Rangeland Drill

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Editor's Note: In reality, this is a history of range reseeding and the discovery and development of the rangeland drill. Much has been accomplished the past 50 years.

The rangeland drill is an angular piece of towed equipment composed of impressively thick and heavy steel members carried on gargantuan steel rims and rubber tires. This is not a machine for drilling holes in rangelands, but an implement for distributing seeds in furrows or drills. The seed-boxes on the top of the drill attest to its direct lineage from farm grain drills. The back of the drill consists of steel disks mounted independently on the end of structural steel arms attached to the bottom of the heavy steel frame. If the drill has been used recently, the disks are bright and shiny from the abrasive polishing received from rolling through rocky soils.

What is the purpose of this ungainly piece of equipment, who developed it, and what has been the impact of its use on the sagebrush/grasslands of western North America?

The Legacy of Misuse

The editor of the Carson City *Morning Appeal* must have felt especially clairvoyant on an early December day in 1886 as he greeted his readers with a stirring editorial offering an answer to the Silver State's declining range productivity. Let the state appropriate funds for the conducting of research to determine how to reseed the grasses on the depleted sagebrush ranges was his plea. The editor was at least 60 years ahead of the technology necessary to accomplish his goal on a large scale. Widespread grazing of cattle had been initiated on the sagebrush/grasslands of the Great Basin only two decades before the writing of the editorial, but already grazing of concentrations of cattle and horses in certain areas had depleted the perennial grass portion of the rangelands and allowed the nonpreferred shrubs to increase. The depletion was on a sufficient scale that it could be perceived by the editor of the state capital's newspaper.

The impetus for reseeding degraded sagebrush came from two sources during the 1930's. First the long established research stations of the Forest Service, especially the Intermountain Forest and Range Experiment Station headquartered at Ogden, Utah, developed techniques for seeding sagebrush rangelands. Secondly, the infant Grazing Service of the Department of Interior began to instigate range improvement projects.

During the late 1930's a surplus of manpower was available through such programs as the Civilian Conservation Corps (CCC) for improvement projects on public lands. For the first time the federal government was willing to spend considerable amounts of money toward improving wildlands. The CCC crews were employed on a variety of projects from building roads and trails to attempting to control the destructive outbreaks of Mormon crickets. Use of labor intensive methods for rehabilitation of degraded rangelands was defeated by the accumulations of woody biomass and the vastness of the sagebrush landscapes. A picture of futility was CCC boys pushing hand garden planters through mature stands of big sagebrush. These efforts were futile because of (a) unreduced biological competition from the shrub, (b) the physical restrictions of pushing a handseeder through the shrubs, and (c) the limited area that could be seeded even with large crews.

Essentially the range rehabilitators were faced with the same problems that had plagued homesteaders. The successful homesteader within the sagebrush zone had sometimes overcome the shrub communities by developing water and flooding potential agronomic fields. The native desert shrubs could not stand wet feet. Thousands of homesteads were cleared by hand grubbing, dragging with rails or timbers, or a combination of several such treatments. The range improvers did not have the option of flooding and rather than a portion of 160 acres to clear they had millions of acres of sagebrush to overcome and seed. The para-military CCC approached problems with a military attitude. More troops were futile, but the war against sagebrush would be more equal if suitable equipment could be substituted for manpower. The logical source of equipment was agriculture, but generally agronomic tillage implements proved too fragile and time consuming to operate on sagebrush rangelands. Borrowing from the techniques used by developers of irrigation tracts, the CCC experimented with dragging heavy railroad rails behind tractors in an attempt to knock down or uproot mature, nonsprouting sagebrush plants. Several types of rails were developed for knocking down big sage-

Sungeneral of Australian stump-jump plow. Note raised pair of disk.

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brush plants. These include the Monte Cristo rail, named for the Monte Cristo Ranger District in the Wasatch National Forest, near Ogden, Utah; the Olson rail, named for a sheep and wheat rancher who developed and extensively used the rail for clearing land of sagebrush in the Columbia Basin north of Hanford, Washington; and the Supp rail developed by the Supp brothers to clear land in the defunct irrigation project at Metropolis, Elko County, Nevada.

These early attempts at seeding sagebrush rangelands met with varying success. Most of the labor intensive efforts of the CCC ended in failure. Efforts to revegetate abandoned cropland were more successful. In 1936 the Rural Resettlement Administration begin drilling the first of 57,000 acres of crested wheatgrasses on land utilization projects in Curlew and Black Pine Valleys in Oneida County, Idaho. The Crooked River National Grassland in central Oregon on the east side of the Cascade Mountains was another center of successful seeding establishment. Crews of local farmers were assembled in 1936 under the Emergency Relief Act as administered by The Rural Resettlement Administration to begin seeding abandoned cropland. The farmers brought their own teams and old farm tractors to pull disks, moldboard plows, and to seed with grain drills. A variety of species were seeded before crested wheatgrass became more or less the standard species.

Private ranchers also experimented with seeding sagebrush rangelands. In 1940 there were three successful stands of crested wheatgrass on rangelands in Nevada and they all were located on private ranches and not on public rangelands. During World War II pressure was applied to the Forest Service by wool and meat processers to allow increased numbers of cattle and sheep to graze on National Forests. Remembering the disastrous results of such increased allocations during World War I, the Forest Service resisted such efforts, but pointed out that livestock production could be increased on National Forests in the West if degraded areas were improved through reseeding. With the support of the agricultural portions of the War Production Boards the Forest Service submitted supplemental budget requests for research on range reseeding. The Forest Service seeded about 20,000 acres in scattered plots throughout the West in this pilot program and with the support of live-

Development Life of the Rangeland Drill

Exploration of Alternative Concepts Phase

1946-1950	Range Seeding Equipment Committee tested farm equipment and considered concepts.

Demonstration and Validation Phase

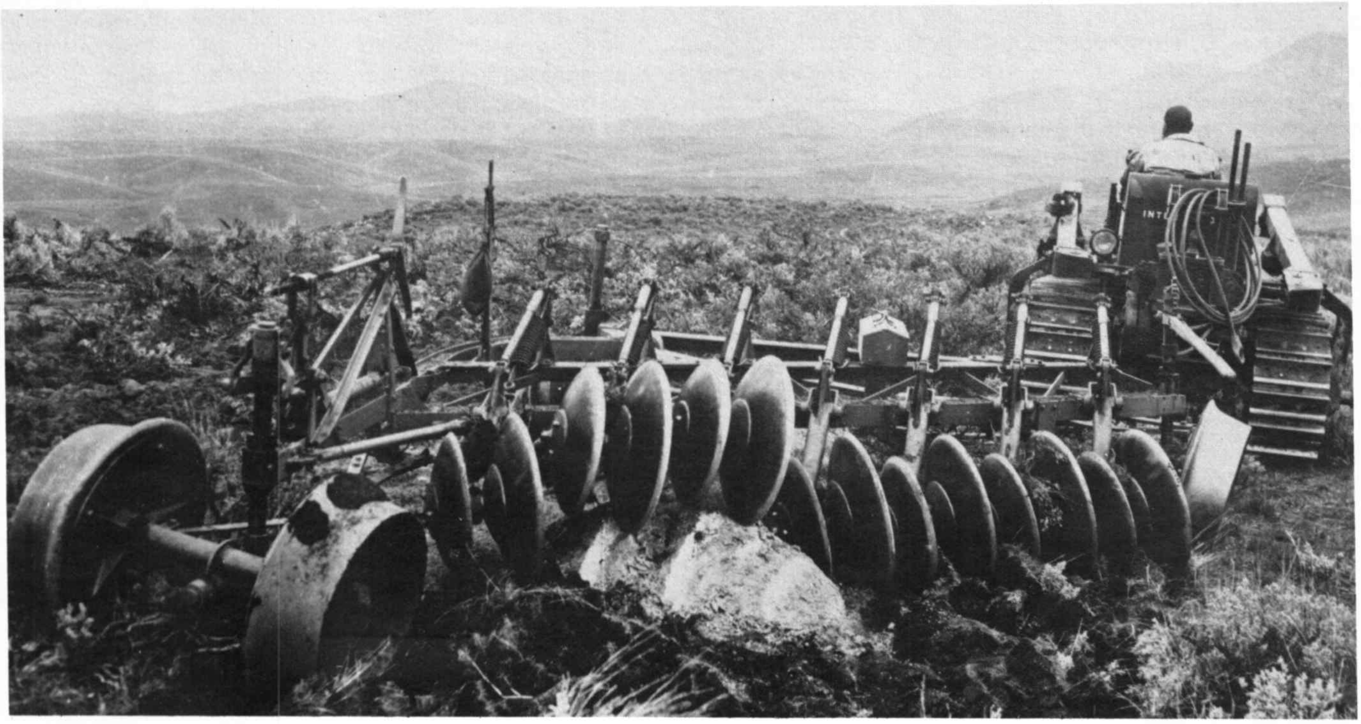
1951	John Kucera, Fremont National Forest, designed and built demonstration model of Rangeland Drill and field tested unit, validating design.

Full-Scale Engineering Development Phase

June 1951	Tom Coldwell, U.S. Forest Service, Arcadia Equipment Development Center (AEDC), visited Fremont National Forest to investigate Kucera's demonstration model Rangeland Drill.
June 1951-October 1952	Prototype Rangeland Drill on Fremont National Forest for field testing.
May 1954	Technical Data Package (drawings and specification) completed and furnished to contracting by AEDC.

Production, Use, and Product Improvement Phase

April 1955	First production Rangeland Drill completed by Laird Welding and Manufacturing Works, Merced, California, and shipped to U.S. Forest Service, Reno, Nevada.
1959	Work done by Forest Service in Washington and Oregon (R-6) on deep furrowing arms.
1960	A hinged fold over drawbar and acreage meter add, part stockage for Rangeland Drill and Brushland Plow established at USFS Equipment Depot, Stockton, California. John Deere discontinued production of B 20 × 6 grain box, grain box replaced on Rangeland Drill by John Deere Model PD 10 × 6, fertilizer and grass seed attachments now also available.
1964	Parts manual for Rangeland Drill completed, printed and distributed.
1966	Hinged-type drawbar and parking stand designed, and *Rangeland Drill Operators, Service, and Parts* Manual completed.
1967	Hinged drawbar and parking stand successfully field tested.
1968	John Deere discontinued production of PD 10 × 6 grain box, John Deere B 206 B grain box selected for replacement. New drawings completed for Rangeland Drill.
1969	Two experimental deep furrowing arms field tested by BLM, Elko, Nevada.
1970	Six redesigned deep furrowing arms fabricated and field tested by BLM, Elko, Nevada.
1971	Adjustable deep furrowing arms designed, two fabricated and field tested by BLM, Elko, Nevada.
1972	Three production prototype adjustable deep furrowing arms, with design changes, fabricated and successfully field tested, Lincoln National Forest, Alamogordo, New Mexico. Adjustable deep furrowing arms available as option in the technical data package.
1973	Rangeland Drills with adjustable deep furrowing arms used to seed 4100 acres in Idaho and Oregon.
1974	John Deere discontinued B 206 B grain box production. Also, 9.00 × 36 tire no longer available replaced by 11.25 × 28 tires.
1975	"Rangeland Drill Operations" completed as BLM Technical Note 289, Forest Service Equipment Development Center, San Dimas, California, assisted Laird Welding and Manufacturing Works, Merced, California, in mounting a John Deere 8250 series grain box on Rangeland Drill, technical data package not updated.
1976	Seed box capable of metering trashy seed tested on USDA/ARS Jornada Experimental Range, Las Cruces, New Mexico.
1977	Oilite and steel bushing bearing in opener arms replaced with triple seal, nonlubricating ball bearings, by Laird Welding and Manufacturing Works.
1978	Hydraulic operated opener arms lift attachment designed and available from Laird Welding and Manfacturing Works.



Protype Brushland Plow designed and built by the Forest Service Equipment Laboratory-Portland Oregon, 1947-48, moving over a large rock.

stock producers funding was greatly increased by Congress.

As a part of the Forest Service range improvement program, Joseph Robertson was assigned by the Intermountain Forest and Range Experiment Station during the early 1940's to assess seedable sites on National Forests in Nevada and Wyoming. In the Ruby Mountains of northeastern Nevada, Robertson suggested the rugged topography, rocky soils, and general condition of the plant communities made seeding unfeasible and undesirable. Robertson suggested that the seeding of degraded sagebrush ranges located off the National Forest would benefit the National Forest ranges by permitting a later turnout date. His suggestion was accepted and 820 acres were seeded in Ruby Valley near Arthur. For many years the seeded area had been a dangerous spring range for cattle because of low larkspur. Its grazing capacity was rated at 16 acres per AUM. The seeded area was a mixture of private and public lands administered by the Bureau of Land Management. After 2 years rest the seeding was grazed for 3 weeks each spring by 400 cows and calves that normally would have been turned out on the National Forest. This example of how the seeding money was spent by the Forest Service illustrated the potential of range improvement to alleviate management problems while increasing red meat production. This and other pilot testing projects done during the war helped dispel the prevailing attitude that sagebrush ranges could not be seeded.

The Forest Service claimed a 90% successful establishment program with the pilot seeding program, but equipment breakage was a major problem. This led directly to the formation of the Range Seeding Equipment Committee. A conference was held in Utah in 1945 which was attended by the western Forest Service administrators and researchers to consider the general subject of range seeding. A lack of effective and suitable equipment was determined to be one of the major stumbling blocks in the way of successful seeding. Other land management agencies with similar problems eventually led to a committee for Range Seeding Equipment of federal interagency composition.

The committee was composed exclusively of Forest Service personnel for the first 2 or 3 years. The first official meeting was held in Portland, Ore., in December 1946. The second meeting followed in Ogden, Utah, in 1947. The list of those attending included a blend of old-time range scientists such as George Stewart and W.R. Chapline and such younger scientists as A.C. Hull and Joe Pechanec. Pechanec was elected chairman of the committee. He was midway in his career as a scientist at this time and was to have a great deal to do with the development of special range improvement equipment both as a scientist and a research administrator.

The Bureau of Land Management, U.S. Department of Interior, joined the committee in 1949, followed by the Bureau of Indian Affairs (USDI) and the Soil Conservation Service (USDA). In 1954 after a portion of the ranch research program was transferred from the Forest Service to the Agriculture Research Service (ARS), USDA, the ARS scientists joined the committee.

Brushland Plow

As previously noted most of the wheatgrass seedings during the 1930's in the Intermountain area were carried out on abandoned cropland. If sagebrush ranges were to be successfully reseeded, mechanical means of brush control had to be developed. Among the first projects undertaken by the Range Seeding Equipment Committee was evaluation of the previously mentioned rail drags and pipe harrows for brush control. Both implements were relatively effective on old growth plants which could be easily uprooted, but did not control supple young plants.

The implement that did the best job of controlling big sagebrush was the wheatland type disk plow. The wheatland plows were subject to a great deal of breakage of castings, disk, and even the frame if they were used on rocky sites. Use of this plow required continued maintenance. Despite its drawbacks many early seedings, including a portion of the Ruby Valley project, were established with wheatland plows with seeders attached.

After his experience with wheatland plows, J.H. Robertson was interested in the development of a plow for rangelands. He noted in the proceedings of the 1939 World Wheat Congress a report on an Australian stump-jump-plow. The plow was designed with each pair of disks independently suspended on spring loaded arms so that when an obstruction was met the disks rode over the blockage rather than breaking. Robertson called this plow to the attention of his colleagues and after a delay a plow was imported from H.V. McKay, Massey Harris Ltd. of Sunshine, Australia and was known as the Sungeneral or Australia stump-jump-plow.

This plow was tested March 17, 1947, on an area south of Boise, Idaho. A portion of this site had lava rocks up to 16 inches in diameter on the soil surface. Following the initial test the plow was taken to an area near Smith Prairie in Boise National Forest where 305 rocky and steep acres were plowed. The site had previously caused excessive breakage when it was plowed with a wheatland plow. Extensive testing of the plow in the Pacific Northwest was conducted. The original plow proved too weak and was subject to extensive breakage.

From this prototype plow imported from Australia the Range Seeding Equipment Committee and the Forest Service Equipment Laboratory at Portland, Oregon developed in 1947 and 1948 the plow which became known as the brushland plow. The engineering work was done by Ted Flynn with assistance from Tom Coldwell and with the approval of J.F. Pechanec.

Land managers now had an implement capable of attacking dense stands of big sagebrush. The plow imported from Australia was relatively inexpensive, costing $413 f.o.b. Sunshine, Australia in 1947 and weighing 3,000 pounds. The brushland plow produced by the Equipment Development Committee's efforts was a much more substantial implement weighing 6,000 pounds. The brushland plow was considerably more expensive and the cost has continued to rise until now it has reached $25,000 (1979 prices). This underscores the capital requirements for range improvement.

The brushland plow is important in the story of the development of the rangeland drill because it was a necessary brush control implement to reduce competition for a drill to be effective and because the independent suspension of disks became roughly copied in the development of openers for the drill.

Rangeland Drill

Grain drills designed for farms had proven even less adapted to sagebrush ranges than plows. In southern Idaho and central Oregon, there were considerable acreages of abandoned cropland that could be seeded to crested wheatgrass by grain drills with limited problems. However, the uneven seedbeds with with clumps of woody trash produced by the new brushland plows proved to be particularly hard on grain drills. A major problem was breakage caused by the presence of large rocks in the seedbed.

In the early summer of 1951 Floyd Iverson, who was Regional Range and Wildlife Officer for the Forest Service, headquartered at Portland, Ore. made a routine trip to the Fremont National Forest in southeastern Oregon. During a discussion of the range seeding program on the forest, the Forest, Range and Wildlife staff officer, John Kucera, mentioned that during an 8-hour working day they were breaking three or four drill arm assemblies. Mr. Iverson "allowed" he would like to see someone develop a drill for rangelands. Kucera immediately said he would attempt such a development if he had the funds. The regional office contributed $700 toward such a project based on Kucera's cost estimate. The drill conversion eventually cost $1,000 with the Forest paying the difference.

Development of the first drill was started in July 1950 (see Table for sequence of development). For a performance goal it was decided to build a drill that could be used anywhere you could drive a small crawler tractor. Up until that time most range seeding was done with John Deere-Van Brunt grain drills. The Fremont Forest happened to have a Minneapolis-Moline drill with a heavy frame so it became the experimental unit. To gain clearance, 12-inch spoke extenders were welded around the existing wheels. This prompted taunts that the experimenters were building a mechanical porcupine. A new rim was placed around the outside of the spokes. The designers then developed *Y* yokes to support the disk openers. These openers made the furrow in the seedbed surface into which the seeds are dropped. The correct angle of these yokes to permit them to ride up over obstructions was determined by trial-and-error.

The nemesis of the commercial grain drills had been breakage of the castings that attached the disk openers. This breakage was caused by side thrust as the disk dug into the seedbed. Kucera and his crew solved this problem with larger, cold rolled steel shafts and welded plates to support the self-aligning bearings. Again, it was necessary to establish the correct angle of the disk for optimum penetration in the soil on a trial-and-error basis.

Once the flexible opener assembly was designed it was necessary to design a boot that would collect seeds as they were metered from the drill box and convey them to the openers. Working after-hours with blacksmith tools, Kucera finally succeeded in fabricating an acceptable metal boot which was connected to the opener with a rubber hose.

These are only the major modifications accomplished by the intrepid Fremont Forest designers. A host of other points ranging from chains to raise the opener's arms to weights to make the openers dig into the ground had to be considered and solved. Lakeview, Ore. is not an industrial center where material or design advice was readily available. Remember, there were 10 openers on the drill; so once a modification was perfected by trial and error, the designers had to make 9 duplicates without drawings, templates, or jigs.

Demonstration model of Rangeland Drill designed and built by John Kucera and N.R. Smith of the Fremont National Forest, Lakeview, Oregon in operation on Coffee Pot Flat, 1951.

In the fall of 1951 the modified drill was used to seed 750 acres on the Coffee Pot seeding in the Paisley Ranger District of the Fremont Forest. The openers worked adequately, but it was necessary to strengthen the frame and tongue. In early January the designers loaded what they called "our monstrosity" on a railcar for shipment to the Forest Service Equipment Development Laboratory at Arcadia, Calif., where it was to serve as a model for development of an engineered drill.

The Range Seeding Equipment Committee adopted the rangeland drill as a project in 1951. Tom Coldwell from the Forest Service Equipment Development center visited the Fremont Forest and saw the Kucera drill and was instrumental in having the drill shipped to Arcadia.

The development of the rangeland drill now passed from a conceptual and demonstration-that-the-idea-was-practical phase to a full-scale engineering and development phase. From June 1951 to October 1952 Tom Coldwell directed the detailed engineering studies necessary to develop a prototype drill. On October 7, 1952, a full-scale engineering prototype rolled out of the shops at Arcadia. The prototype drill was sent for testing to the Fremont Forest where it is still in use.

During May 1954 a technical data package for the rangeland drill was released by the Equipment Development Center of the Forest Service. This package contained detailed drawings and specifications that permitted its manufacture by commercial firms. The production phase was initiated when the first commercially manufactured drill rolled out of the fabrication facilities of Laird Welding and Manufacturing Works at Merced, Calif., on April 29, 1955. This drill had been purchased by the Forest Service under contract and was shipped to Reno, Nev.

The original drill certainly was not perfect. Over the years many modifications and attachments have been added. The major product improvement has been the addition of deep furrow openers. The disks on the original model drill were equipped with metal bands to prevent them from digging into seedbed and burying small grass seeds too deep. Users in the field soon discovered that in many conditions it was desirable to have the maximum amount of penetration and to plant the grass seed in a small furrow. Joseph M. Mohan was working in the Fremont National Forest when the first drill was being developed. Later in his career Mohan and Bill Currier decided to undertake a do-it-yourself program to modify the drill openers so they would make deep furrows. Mohan and Currier started with simple changes such as removing the depth bands and adding weights and worked up to cutting off the openers and changing the angle of the disk in two planes.

At the same time land managers were experimenting with modifications of the drill, scientists were defining the environmental parameters of deep furrows that resulted in improved seedling establishment. It was determined that furrows allowed earlier germination permitting more growth and a better chance of seedling establishment before soil moisture was exhausted by summer drought.

The scientists (Richard E. Eckert, Jr. and Raymond A. Evans, Agricultural Research, USDA) and land manager (Jerry Asher, BLM) combined in an appeal to the Range Seeding Equipment Committee for development of an engineered deep furrow arm for the drill. The committee adopted this project in 1969. Engineered deep furrow arms were developed under the direction of Dan McKenzie of the

Hydraulically operated opener arms lift attachment for Rangeland Drill. **Down.**

Forest Service

Hydraulically operated opener arms lift attachment for Rangeland Drill. **Up.**

Equipment Development Center of the Forest Service. These arms were field tested and finally adopted as an option in 1972. Large-scale testing indicated conditions of vegetation cover and soil texture, moisture, or freezing required adjustment to the angles once or twice a week.

Not only was the drill modified to become more functional, the availability of the drill modified technology. When Kucera originally visualized the rangeland drill, he contemplated a piece of equipment which could be used to seed grasses in standing sagebrush. He planned to reduce competition by killing the brush with an application of the herbicide 2,4-D [2,4-dichlorophenoxy) acetic acid]. This herbicide was being widely used to control sagebrush where sufficient perennial grasses remained preempting the environmental potential released by killing the shrub. Joe Mohan and Bill Currier perfected this technique in the late 1950's and B.L. Kay and Jim Street, working on sagebrush ranges located on the Likely Table lands in northeastern California, evaluated this vertical integration of these technologies in experiments.

It is not enough to conceive, develop, and produce a technological advance such as the rangeland drill. In order for users to fully benefit from the advance it is necessary to develop an operational manual and a parts list for the drill.

The rangeland drill is an inanimate hunk of steel, but its continued development reflects changing land uses. Currently the drill boxes can be furnished with double shaft agitators to aid in seeding trashy native grass seeds on strip mine reclamation sites.

Significance of Rangeland Drill

Since the prototype drill was developed, approximately 320 drills have been manufactured for use in the United States, and for export. As technological developments to accomplish specific jobs, the brushland plow and rangeland drill must be given the highest marks for ingenuity and technical engineering. The method of development with ideas born of need in the field being fed through a functional, interagency committee to be interacted on by engineers and biological scientists also deserves the highest praise. Although the rangeland drill was developed largely by agencies of the federal government, actual manufacturing of the equipment has always been accomplished by private enterprises. It should be recognized that the development of highly specialized and very costly pieces of equipment have created very high capital requirements for range improvement. The cost of this equipment may be excessive for private ranchers unless they band together in cooperative units.

The rangeland drill is a symbol of a subtle change in the evolution ot technology that occurred after World War II. The rangeland drill was conceived, developed, engineered, and largely used by the federal bureaucracy. Because the federal employees involved believed the volume of drills built would not justify the cost of obtaining patents, they did not pursue this documentation of their contribution; as a result the evolution of the rangeland drill was free of lawsuit. This is a sharp contrast to the initial development of machines for agriculture where the rights for virtually every innovation were contested in the courts for years.

The application of the post-World War II technology in range improvement was startling in its results. Using the sagebrush ranges of Nevada as an example, we find that about 1 million of the 27 million acres of sagebrush rangeland were seeded. This seeded area, that constitutes 2% of the total rangeland in Nevada, produces 10% of the harvestable AUM's (Animal Unit Months) of grazing. The crested wheatgrass seedings produced early spring grazing on a sustained basis. Early spring is especially valuable to the livestock industry and it is the period when native forage species are most susceptible to damage by excessive grazing. The successful seeding of wheatgrasses on degraded sagebrush ranges helped stabilize the livestock industry and added a new dimension to range management in the intermountain west. On the other hand the acreage estimate of crested wheatgrass in Nevada was produced by planimetering the outline of angular wheatgrass seedings on imagery reconstituted from data collected from a satellite orbiting 500 miles above the earth's surface. A mere 320 machines have changed the appearance of planet earth as viewed from space. Obvious type conversions from degraded silver-gray brush to golden wheatgrass are visible to the general public. Environmentally concerned individuals have often protested such conversions as damaging to visual, wildlife, and cultural resources. Appropriate application of the range improvement technology can enhance and protect all of these resources and this is the challenge of wildland managers in the next decade.