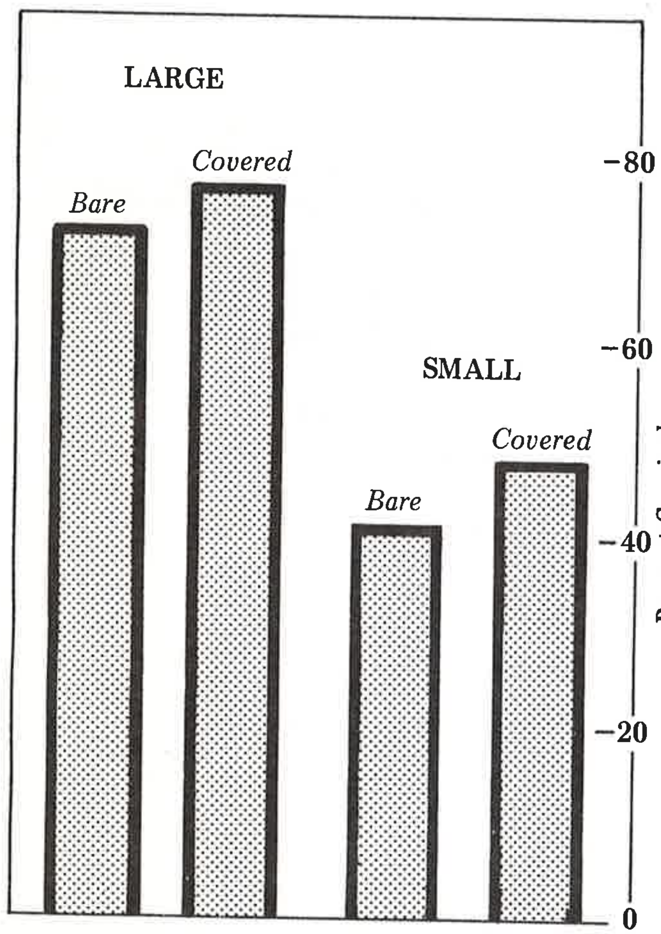


Figure 5.—Survival of kleingrass*(Panicum coloratum)* transplants at Temple, Tex. after a hot dry summer.

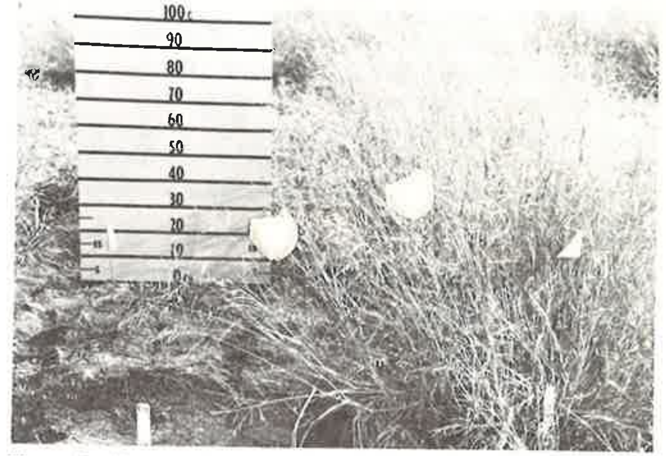


Figure 6.—Kleingrass*(Panicum coloratum)* produced near the end of the first growing season, by untreated seed in a furrow on the left, and by transplants in small bandoleers on the right.

There was no statistical difference between survival of plants with bare or plastic covered root plugs. Some plants ruptured the plastic casing, but others did not. In both cases, new plants and roots were established outside the plastic casing. Figure 7 shows a blue grama (*Bouteloua gracilis*) plant that was planted in a small, plastic encased bandoleer plug at Big Spring, Tex. It was subjected to 50 rainless days and 32 days with air temperature above 38° C (100° F) during the first summer after transplanting.


Figure 7.—A healthy blue grama *(Bouteloua gracilis)* grass plant in spring, 10 months after transplanting at Big Spring, Tex. The small, plastic bandoleer casing remained intact.

Planting Germinated Seed

Grass establishment from seed might be improved if the germination and seedling growth process could be speeded up. Vegetable seeds that were germinated before planting emerged faster and produced more plants than dry or untreated seeds (Gray 1981). I conducted both greenhouse and field studies to evaluate the potential use of grass seeds that were germinated before planting.

I germinated grass seeds in acrylic tubes 4.4 cm inside diameter and 25 cm long, each holding 200 ml of water. Air was injected into the base of the rube through an air stone to supply oxygen to the seeds and keep them in motion. The tubes were maintained at a constant temperature of 25° C. The germinated seeds were gently removed from the water bath and immediately suspended in gel to protect them from mechanical damage during planting.

Seeds with protruding radicles (fig. 8) are easily damaged during handling and planting. Therefore, it is important to know how far the germination process must be carried to get the benefit of germination before planting. Kleingrass seeds treated in the germination chambers for 48 hours at 25° C produced numerous radicles 1 mm long or longer; at 32 hours the seed was swollen but the seed coat was not visibly broken on most seeds.

Figure 9 shows the results of a greenhouse test in which seeds were germinated 0, 12, 20, 28, 36, and 48 hours before planting. More than 20 hours of germination at 25° C are required for kleingrass to achieve the full benefits of germination before planting. There was not statistically significant difference between the 28-, 36-, and 48-hour treatments. After 28 hours of germination treatment no radicles were emerged, thus, these seeds could be handled with minimum damage.

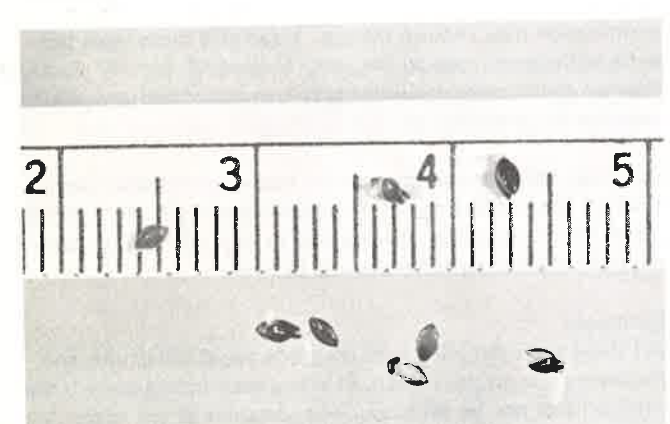


Figure 8.—Germinated kleingrass*(Panicum coloratum)* seeds (scale in cm). The radicle tip is just visible on the seed at left; the seeds on the right are typical of 48 hours of germination at 25° C in an aerated water column.

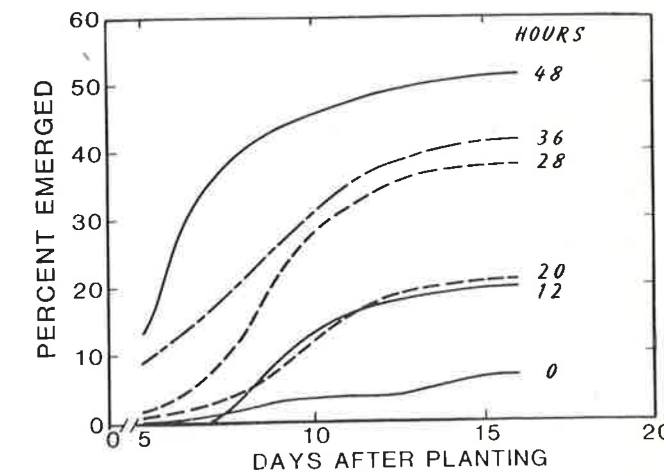


Figure 9.—Percent of live kleingrass*(Pancum coloratum)* seeds that produced plants after 0, 12, 20, 28, 36, and 48 hours of germination treatment before planting.

My greenhouse studies demonstrated that: (a) seeds that were germinated before planting established substantially more seedlings than untreated seeds under either wet or dry conditions; (b) seed germination should be carried far enough so that the radicle is just ready to emerge; and (c) some germinated seeds, that did not produce plants during 20 days in dry soil, did so when watered after day 20. Seeds germinated before planting avoided the rapid drying of the seed zone soil and established many more grass seedlings than untreated seed (Hauser 1981).

Field Comparisons

I studied kleingrass in a field test at Big Spring, Tex. The variables were: (1) small bandoleer cells (9-week-old plants) with plastic removed, (2) untreated seed in a furrow, (3) germinated seed in a furrow, and (4) germinated seed in a furrow plus 300 ml of water. Seeds in treatments 3 and 4 were germinated for 24 hours. The test was planted in wet soil on May 20 and 4 cm of precipitation, mostly hail, fell near sunset on the day of planting. The next 90 days were unusually hot and dry; the potential evapotranspiration was 3.8 times more than rainfall. Figure 10 shows that most of the transplants that survived the hail storm also survived through the winter. Equal numbers of plants were found in spring for untreated seed or for germinated seed without water in the row. Most of the plants established from untreated seed died before the next spring, but most of the plants established early from germinated seeds were growing in the following spring.

A field test of kleingrass at Temple, Tex., compared: (1) untreated seed in a furrow, (2) germinated seed in a furrow, (3) large transplants, and (4) small transplants. The transplants were 8 weeks old and the root plugs were encased in plastic. I planted 15 transplants or more than 100 seeds per 3-meter row. The test was planted in wet soil on May 7 and the growing season was unusually wet. During the first 90 days of the test the rainfall was equal to potential evapotranspiration. Figure 11 shows that in spite of the favorable rainfall, untreated seed did not establish a satisfactory number of seedlings, but the germinated seed established significantly more plants. The transplant survival was similar to that encountered in several other field tests.

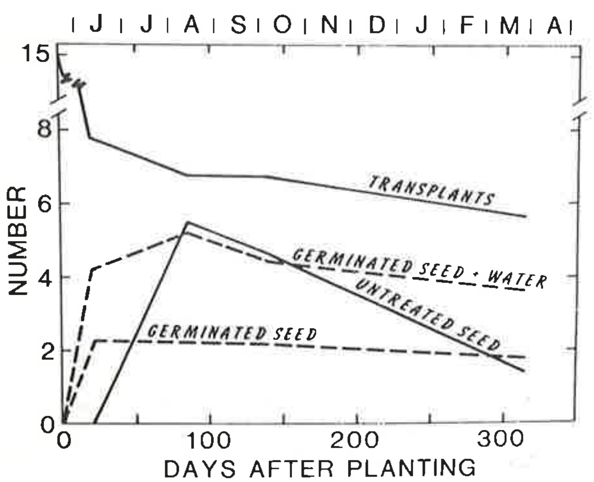


Figure 10.—Number of living kleingrass *(Panicum coloratum)* plants per 3-meter row at Big Spring, Tex. with a hot, dry summer.

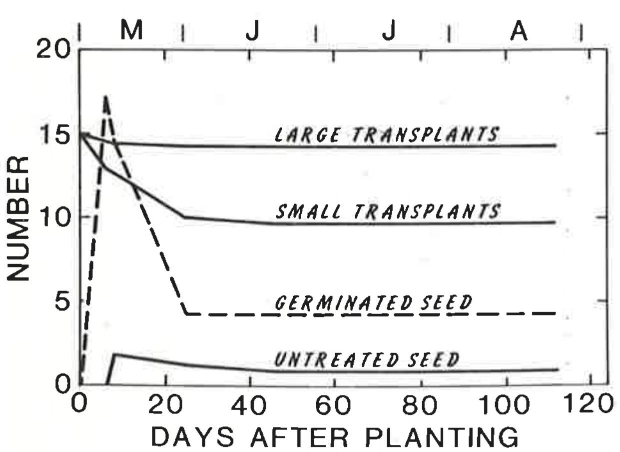


Figure 11.—Number of living kleingrass *(Panicum coloratum)* plants per 3-meter row at Temple, Tex. during a wetter than normal year.

Discussion

Punch planting avoids the problem of rapid surface soil drying; however, the problems presented by rainfall filling the holes with soil and the lack of suitable planting machinery must be overcome. Both problems could probably be overcome by research and development; however, the cost may be high, and other means to get a satisfactory stand of grass may be developed at lower cost.

Machinery is not available to mechanize the growing and transplanting of live grass plants into the field on a commercial basis. The correct size of transplant root plug is unknown. Of the two sizes tested, the large plug is too large for economy in growing operations and the small one may be too small to insure adequate stands of grass plants under adverse conditions.

This research demonstrated that the plastic casing could be left on the root plug when the transplants were set into the soil. This finding will greatly simplify the development of transplanting machines, because the bareroot plugs stick to machine parts and tend to fall apart easily.

Grass seeds that were germinated before planting produced more plants than untreated seed in both dry and wet years. One advantage for germinated seeds, as compared to punch planting or transplanting, is that equipment and machines are available now to permit commercial planting of germinated vegetable seeds. It should be possible to develop machinery to handle germinated grass seed also.

Preliminary evidence (data not shown) shows that germination before planting may not be an advantage for all grasses. Some grasses, such as sideoats grama, that germinate fast may perform as well without treatment.

Germinated seeds that cannot be planted on the day of germination may require storage. Vegetable seeds have been held, without damage to the seed, for several days by placing them in cold storage; however, this is an added and undesirable expense for grass.

An important consideration is the fate of germinated seeds that are planted in dry soil. In preliminary tests, seeds germinated before planting and planted in dry soil for 20 days emerged after a rainfall (data not shown).

Summary

All three grass establishment methods avoid soil drying and improve grass establishment. Planting germinated seeds is the method that can be developed for commercial use easiest and quickest; however, transplanting has the greatest probability for success in establishing grass. This research demonstrates that substantial improvement in grass establishment technology is possible.

References

Bateman, H. P. 1972. Planter metering, soil and plant factors affecting corn ear populations. Trans. Am. Soc. Agr. Eng. 15(6):1013-1020.

Boa, W. 1979. Automatic transplanting. The Agr. Eng. 34(2):35-37.

Brewer, H. L. 1978. Automatic transplanter system for field crops. Am. Soc. Agr. Eng. Paper No. 78-1011. 19 pp.

Chichester, F. W. 1981. Selecting for nutrient use efficiency within forage grass species: I. Development of a screening system. Jour. Plant Nutrition 4(3):231-246.

Gray, D. 1981. Fluid drilling of vegetable seeds. Hort. Rev. 3:1-27.

Great Plains Council. 1966. A stand establishment survey of grass plantings in the Great Plains. Great Plains Council, Report No. 23. 60 pp.

Hauser, Victor L. (In press). Punch planting to establish grass. Jour. Range Management.

Hauser, Victor L. 1981. Planting germinated grass seed. Trans. Am. Soc. Agr. Eng. 24(5):1127-1130.

Moden, Walter L., Jr., Thomas W. Chappell, and Frank H. Pitkin. 1976. An intermittent dibble-type container planter. Trans. Am. Soc. Agr. Eng. 21(3):455-459.

Moden, Walter L., Jr. and Harold L. Brewer. 1979. Automatic bandoleer feeder for transplanters. Am. Soc. Agr. Eng. Paper No. 79-1613.

Moden, Walter L., Jr. and Victor L. Hauser. 1980. Automatically fed transplanter using the bandoleer concept. Am. Soc. Agr. Eng. Paper No. 80-1554.

BLM Scientific Systems Development

Ralph Marker, *Chief, Division of Scientific Systems (D-440), Bureau of Land Management, Denver, Colo.*

The BLM Division of Scientific Systems (DSS), located at the Denver Service Center, provides servicewide special scientific technological support to the Bureau of Land Management. DSS is composed of the Branch of Scientific Systems Development and the Branch of Scientific Systems Applications. The Division is responsible for conducting research and development activities in the physical, analytical, and engineering sciences, and for applying proven results of these studies to operational requirements. Within the Division, the respective Branches work cooperatively to ensure a smooth transition and implementation of complex technology in support of Bureau of Land Management programs.

The Branch of Scientific Systems Applications is the operational and application arm of the Division. The Branch is responsible for routine application of technology in support of BLM servicewide programs. A major portion of this effort is the application of remote sensing to inventory and assessment. The Branch works closely with the Branch of Scientific Systems Development and field offices to operationally support bureau programs.

The Branch of Scientific Systems Development is the research and development arm of the Division. The Branch is responsible for the development and adaptation of complex scientific technology to BLM programs. All projects are designed to provide a thorough evaluation of the technology as well as transfer of that technology to a bureau user. Costs are carefully tracked to allow a realistic assessment of the cost benefits of implementation.

The Division was formed in 1974 and currently has a staff of 28. The staff of DSS consists of 15 engineers, scientists, and technicians in the following disciplines: engineering analyst, physicist, electronics engineer, remote sensing scientist, statistician, mechanical engineer, operations research analyst, geologist, mining engineer, and engineering technicians. The basic policy of DSS is to capitalize on existing technology which has been developed through the conduct of applied research and development by universities, industry, and other Government agencies, and avoid large new efforts requiring extensive man-hours for research and development. This policy is necessary because of the small staff of DSS and the depth and range of expertise required on many of the projects assigned to DSS. Also as policy, DSS staff trains BLM employees (or arranges for training) to operate and maintain developed systems. When the system becomes operational, DSS staff withdraws and tackles a new development project.

Some of the projects DSS has been assigned are:

Lightning Detection System. This project, started in 1975, has the objective of detecting cloud-to-ground lightning strikes using technology developed by the University of Arizona for BLM, NASA, and the Navy. A system can detect and record the location of lightning strikes within a 250 mile radius, even on the opposite side of a mountain. The system differentiates and rejects cloud-to-cloud strikes because the electromagnetic signals differ from cloud-to-ground strikes. With two systems recording the same strike, a location of the strike can be determined, within 1 mile.

Remote Automatic Weather Stations (RAWS). Raws have been developed by BLM in conjunction with the USDA Forest Service. RAWS utilize the GOES satellite to instantaneously relay remote environmental data to the BLM satellite earth station at Boise, Idaho. Additional sensors and applications for RAWS to benefit a broad spectrum of BLM users are under study. It is proposed to have 300 RAWS systematically placed on BLM-managed lands.

Alternate Energy. DSS assists with the development, design, and installation of alternate energy systems such as photovoltaic water-pumping, wind-powered generators and other applications of solar energy.

Remote Sensing. The DSS program objective is to use remotely sensed data from satellites, high altitude photographs, low altitude photographs, and selected surface information to develop data for use in management of BLM lands. DSS has a number of projects and applications using remote sensing:

- Mapping mineral areas using a Fraunhofer line discriminator.
- Determining range vegetation type and range condition trend.
- Determining and mapping of surface disturbances to detect and locate mining trespasses.
- Air quality determinations.
- Development of a remote sensing system for fire management.

Surveying. DSS has adapted inertial navigation systems for land surveying resulting in high accuracy and rapid surveying.

Operations Research. Operations research projects include:

- Computer-based techniques for selecting preferred alternatives to resource management.
- Development of a vegetation allocation model for use in determining vegetation production requirements for maintenance of wildlife and animal grazing.

Savory Grazing Method

Noel Marsh, *Bureau of Indian Affairs, Albuquerque, N.Mex.*

The Savory Grazing Method (SGM) derives its name from its originator, Allan Savory. SGM is a flexible grazing method that maximizes stock density for a minimum time and best can be defined as: "A method of managing the range and livestock through the optimization of four ecological phenomena by manipulating four range influences through a series of grazing management principles."

The four ecological phenomena are:

1. Energy capture and flow.
2. Mineral and nutrient cycle.
3. Water or hydrologic cycle.
4. Biological succession.

The four range influences are:

1. Rest.
2. Fire.
3. Physiological grazing and browsing.
4. Physical animal impact.

The grazing management principles are:

1. Time control.
2. Stock density.
3. Herd effect.
4. Health of the ecosystem as a whole.
5. Chain is the strength of its weakest link.
6. Cause and effect relationships:
   Brush problem.
   Range poisonous plants.
   Insect outbreaks.
   Drought management.
   Erosion control.
7. Flexibility—strategic and daily.

SGM has been proven effective in improving rangelands in three continents over the past 17 years in climates ranging from 2 to 100 inches of annual precipitation. The SGM grazing method has been implemented on the Sandia Pueblo Indian Reservation near Albuquerque, N.Mex., using an eight paddock cell layout.

The full understanding of SGM cannot be grasped without attending one of the courses that Allan Savory of SGM Range Consultants, Inc., conducts. The courses available on the method are:

"Range and Ranch Management School"—a 9-day course for ranchers; instructed by Allan Savory and Stan Parsons in Albuquerque. For more information, write to Ranch Consultants, 7719 Rio Grande Blvd., NW., Albuquerque, N.Mex. 87107.

"Interagency Seminar on Savory Grazing Method"—a 5-day course for U.S. Government range conservationists, natural resource managers, wildlife biologists, foresters, and soil scientists instructed by Allan Savory in Albuquerque. This course is sponsored by Soil Conservation Service, Bureau of Indian Affairs, Forest Service, and Bureau of Land Management. For more information, write to Noel Marsh, Range Conservationist, Bureau of Indian Affairs, P.O. Box 8327, Albuquerque, N.Mex. 87198.

"Indian Stockmen Workshop on SGM"—a 5-day course for Indian livestock operators instructed by Allan Savory, Noel Marsh, and other BIA range conservationists; held at Continental Divide Training Center, N.Mex. For more information, write Noel Marsh.

Allan Savory is completing a textbook on the Savory Grazing Method titled *The Savory Grazing Method of Holistic Grazing Management,* which should be published and available soon.