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Chapter

9

Mechanical Plant Control

When planning a restoration or rehabilitation project, proper equipment selection should be a high priority. Equipment should be selected that is adapted to the treatment site, and that when properly used, will fulfill and add to the objectives of the treatment. Equipment should be economical and ecologically sound.

Basic equipment available and commonly used in range and wildland restoration is described in this chapter along with primary functions and principal areas of use. For the convenience of the reader, equipment has been grouped into three categories.

1. Seedbed preparation equipment
   - Disks and plows
   - Chains and cables
   - Pipe harrows, rails, and drags
   - Land imprinters
   - Root plows
2. Seeding equipment
   - Drills
   - Broadcast seeders, ground broadcasting, aerial broadcasting, fixed-wing, helicopters
   - Seed dribblers
   - Brillion seeder
   - Surface seeder
   - Interseeders
   - Hydro seeders
3. Special use equipment
   - Transplanters
   - Roller choppers
   - Dozers and blades
   - Trenchers, scalpers, gougers
   - Fire igniters
   - Herbicide sprayers
   - Steep-slope scarifier seeders

Seedbed Preparation Equipment

Disks and Plows

Disks and plows are designed to turn over soil and surface debris, kill existing vegetation, and prepare a seedbed (table 1).

Moldboard Plow—Plows with large curved bottoms (moldboards) with blades or shears and large curved wings above. Each moldboard can be independently spring-loaded to enable each bottom to rise when obstructions are encountered.

Disk Plow—Consists of a single gang of a few to several disks on a frame supported by wheels. Each disk is slanted at an angle to the vertical, with a separate bearing and frame attachment.

Brushland Plow—A specially designed rangeland disk. The brushland plow consists of seven pairs of opposite, opposing disks attached to spring-loaded arms that are connected to a heavy duty frame supported by three wheels. Each pair of disks is independently suspended (fig. 1) (Larson 1982).

Off-Set Disk—Two rows or gangs of disks are set at an angle to each other (fig. 2) (Brown 1977; Larson 1982). Angles are adjustable. Disks cut in two directions, turning over soil and vegetation both ways. Disks can be smooth or cutout (table 1).

Disk-Chain—An anchor chain, with cutout disks connected to every other link (fig. 3). Varying lengths of disk-chains are connected to either end of a double roller bar, forming an "A" with the apex forward and the roller bar back. A spreader bar is connected from the center of the roller bar to the apex. The length of the spreader bar determines the angle of the chains and disks. Chains are connected to each other; the roller bar is connected by swivels (Wiedemann 1985).

Table 1—Description, primary areas of use, and limitations of some major seedbed preparation equipment.

Equipment	Description	Primary area of use	Limitations
Disk-plow	Single gang of a few to several disks mounted on a frame.	Deep plowing of rock-free and debris-free soil. Controls deep rooted plants.	Restricted to fairly rock-free and large debris-free sites. Slow speed. Large amount of power required to operate.
Brushland plow	Pairs of disks connected to independently suspended spring-loaded arms. Arm connected to heavy duty frame with wheels.	Shallow plowing on smooth, rough, rocky, and uneven terrain. Controls grasses, forbs, and nonsprouting shrubs. Low maintenance costs.	Will not control sprouting shrubs. Difficult to transport. Operational speed is slow.
Off-set disk	Two rows or gangs of disks set at an angle to each other.	First gang of disks turn soil and vegetation. Second gang turns soil and vegetation in opposite directions. Vegetation is cut up and broken. Controls most grasses, forbs, and small nonsprouting shrubs. Works well on dry, heavy, and moderately rocky soils.	Cannot be operated in soil with large rocks and on slopes over 30 percent. Fairly slow operational speed.
Smooth anchor chain	Anchor chain weighing 40 to 160 lb per link, 90 to 350 ft long, with swivels on either end and sometimes in the middle.	Moderate soil scarification. Uproots and breaks off trees and shrubs and releases understory vegetation. Covers seed. Cost per acre to operate is moderate. Can be operated on uneven rocky terrain. Ideal for removing trees, releasing understory shrubs, grasses and forbs, and covering seed.	Will not control sprouting shrubs. A less than acceptable job of killing nonsprouting shrubs and trees. Will ride over young, flexible trees.
Ely-anchor chain	Anchor chain weighing 40 to160 lb per link, 90 to 350 ft long, with steel bars or railroad rails welded cross ways to chain links. Swivels are attached at either end and throughout.	Uproots and breaks off trees and shrubs. Releases understory vegetation. Percent kill of shrubs and trees is higher than with a smooth chain. Does an excellent job of scarifying soil surfaces and covering seed. Can be operated on rough, rocky terrain. Cost to operate is moderate.	Has tendency to hook and drag trees, and rolls downed trees and shrubs to the middle of the chain. This lifts the chain off the ground, resulting in poor soil scarification. Can uproot and kill some understory vegetation.

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Table 1 (Con.)

Equipment	Description	Primary area of use	Limitations
Dixie sager	Anchor chain weighing 40 to 160 lb per link, 90 to 350 ft long, with railroad rail welded to each side of each link horizontal to the link. Crown of rail welded next to link. Swivels are attached at either end and throughout.	Uproots and breaks off trees and shrubs. Releases understory vegetation. Does an excellent job of uprooting and killing big sagebrush, scattering smaller pinyon and juniper, and scarifying the soil. Covers seed. Can be operated on rough, rocky terrain. Cost of operation is moderate.	Does not work well in full pinyon-juniper stands. Trees are hooked by the railroad rail and are dragged along. This lifts the chain off the ground and results in poor sagebrush kill and soil scarification.
Cables	Cable 1.5 to 2 inches thick, 100 to 550 ft long, with swivels at both ends and throughout.	Will uproot larger trees, slightly scarify soil surface and cover seed. Can be used on rocky, uneven terrain. Cost of operation is low. Ideal for removing scattered large trees and releasing understory shrubs.	Percent kill of trees is lower than with smooth, Ely, or Dixie-sager anchor chains. Soil is poorly scarified.
Pipe harrow	Spiked pipes trailed behind a spreader bar. Pipes are attached to spreader bar by swivels at equal intervals along bar.	Scarifies soil surface, removes small brittle shrubs, covers seed. Ideal for interseeding desirable species into sparse vegetation stands. Works well on rocky land and uneven terrain. Cost of operation is low. Seeding can occur concurrently.	Does not control plants other than brittle shrubs. Soil scarification is limited on compacted soil.
Land imprinter	Cylinder or drums with various configurations, sizes, and shapes of angle iron welded to the drum surface. Seed dispensers may be attached to frame-tow bar combination.	Operation on rough, rocky, and brush covered terrain on most soil types. Creates small depressions. Seeds are deposited into depressions in a firm seedbed. Cost of operation is moderate.	Does not work well in dense shrubs or grass communities or on compacted and rocky soil.
Root-plow	Straight or V-shaped blade attached to shanks. Shanks are attached to a trailing draft or arm or tow bar, dozer blade, or dozer frame.	Used to undercut undesirable grasses, forbs, shrubs, and small trees in soils free of large rocks. Works well in dry soils.	Not adapted to shallow, rocky, steep, or wet areas. Kill of sprouting and rhizomatous species may be low. Cost of operation can be high.

Figure 1—Brushland plow.

Figure 2—Off-set disk.

Only one tractor is required to operate a disk-chain. Seeding and disking can occur simultaneously. Broadcast seeders can be connected to the roller bar on a trailing trailer. Seed boxes have been placed over the roller bars.

Principal Areas of Use—Disks are designed to kill plants by turning over sod, vegetation, and debris; and for preparing a seedbed. Disk plowing has the advantage of leaving plant material at or near the soil surface. Offset disks and moldboard plows are well adapted to fairly deep soils with few large rocks and debris. Offset disks are fairly effective on moderately rocky soils taking out small and medium shrubs, but not effective when worked in large shrubs and trees that have large woody stems and heavy roots.

The brushland plow was developed specifically for range and wildlands. It is well suited to rocky, rough, and uneven terrain. This plow does a good job of killing low growing nonsprouting shrubs. Each set of disks, being independently suspended, will lift up and go over rocks and debris leaving the other sets in the ground.

The disk-chain is designed for use on smooth, rough, uneven, and rocky terrain in all vegetative types ranging from grass communities to large shrubs and sparse stands of small trees. Width of treatment is determined by width of the roller bar. Roller bars vary from 24 to 46 ft (7.3 to 14 m) wide. Width of roller bars and length of chain determine disk angle and distances between disk cutting points. If complete disturbance and vegetation turnover is desired, spreader bar or chain length is increased, causing the angle of the chain to the roller bar to be readjusted. When it is desirable to have some area undisturbed (interseeded), spreader bar or chain length is decreased. Care must be taken in extending the spreader bars too far. If the angle between the spreader bars and the chain exceeds 30°, excessive wear to the components will result. Broadcast seeding can occur simultaneously with disk chaining from a broadcaster mounted on a trailing trailer (fig. 3A) that throws the seed forward behind the disks and ahead of the roller bars that covers the seed. Drill boxes can be mounted directly over the roller bars that deposit the seed directly onto the roller bar, and subsequently in front of the roller bar that cover the seed and turns up the seedbed (fig. 3B). The disk-chain is an ideal piece of equipment for large sites, strips, and localized site seeding in sparse trees and shrub stands. The disk-chain does an excellent job in reducing the density of cheatgrass and perennial species.

Chains and Cables

Cables and anchor chains and modified anchor chains are generally pulled between two crawler tractors for the purpose of removing or thinning trees, shrubs, and grasses and for covering seed (table 1).

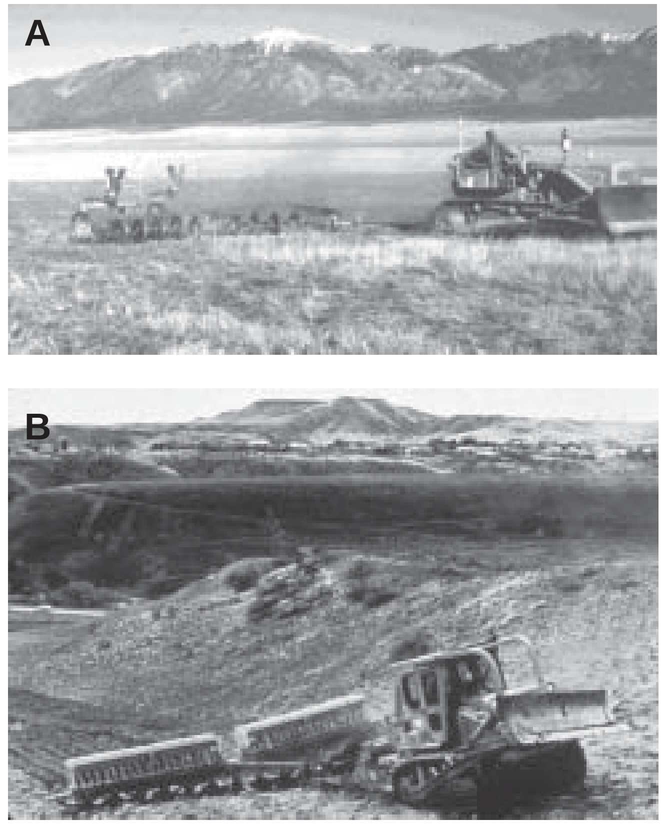

Figure 3—Disk-chain. (A) Seed broadcast with electric powered cyclone seeder. (B) Disk-chain with seed boxes mounted above roller bar.

Cables—The steel cable is 1.5 to 2 inches (3.8 to 5 cm) thick and 100 to 550 ft (30.5 to 168 m) long. Swivels are required at both ends and are sometimes installed in the center of the cable. They are necessary so that the cable does not unwind, and to permit the cable to rotate and keep itself relatively free of trash and debris.

Anchor Chain—A destroyer or cruiser-type anchor chain, 40 to 160 lb (13.6 to 72.6 kg) per link (fig. 4) (Davis 1983b; Larson 1982; Roby and Green 1976) varies in length from 90 to 350 ft (27 to 107 m). Swivels (fig. 5) (Larson 1982) are required at both ends and are recommended additionally, at least in the middle of the chain.

Ely Chain—This device consists of anchor chains with steel bars (fig. 5). Hard surfaced railroad rails are I-beam (fig. 5 and 6) welded crossways to every link, every other link, or every third link (Larson 1980). Bar length will vary with link size but should extend 4 to 6 inches (10 to 15 cm) beyond both sides of the link. Swivels are required on both ends of the chain and intermediately throughout the chain. Chain length

Figure 4—Smooth anchor chain.

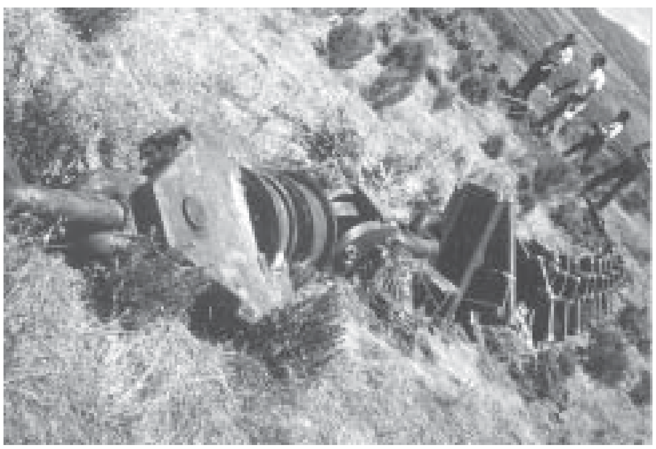

Figure 5—Swivel within an Ely chain.

Figure 6—Ely chain. Anchor chain with railroad rails welded crossways on every other link.

varies from 90 to 350 ft (27 to 107 m) long. The ten to 15 lead links at either end of the chain are left smooth because this part of the chain is not in contact with the ground.

Dixie Sager—An anchor chain with a railroad rail welded to each side of each link, horizontal to the link (fig. 7) (Larson 1982). Length of rails depends on link length. The rail should be approximately one-half the total length of the link. Rails are welded with the crown of the rail next to the link, and base of rail out. Swivels are required on both ends of the chain and intermediately throughout the chain. Chain length varies from 90 to 350 ft (27 to 107 m). Ten to 15 smooth lead links are on each end of the chain.

Disk-Chain—See "Disks and Plows" section, "Disk-Chain" paragraph.

Principal Areas of Use—Anchor chains and cables are primarily used to uproot trees and shrubs, to create seedbeds, to top and prune large shrubs, and to cover seed (table 1). Some grasses and forbs can also be uprooted. Use is also limited due to concerns for protection of archaeological sites, damage to nontarget vegetation, and aesthetic and hydrologic impacts.

Anchor chains and cables are pulled behind two crawler tractors traveling parallel to each other. To

Figure 7—Dixie Sager. Anchor chain with railroad rails welded horizontally to both sides of each link.

Figure 8—Uprooting pinyon and juniper with an anchor chain. For maximum results chain should be dragged in a loose J-shape as is being done.

be effective, chains and cables should not be dragged or stretched taut, but must be dragged in a loose, J-shaped (fig. 8), U-shaped, or half circle pattern. The half-circle configuration provides the greatest swath width, lowest percentage kill, and should only be used in mature, even-age tree stands. Kill and disturbance increases as the width of the J- or U-shaped pattern decreases. Chain length to swath width ratio of 2:1 to 3:1 are commonly used. As the proportion of young trees and shrubs increase, chaining width should decrease in order to achieve the greatest amount of kill. Individual chain link weight varies from 40 to 160 lb (18 to 72.6 kg). The heavier the link, the better the chain stays on the ground, and the higher the percentage kill.

Chaining commonly occurs on slopes of up to 50 percent grade (Vallentine 1980). Chaining can occur up and down or across the slope without adversely affecting watershed values.

Success in removing trees and shrubs varies with species composition, age structure, density, and rooting habit. Trees in mature, even-age stands can be killed more effectively and efficiently than in uneven-age stands. Young trees less than 48 inches (1.2 m) tall may not be killed with single or double chaining because the chain may ride over them. Small junipers can be uprooted and killed more effectively than small pinyons that tend to be more flexible than junipers. Sprouting trees and shrubs may resprout following chaining. Anchor chains can be used to improve esthetics and livestock movement in burned tree and shrub stands, particularly those with a large number of standing dead trees and shrubs.

Chaining generally does not increase runoff or erosion. The opposite generally happens; runoff and erosion are decreased through increased retention and detention of surface water. This is the result of the large amounts of debris, trash, shrubs, litter, and trees that are deposited and left on the soil surface and the establishment of seeded vegetation. Downed trees, shrubs, and plants increase ground cover and protect the soil from wind and water erosion. In addition, they provide favorable microenvironments for plant establishment, growth, and protection. Live standing trees provide only canopy cover, very little ground cover, and little, if any, retention and detention of surface water.

Percent kill and amount of soil disturbance increases with link size. Ely chains do a good job of scarifying soil and preparing a desirable seedbed. The Ely chain has a tendency to roll downed trees and shrubs to the center of the chain. Tree and shrub kill is improved with an Ely chain over a smooth chain.

The Dixie sager was designed to uproot big sagebrush. It does an excellent job of uprooting sagebrush and scattered pinyon and juniper. The Dixie chain will do a better job than a smooth chain of soil scarification, and of sagebrush, small juniper, and pinyon kill. The Dixie sager does not work well in full pinyon-juniper stands since the railroad rails tend to hook trees and carry them along; this lifts the chain off the ground and reduces soil scarification and the number of trees and shrubs killed. Smooth chains are preferred when the objective is to release and open up tree and shrub communities such as big sagebrush, aspen, mahogany, serviceberry, Gambel oak, chokecherry, bitterbrush, cliffrose, winterfat, and shrubby eriogonum. When removing trees and most shrubs, twice-over chaining is necessary. The first chaining completely uproots some trees; however, many trees are not completely uprooted and are laid down in the direction of chaining. The second chaining should occur in the opposite direction, this generally uproots and tips the downed trees over. Most shrubs that come in contact with the chain are uprooted or broken off near ground level. Twice-over chaining increases percent kill and topping of shrubs. Seeding should occur between chainings, as the second chaining covers the seed. If single chaining occurs, seeding should take place prior to chaining.

First and second chainings can follow each other in the fall, with seeding occurring between chainings. Another technique is to chain once during the summer months. Uprooted and partially uprooted trees are allowed to dry before seeding and the second chaining is done in the fall. The dry trees and limbs break up easily and are fairly well scattered over the areas with the second chaining. Trees, limbs, and dry foliage create excellent microclimates for seedling establishment. Once-over chaining may be adequate when sufficient understory remains, trees are mature, and seeding is not planned. Cabling is less effective than chaining in removing trees; however, cables disturb

Figure 9—Pipe harrow consisting of spreader-bar and trailing spiked pipes.

the understory less. Use of a cable of lighter link chain is satisfactory where it is desirous to leave some trees or shrubs or to remove dead material from old shrubs and stimulate new growth.

It is generally advantageous to leave downed trees in place and not pile or burn them. Some advantages to leaving trees in place include: (1) increased amount of infiltration by increased retention and detention of surface water; (2) increased ground cover; (3) decreased erosion; (4) cover maintained for wildlife; (5) big game and livestock movement onto the treated area is encouraged, resulting in more even distribution and use; (6) provides shade for livestock and big game; (7) decreased livestock trailing; (8) seedling establishment is improved, especially of shrubs, and (9) cost of piling and burning is eliminated. Some advantages to removing trees are: (1) improved vehicular access; (2) enhanced access to all forage by grazing animals; (3) lower rodent density; (4) reduction in fire potential, and (5) improved esthetics.

Pipe Harrows, Rails, and Drags

Pipe harrows, rails, and drags are used to scarify soil surfaces, prepare seedbeds, cover seed, thin or reduce shrub density, and to release shrubs by removing top growth (table 1).

A pipe harrow consists of a spreader bar (usually railroad rails) and trailing spiked pipes (fig. 9). The spiked pipes are attached at equal distances along the spreader bar with swivels (Larson 1980, 1982). Cables or chains connect the spreader bar to a tractor. Rails come in various configurations. An A-rail is a rigid frame with the apex forward (Larson 1980, 1982). Rails consist of any number of tiers of rails connected with chains or cables that are dragged at right angles to the direction of travel. Drags consists of chain link fence, trees and shrubs drags, and combinations of rails and chains (fig. 10).

Principal Areas of Use—A pipe harrow can be used to uproot, break off, or thin shrubs; scarify soil; and cover seed (fig. 11). A pipe harrow can be very useful for preparing a seedbed and interseeding desirable species into sparse grass, forb, shrub, and tree stands, and for removing and thinning plants and seeding rocky and otherwise inaccessible areas. Weight of pipe harrows can be increased by filling the

Figure 10—A drag consisting of an I-beam Ely chain combination being used to thin sagebrush and cover seed.

Figure 11—Pipe harrow and Hansen seed dribbler being used to seed shrubs and cover herb seeds to improve interspaces between pinyon and juniper trees and Gambel oak. Herbs were broadcast seeded prior to treatment.

spiked pipes with cement; increasing weight increases scarification. Rails are used for removing shrubs and covering seed. Rails are less effective than pipe harrows. Chain link fence, trees or shrubs drags are used to prepare a seedbed and to cover seed. Broadcast seeding can take place simultaneously with pipe harrowing, railing, and with drags.

Land Imprinter

The land imprinter (fig. 12) was developed by USDA Agricultural Research Service for covering broadcast seeds and creating microdepressions in the soil to improve moisture collection and infiltration (Dixon 1980). The equipment was designed to operate on untilled surfaces, and can be used to treat burns, or other disturbances where remnant vegetation should be retained (table 1).

The land imprinter consists of cylinders or rollers mounted on a single axle. The axle is attached to a steel tubular or pipe frame with a tongue for pulling. Cylinder surfaces have various configurations, and sizes, and shapes of angle iron welded to the surface of each drum. Angle irons make indentations or imprints in the soil (Larson 1980). Cylinders or rollers can be constructed from discarded asphalt rollers or similar items (Johnson 1982). The cylinders can be filled with water to increase weight and allow for deeper imprints. Broadcast seeders can be mounted on the frame assembly to dispense seed over the imprints; or a grain box can be mounted in front of the rollers with seed being distributed on the surface and impacted into the soil by the imprinter. The imprinter is commonly about 10 ft (3 m) wide, with individual angle irons 6 to 10 inches (15 to 25 cm) deep with vertical lengths between 3 to 4 ft (0.9 to 1.2 m) long. A 60 to 125 hp tractor is required to tow most land imprinters.

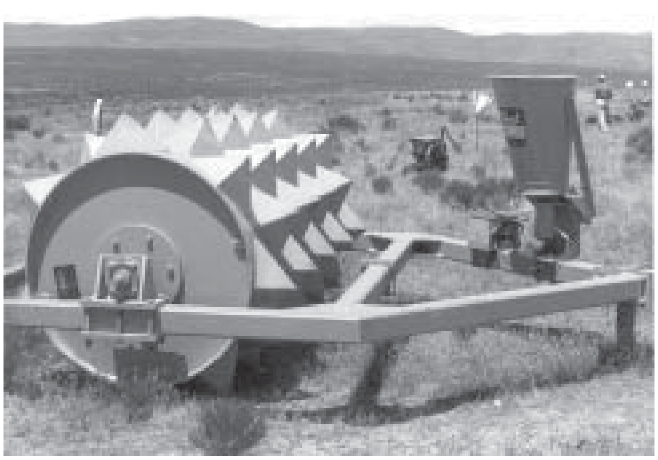

Figure 12—Land imprinter equipped with an electric broadcast seeder.

Principal Areas of Use—The land imprinter is designed to be towed over burned and low stature brush and herbaceous vegetation where other control measures are not used. The weighted cylinders are able to crush and compact standing vegetation, providing litter and surface protection. However, Haferkamp and others (1985) reported that both regular drill seeding and deep furrow drill seeding were more successful than imprint seeding on an unprepared Wyoming big sagebrush and Thurber needlegrass site. Imprint seeding is practical on sites where weed competition is low, and excessive debris does not interfere with seed placement.

The imprinter is well suited for seeding on loose, unstable seedbeds and barren surfaces left after a fire or light disking. Impressions can be created in the soil to reduce soil movement and deterioration of the seedbed. However, imprinting cannot eliminate soil erosion on all sites for extended periods. The V-shaped furrows or inverted pyramids are effective in collecting moisture and creating variable seedbed conditions that extend the germination period, and often tend to favor seedling success. The various surface configurations result in small furrows aligned at different directions, creating different microsites that may benefit the establishment of multispecies seedings.

Haferkamp and others (1985) found that seedling establishment on loose soil was greatest from broadcast seeding followed by imprinting, and that imprinting prior to seeding was not as effective. These investigators found imprint seeding more successful than drill seeding of areas disked prior to seeding. These results may not be universally applicable.

Placement of most seeds into a firm seedbed usually improves seedling establishment. Small seeds generally benefit from shallow seeding. The land imprinter lends itself to this type of seedings.

The imprinter appears useful on heavy textured soils where surface crusting can be expected, such as areas where black greasewood dominates. The machine can be used to retain and incorporate litter into the soil surface, reducing the potential for crusting. However, the machine should not be operated when soils are moist, or during periods when excessive compaction may occur. The machine is suited to seeding mine and roadway disturbance where loose, rough surfaces are created following ripping of spoil piles, dump sites, and temporary roads.

The imprinter can operate on most rough sites that are free of large rocks or obstructions. It can treat slopes up to 45 percent (Larson 1980), but it is not well suited to extremely irregular terrain. The land imprinter is not able to treat dense, erect shrubs with stems having a diameter greater than 3 to 4 inches (7.6 to 10 cm). Larson (1980) reports the imprinter is capable of production rates of over 4 acres (1.6 ha) per hour, which is somewhat less than conventional drill seeding. However, equipment breakdown and maintenance is generally less for imprinters. Imprint seeding can be used in conjunction with herbicide treatments. Spraying often leaves standing litter and dead plants that interfere with most conventional drill seeding, but not with an imprinter.

The imprinter may also be used to aid in site improvement by natural seeding. Imprinting of seed formed within the treated area can often be achieved if a sufficient seed reservoir is present and treatment is completed at the proper season.

Root Plows

Root plows are used to uproot undesirable grasses, forbs, shrubs, and small trees (table 1).

A root plow is a straight or V-shaped blade attached to two shanks (Larson 1980, 1982). Shanks are attached to a trailing draft arm or towbar, which are attached to the rear of a crawler or rubber tired tractor. Shanks can be attached to dozer blades, dozer frames, or as a front-end tractor attachment. Fins may be attached to the top of the blade.

Primary Areas of Use—Shearing blades are pulled or literally pushed through the subsoil at desirable depths, cutting off and uprooting most vegetation to the cutting depth. Fins attached to the top of the cutting blade provide some vertical cutting action and can move severed roots and root crowns to the surface. Plants with severed roots generally die from lack of water, and plants whose roots are exposed die of desiccation. Hot dry periods are the ideal time to root plow. Rate of kill is generally higher in loose soils. More power is required to root plow in hard, dry soil than in damp soils. Plants are, however, less likely to reestablish in dry soils (Larson 1980).

Root plowing kills most desirable and undesirable shrubs and nonrhizomatous grasses and forbs. Seeding is generally required following root plowing. Broadcast seeding can be accomplished simultaneously. Root plowing is limited to deep soils that are fairly free of rocks and obstructions.

Seeding Equipment

Drills

Drills dispense and place various types of seed in the most ideal situations for germination and establishment. Drills adapted to range conditions require most or all of the following characteristics:

1. Minimum drill breakage and maintenance under rough, rocky, and brushy conditions.
2. High clearance.
3. Heavy duty frame.
4. Individually suspended planters that can adjust independently to irregular planting surfaces.
5. Disk furrow openers that have depth regulators.
6. Seed boxes that will accommodate seed of various sizes and shapes, including seeds with appendages.
7. Seed agitators in each seed box that will prevent seed bridging and allow for even flow of seed to seed metering devices.
8. Precise metering devices for each seed box.
9. Baffles in seed boxes to maintain even seed distribution.
10. Devices for accurate and rapid setting of seeding rate.
11. A seed metering device that will disperse fluffy, plumbed, or trashy seed when these types of seed are used.

Seeding multiple species with varying sizes, shapes, and surface characteristic requires multiple seed boxes, each with differing seed metering devices and rates. Seeding depth requirements also vary between species. Some modifications to, and incorporation of equipment to facilitate these requirements have occurred. A variety of drills are available; however, all have some but very few possess all of the above required characteristics.

Primary Areas of Use—The Rangeland drill (fig. 13) was designed by the Forest Service specifically for rangeland use (Larson 1982; Roby and Green 1976; USDA Forest Service 1967; Young and McKenzie 1982). This drill possesses many desirable characteristics. It is well adapted to seeding rough, rocky terrain; however, breakage and down time can result in areas with heavy brush and trash. Some of the many improvements and modifications made to the Rangeland drill (Young and McKenzie 1982) have resulted in

Figure 13—Three Rangeland drills with drag pipes and depth bands.

the development of the deep furrow drill. Special adaptations are available to seed fluffy and trashy seed (Laird 1980). Depth bands (fig. 14) are fairly effective in regulating seeding depth except in loose soils. The deep furrow Rangeland drill is especially effective in creating water catchment impressions. Rangeland drills come in a number of models and sizes. Service, parts (USDA Agricultural Research Service 1967), and operation (USDI Bureau of Land Management 1976) manuals are available.

The Truax drill seeder (fig. 15) incorporates many desirable characteristics plus all the features of the Rangeland drill with the exception of high clearance. It is designed to seed rangeland sites and rough terrain where dense litter has not accumulated. The wheels and disks are positioned for planting using hydraulic cylinders. The drill has been designed to transfer weight from the machine to the ground engagement planters through elastometer torsion knuckles, unlike units using mechanical linkage. This has reduced breakage and eliminated regular repairs.

The Truax drill has three different seed boxes designed to accommodate seeds of different sizes and

Figure 14—Individually suspended arm on a Rangeland drill. Disk furrow openers are equipped with depth bands and a drag chain.

Figure 15—Truax drill with three seed boxes and three sets of drops that can seed three different seed mixes or species at the same time at different rates and depths.

shapes. Seed metering is independently regulated for each seed box. A front mounted seed box is designed to plant small hard seeds. A second box is used to plant fluffy or trashy, lightweight seeds, and the third seed box is used to plant larger grain-size seeds. Seeds are metered through the small seed box and the grain-size seed box using a fluted feed regulator. Fluffy seeds are removed from the seed box by picker wheels, which remove and deposit a specific amount of seed. The picker wheel is driven by a chain and sprocket system that is attached to a ground wheel. Seeding rates are controlled by changes in the sprockets, through use of a bicycle-type derailer. The fluffy seed box contains an auger type agitator to assure uniformity in seeding rates. Pin agitators are mounted over the seed gate within the large seed box to provide uniform movement of seed. Under harsh conditions the machine requires 5 hp per planter row to effectively operate. Seed boxes are positioned directly over the drop tubes, which eliminate plugging of the seed in the tubes.

Seed slots or furrows are created by one leading concave, notched, no-till disk that is mounted on a slight angle. Seeds are directly placed in the soil, and compacted with a press wheel. A V-shaped cast iron press wheel is available and is used in hard soils to break up clods. A more universal type pneumatic press wheel is also available, and is better suited for wet or moist sites as mud does not accumulate on the wheels.

Depth bands are available and can be mounted or removed from each disk with four nuts. Different depth bands can be used to regulate planting depths ranging between 0.25 to 2.0 inches (0.6 to 5 cm).

The Truax drill is an improvement over the Rangeland drill as it provides three different seed boxes that can be independently regulated to meter seeds of different shape and condition. Bridging of seed in the seed tubes has been eliminated. Depth bands are much easier to remove or exchange, and better control of planting depths is maintained. The press wheels provide a better, firm, and compacted seedbed. Repair and operation costs are much less due to a new design of the supporting weight of the unit.

A number of reclamation and no till drills have been developed in the past 10 years. Each has their own characteristics, advantages, and disadvantages. Drills that have shown application on various range and wildland conditions include: Oregon press drill, Horizon (fig. 16), Tye (fig. 17), Haybuster, Great Plains, and Amazon (fig. 18) no till, stubble, and pasture drill.

The Rangeland and Truax drills are well adapted to seeding areas that have been cleared of trees and shrubs or burned. These drills have the capacity to seed many rangeland species out of one to three seed or fertilizer boxes or both (fig. 19).

Figure 16—Horizon drill with four press wheels down and 10 press wheels in the up position. Press wheels can aid in seedling establishment of some species. Species are separated in seed boxes according to seeding requirements.

Figure 17—Tye drill with four seed boxes and drops. Individual species or groups of species can be seeded at differing depths and rates and with or without press wheels.

The inability to regulate seeding depth, especially in loose soils on undulating topography, and with surface and shallow seeded species, is a major problem with the Rangeland drill. Seeding depth, especially shallow seeding, cannot be properly regulated. Seeds are deposited and covered in the bottom of furrows created by the disk-furrow opener. In loose soils the furrow generally fills in with soil, covering the seed even deeper. Drills being pulled uphill will generally seed deeper than when pulled on the level, and shallower when going down hill. Many wildland species require surface seeding or very minimal seed coverage (fig. 20). Most species are, however, ideally seeded ¼ to ⅜ inches (0.6 to 0.9 cm) deep. Most drills do not have the capacity to seed at these shallow depths. The Truax drill, however, does provide precise seeding depth and rate of seeding capacity. Drop tubes on many drills can be pulled from between and placed behind the furrow openers, so the seed will be deposited on disturbed soil.

Seeding rate adjustments on most drills are rated for small grains. Care must be taken to ensure that proper seeding rates occurs. Many wildland species have small seed, and when seeded singly may require

Figure 18—Amazon no-till drill.

Figure 19—Mixture of grasses, forbs, and fourwing saltbush seeded with the Rangeland drill. Fourwing saltbush was seeded through separate drops, independent of grasses and forbs.

being mixed with a carrier such as rice hulls. Individual species or mixtures can be seeded down one drop or a group of seed drops by partitioning seed boxes according to needs.

Stumps, downed trees, tree limbs, large shrubs, trash, large rocks, gullies, and moderately steep slopes can limit the use of many drills. Multiple hitches that accommodate two or three Rangeland drills have been developed (fig. 20) (Larson 1980).

Most no till and reclamation drills have heavy duty frames, individually suspended planters that adjust independently, multiple seed boxes, precise seeding range and depth adjustments, the ability to handle fluffy, plumed, and smooth seed of many sizes, and press wheels. They do not have sufficient clearance to operate on rocky sites, or sites with downed trees and other debris, or in gullies.

Prepared sites and semiwet and irrigated pastures can be effectively seeded and interseeded with many no-till drills (Bauder and others 1985).

Conventional grain drills are not well adapted to most range and wildland conditions. They are generally too lightly built; planters are not individually suspended, and many rangeland species will not flow evenly through their metering devices. In addition, the seeding depth regulators may be inadequate, and many species will be seeded too deep.

Broadcast Seeders

These devices broadcast seed by means of a blower or rotary spreader. There are two basic types of broadcasters, those that employ a blower or air source, and those that employ some type of rotary wheel to distribute seed.

Principal Areas of Use—Broadcast seeding can be an economical means of seeding large, as well as small areas and inaccessible sites where other equipment cannot function. Consequently many extensive and vital wildlands can only be seeded by broadcast seeding.

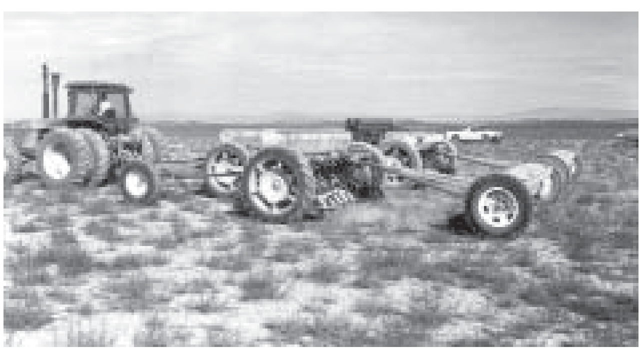

Figure 20—Rangeland drills followed by sagebrush seeders and chain drags. Species requiring seed coverage are put through Rangeland drills. Species that require surface or near-surface seeding are run through the sagebrush seeders.

Broadcasting is an effective means of uniformly distributing seed; however, scarification is required in most cases to incorporate seed into the soil. In only a few instances can seed be broadcast planted and expected to establish well on an unprepared seedbed. Broadcasting onto a tilled or roughened surface can be successful if natural soil sloughing occurs enough to bury the seed. For some species a firm seedbed is normally required to reduce surface evaporation and provide good seed-soil contact. Broadcast seeding alone normally does not achieve these results.

Aerial or ground broadcast seeding normally requires more seed than drilling. Approximately 33 to 50 percent more seed is recommended for broadcast planting. With proper seed coverage, most grasses, broadleaf herbs, and some shrubs can be successfully broadcast seeded. Where costly and scarce seeds are being used, they should be planted only where they have the best chance to establish.

Small seeded species are often planted too deep with drill seeding. Soil compaction and crusting that can occur with drill seeding is generally not a problem with broadcast planting. In addition, broadcast seeding, when compared to drill seeding, does not dislodge or impair existing plants and allows for quick recovery of native and onsite species. Rodent seed predation and insect damage is generally less with broadcast seedings. Drill seeding occurs in rows, which rodents tend to follow.

Seeds have been pelletized or coated in an attempt to increase planting success and to eliminate the need of soil scarification. To date, these treatments have not proven effective.

Ground Broadcasting

This is a method for uniformly broadcasting seed from handheld or vehicular mounted seeders. Seed is generally distributed by means of a rotary wheel. An airstream has been employed in a few ground seeders (McKenzie and others 1981).

Ground broadcasters can be operated manually by a tractor's track or by hydraulic, gasoline, or electric motors (fig. 21). They can be mounted on trucks, trailers, or tractors and other prime movers, and attached to various types of seedbed preparation equipment. A new concept in hand broadcast seeders has been developed by Truax Equipment Company called the Truax Seed Slinger. This unit is similar to older, conventional handheld broadcast seeders, however, it consists of a rigid plastic seed box that is partitioned into two compartments. Having two independent metering systems, seeds of different size, density, and condition can be uniformly distributed across rough terrain. It is designed to simultaneously distribute

Figure 21—Two electric broadcast seeders mounted on a crawler tractor that is pulling a pipe harrow.

fluffy seed kept in one seed box compartment with hard or smooth seed stored in the second compartment. Hard or smooth seeds drop directly out of the bottom of the seed box through an adjustable gate onto a rotating fan plate that throws or distributes the seed. A wire agitator is mounted in the bottom of this seed box to prevent seed bridging and maintain uniform flow or movement of the seed. The agitator, consisting of a wire rod, is positioned in the bottom of the seed box and attached to a shaft driven by the hand crank. As the hand crank is turned by the operator, the wire rod is moved up and down driven by a cam lever. Seed in the fluffy seed box is metered by two picker wheels, and deposited onto the rotating fan plate. The pickers remove a selected amount of seed and seeding rates can be regulated by speed of hand cranking. Seed bridging is controlled or prevented by an auger agitator. Seed can be distributed from 4 to 25 ft (1.2 to 7.7 m) depending upon seed density and wind conditions. The seeder can be mounted on all terrain vehicles, wheel tractors, or small cats and operated using a 12-volt motor.

Principal Area of Use—Broadcast seeders are used to seed areas that are inappropriate for drill seeding, such as rocky or rough terrain, rocky soils, areas with large amount of debris, and small, irregularly shaped areas. Broadcast seeders can be used alone or in conjunction with seedbed preparation equipment. Broadcast seeding coupled with anchor chaining, disk-chaining, pipe harrowing, land imprinting, drilling, scalping, harrows, or other seed coverage treatments is often preferred over drill seeding. Costs are generally much lower than for drilling. Variable planting depths are achieved by broadcasting which often favors mixed species plantings.

Sagebrush, rabbitbrush, forage kochia, and a number of other species do best with surface seeding on a disturbed surface. Broadcast seeders have been designed to facilitate surface seeding. With proper equipment, multiple species mixtures with differing seeding requirements can be seeded simultaneously.

Aerial Broadcasting

Aerial broadcasting using fixed-wing aircraft and helicopters is used to distribute seed over large areas and on rough terrain where slope steepness and irregularities, rock, or debris make drilling impractical (fig. 22).

Aerial broadcasting is usually the most economical method for seeding large acreages. This technique is also applicable for narrow corridors, roadways, disturbed right-of-ways, fence lines, and riparian drainage ways. Aerial seeding is an effective method for uniformly distributing a variety of seeds.

Seed hoppers within the fuselage of the fixed-wing aircraft (fig. 23) hold the seed. An electric rotary or Venturi spreader distributes the seed. Agitators within the seed hopper help to assure continuous and uniform seed flow. Small obstacles can obstruct seed passage. Venturi-type spreaders use the propeller slipstream to carry the seeds out of the base of the

Figure 22—Broadcast seeding a chained pinyon-juniper area with a fixed-wing aircraft.

Figure 23—Loading seed into a fixed-wing aircraft seed hopper.

seeding device and spread them beneath the aircraft (Larson 1980).

Seeding rates are computed based on hopper gate opening, air speed, and elevation of the fixed-wing aircraft. Desired seeding rates can be achieved with frequent monitoring. Ground spotters, "flaggers," or automatic flag dispersed equipment must be employed to assure uniform seed distribution. Fixed-winged aircraft generally operate at an elevation of under 50 ft (18.3 m), and at an air speed of 80 to 100 miles (128 to 160 km) per hour (USDA Agricultural Research Service 1976). Under favorable wind conditions and level terrain, flight elevation may be between 15 to 30 ft (4.5 to 9 m). Most fixed-wing aircraft have the capacity to carry approximately 1,000 lb (455 kg) of seed, but larger aircraft may carry three times this amount. Seed is usually distributed on a strip varying in width from 100 to 250 ft (31 to 77 m).

Helicopters equipped for aerial seeding have a suspended seedbin or an attached seed hopper that holds 250 to 2,000 lb (113 to 907 kg) of mixed seed. Seeding width can vary between 25 to 250 ft (7.6 to 76 m). Helicopters normally operate at 15 to 25 ft (4.5 to 7.6 m) above the ground at an airspeed between 35 to 50 miles (56 to 80 km) per hour. Lower speeds may be used to reduce seed drift and for precise seed placement. Seedbins are equipped with agitators and blower spreaders to regulate seed flow and spread.

Principal Areas of Use—Fixed-wing aircraft broadcasting is an effective technique for distributing seed over large range and wildland sites (National Research Council 1981). Planting success is usually dependent upon time of seeding, seedbed conditions, and thoroughness of seed coverage. Aerial seeding is particularly useful for seeding mountain brush, pinyon-juniper, and big sagebrush sites where chaining is used to cover the seed. Burned areas can be successfully revegetated with aerial seeding followed by proper seed coverage, in some cases seed coverage may not be necessary. Aerial seeding has also been a successful method of seeding desirable species into aspen, Gambel oak, and other deciduous tree and shrub stands just prior to leaf fall. No further treatment is required as seeds are covered by the falling leaves.

Large acreages can be aerial seeded in an extremely short time period. Major revegetation projects can often be more successfully seeded using aerial techniques and chaining than drill seeding, as plantings can be completed during short planting periods or windows when seedbed and weather conditions are most favorable. Aerial seeding can be conducted when wet soil conditions hamper drilling. Drill seeding occurs at a much slower rate than does aerial seeding. Many times it is impossible to physically get over large acreages during critical seeding periods with drills. This can result in considerable acreages being seeded out of season or totally omitted. With aerial broadcasting, seeding can be delayed until late fall or early winter, and then seeded in a relatively few days using aircraft, chain, rail, or cable scarifiers.

Irregular seeding patterns can occur with aerial seeding where poor flagging or spotting occurs, and from wind drift. Irregularities in seed placement and density may not be too serious if there is a fair native population, as this allows for natural recovery of native species.

Aerial seeding is often the only appropriate technique available for seeding deteriorated wildland sites, particularly when the terrain is inaccessible to motor driven vehicles. However, level and more gentle sites are often selected for drill seeding. Consequently, areas requiring special or tailored treatment are often ignored in favor of more conventional operating systems on less important sites. Aerial seeding should be recognized as an appropriate method of seeding, and used in areas where drills have proven less effective and are more costly to use.

Fixed-wing aerial seeding requires access to a landing strip and loading site. Normally, aerial seeding is much less costly than drilling unless the aircraft must be transported a considerable distance, or a landing site is not available close to the project. Aerial seeding may be used as a means of "overseeding" or as one of a number of methods used to seed a single site. Species like alfalfa, clover, big sagebrush, rabbitbrush, small burnet, or forage kochia can be successfully established by broadcasting on a rough seedbed. These species can be overseeded following drill seeding. Seeds that germinate quickly and early in the spring are often lost to frost if fall planted. Species that require winter stratification can be fall seeded with conventional equipment; species best adapted to spring planting can be aerially overseeded in spring at an appropriate date. Aerial seeding is also an effective method of seeding different seed mixtures on specific sites.

Aerial seeding requires a number of field support personnel, flaggers, and loaders. Seed must be prepared and available for rapid loading (fig. 24) and seeding. Seeding is often limited to early morning hours when flying conditions are most satisfactory and safe. Winds over 10 miles (16 km) per hour can create unsafe seeding conditions.

Normal monitoring of wind conditions and planting procedures will help to increase the probability of seeding success. Aircraft should not be allowed to operate under less than favorable conditions. Aerial seeding can be done in such a short period that minor delays are insignificant.

Helicopters are usually selected over fixed-wing aircraft if irregular-shaped sites and variable terrain are seeded and when air strips are unavailable. Effective seeding of right-of-ways, fence lines, steep slopes,

Figure 24—Loading seed into a seed hopper suspended from a helicopter.

Figure 26—Seeding small and irregular areas on rough terrain from a seed hopper suspended from a helicopter.

small areas, rocky terrain, and specific species placement can be accomplished with helicopters.

Helicopter seeding is recommended for planting high elevation sites, streambanks, and roadways where fixed-wing planes do not operate as safely or satisfactorily.

Downdraft and wind can cause seeds of different species to dissipate and fall separately, sometimes creating differences in stand composition and density. Variation in seeding and establishment is often advisable, allowing for natural succession and spread of desirable species. Drift can be reduced by slowing air speeds and the distance from the seedbin to the ground. Markers or flaggers can aid in more complete and even seed distribution.

Helicopters equipped with seedbins (fig. 25) or seed hoppers (fig. 26) that broadcast seed over large and small areas are used in aerial broadcasting projects that require more maneuverability than fixed-wing aircraft. They can also function more economically when seeding small, irregular tracts or when precise placement of seed is required. Helicopters require small landing pads, and thus can be used to seed sites where a conventional landing strip is not available to service a fixed-wing aircraft.

Figure 25—Seed bins attached to a helicopter. Seed is dispersed by airflow.

Seed Dribblers

Seed dribblers deposit selected seed onto crawler tractor tracks (fig. 27). The seed is carried forward, dropped onto the soil, and pressed into a firmed seedbed. Tractor-pulled seed dribblers deposit seed directly into prepared seedbeds.

The Hansen seed dribbler (fig. 27A) and thimble seeders (fig. 27B) (Larson 1980; Stevens 1978, 1979) are tractor-driven seeders, mounted on fenders of crawler tractors with drive wheels positioned on top of and driven by tractor tracks. Seed is gravity fed on both dribblers. A fluted shaft, similar to metering devices on most grain drills, moves the seed out of the Hansen dribbler. Seeding rate is determined by seed size and position of an adjustable gate over the fluted shaft. In the thimble seed dribbler, a spoked wheel with small cups attached to spokes rotates through the seed, filling the cups with seed. Seed is dropped through an opening and deposited on top of the tractor tracks. Seeding rate is determined by size of cups and number of spokes with cups attached.

Seed is deposited on tractor tracks by both dribblers. Seed is then carried forward on the track and deposited on the ground where it is pressed into the soil. The weight of the tractor buries the seed into a firm seedbed with the track cleates creating small water

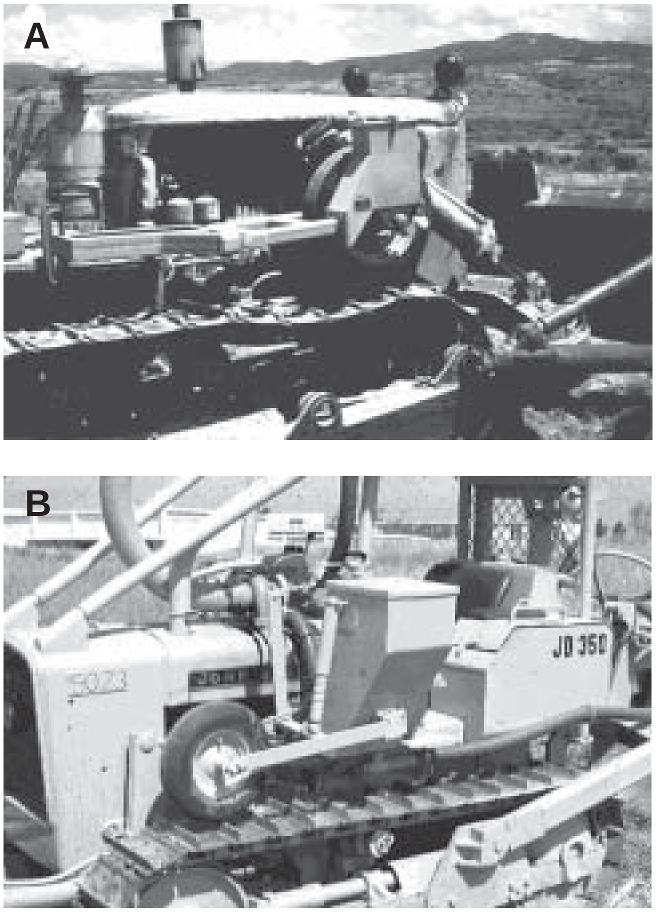

Figure 27—(A) Seed dribbler and (B) thimble seeder mounted on the fender of crawler tractors. The Drive wheel meters seed onto the tractor track which moves the seeds forward and deposits them on the ground. Tractor weight buries the seed in a firm seedbed.

catchment depressions. Thimble seeders have been modified to operate in conjunction with scalpers and to dispense seed within the scalp.

Primary Areas of Use—Dribblers are ideal for planting species that require firm seedbeds or whose seed is in short supply or extremely costly. The Hansen dribbler, being gravity fed through a fluted shaft, does not handle fluffy, plumbed, or trashy seed well. The Thimble dribbler will handle all types of seed. Generally, seedling establishment of shrubs and forbs is greater when seeded through a dribbler than when broadcast or drilled. Species that require minimal coverage, like rabbitbrushes, sagebrushes, asters, and forage kochia establish much better when dribbled than when drilled. Dribblers are generally used in conjunction with other operations like chaining, cabling, and pushing trees and shrubs.

Depending on seed size, 0.25 to 1 lb of seed per acre (0.28 to 1.12 kg/ha) can be seeded through one dribble during one-way chaining. Dribblers can be placed on both tractor tracks and operated during both passes of a two-way chaining. If dribblers are only used during one chaining, the second chaining is preferred.

Brillion Seeder

The Brillion seeder (fig. 28) consists of a two-compartment seed box mounted above and between two standard cultipackers. Each cultipacker consists of closely spaced, V-shaped, grooved steel wheels. The grooves of the two cultipackers are offset. The first cultipacker smooths and firms the seedbed and makes small furrows. The fluted seed metering device broadcasts the seed between the cultipackers onto the created furrows. The second cultipacker, which is offset, covers the seed in the original furrows and creates new ones. The two compartments in the seed box allow for seeding two types or mixes of seed.

Primary Areas of Use—The Brillion seeder is used to seed smooth areas. It creates an excellent firm seedbed and can seed at quite precise rates.

Surface Seeder

Surface seeders have been developed to accommodate species that require surface, or near surface seeding. The surface seeders consist of a seed box that drops the seed onto a line of tires that gently push the seed into the soil surface (fig. 20).

Primary Areas of Use—Some species that require surface seeding on disturbed soil include the sagebrushes, rabbitbrushes, asters, and forage kochia. Surface seeders provide the means for depositing seed onto the surface of disturbed soil. Use is restricted to areas where a tractor can operate.

Figure 28—Brillion seeder.

Interseeders

Interseeders are designed to seed desirable species into existing vegetation with minimal disturbance. Interseeders consist of a one- or two-way scalper or furrow opener and a heavy-duty seeder (Monsen 1980a, 1979; Stevens 1983a,b, 1979; Stevens and others 1981) (fig. 29A,B). Seeders are driven by rotation of a press wheel. Seed is metered out by a fluted shaft or a spoked wheel with cups attached on the spoke ends. Scalp or furrow depth can be regulated with a depth regulator wheel or hydraulics of the tractor. Seed is covered by the press wheel or drag chain.

The Truax single row seeder is designed to plant large irregular-shaped seeds, including acorns and nuts, in a single row. Seeds of different size can also be planted by exchanging the finger-pickers, which remove seeds from the seed box. The seed box is divided into three separate compartments. Seed of different species can be placed in each compartment and metered independently to control the distance between seeds placed within the furrow. Consequently, seed placement within and between species can be carefully regulated.

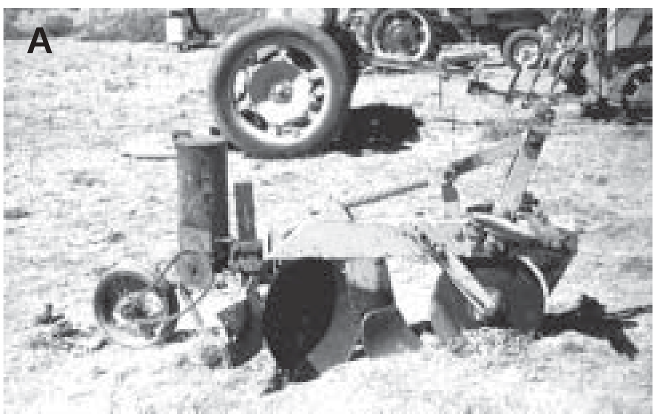

Figure 29—(A) The scalper-interseeder consists of a fire plow and Hansen shrub seeder. (B) Seeding bitterbrush and alfalfa into a sagebrush community with a scalper-interseeder.

Figure 30—The scalper removes competitive vegetation and creates water and snow catchment basins.

A single disk is positioned in front of the machine, and when drawn into the soil, cuts the dense sod or surface litter. A single shank is mounted directly behind the disk opener and is drawn into the soil to create a seedbed or furrow. Gauge wheels are attached to the machine to control planting depths. After seeds are deposited, one 16-inch press wheel is used to compact the seedbed. The seeding mechanism is activated by a drive chain through sprockets mounted on the press wheels and the base of the seed box.

Primary Areas of Use—The use of interseeders is restricted to soils that are fairly free of rock, roots, and stumps, and to terrain on which the tractor can safely operate. Grasses, forbs, and shrubs can be seeded through interseeders with or without previous seedbed preparation. Scalpers or furrow openers remove existing competing vegetation and create water and snow catchment basins (fig. 30). Interseeders are used as a single unit, or two or more units can be mounted on a toolbar (fig. 31).

Fluted shaft seeders, unless modified with a drum agitator, will handle only smooth seed. Thimble type seeders will plant all types of seed, including fluffy, plumed, or otherwise trashy seed.

Interseeders are used to establish desirable species in cheatgrass and other annual communities, monotypic grass stands (fig. 32A,B), perennial communities, burned areas, and disturbed sites. On these sites, establishment of seeded species can be superior to broadcast and drill seeding.

The Truax single-row seeder can be used to interseed shrubs or herbs into established stands of sod or weeds and can be operated on any terrain on which a cat or wheel tractor can safely travel.

Figure 31—Two shrub interseeders connected to single tool bar.

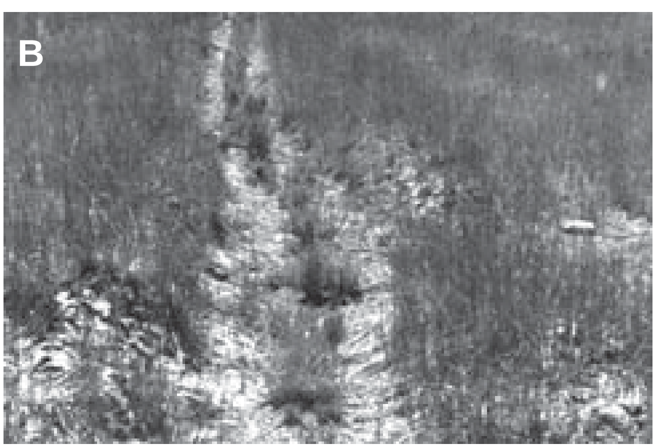

Figure 32—Grass stand scalped and seeded with desirable forbs and shrubs (A) 1 year and (B) 3 years following seeding.

Hydroseeder

Hydroseeders (fig. 33) are designed to apply seed, fertilizer, soil amendments, and fiber mulch to the soil surface in a hydraulic spray. Hydroseeders consist of a truck or trailer, tank, pump, discharge nozzle, and engine. The tank is equipped with various types of agitators to assure uniform mixing. The pump sprays the mixture up to 200 ft (61 m). Interchangeable nozzles provide for various spray patterns and quantity of delivery. Nozzles are designed to rotate horizontally and vertically.

Principal Areas of Use—Hydroseeders are generally used to seed steep slopes or very rocky areas. There are a number of disadvantages to hydroseeding. They include: (1) seed is not placed in the soil, (2) seed and seedlings can dry out, (3) some seedlings cannot grow through the mulch, (4) seed can be damaged by agitators and pumps, (5) precocious germination can occur as a result of moisture in the mulch, (6) seeding may be done during unfavorable seeding periods, (7) expense, and (8) large water requirements.

Special Use Equipment

Transplanters

Transplanters are tractor-drawn implements that scalp the soil surface and open a furrow. Bareroot stock, wildings, cuttings, or container-grown plants are placed in the furrow and soil are packed around the plant roots (fig. 34).

Transplanters consist of a heavy frame, a furrow opener, a set of packing wheels, an operator seat, and

Figure 33—Hydroseeding roadcuts and fills.

Figure 34—Transplanting big sagebrush wildings into a cheatgrass community during early spring when soil moisture is high.

a place to store seedlings. A single-disk coulter, semi-automatic seedling placement device and scalper may be installed on some machines. Transplanters are towed or mounted on crawler or rubber tired tractors and four-wheel drive vehicles. The furrow opener cuts open a furrow in which the seedling root system is placed. The packing wheels are angled inward to close the furrow and compact soil around the roots of the transplant.

Principal Areas of Use—Shrubs make up the majority of plants that are transplanted on range and wildlands. However, grass, forbs, and trees are also transplanted. While transplanting is fairly expensive compared to direct seeding, it has its place. Transplanting can be economically utilized on critical big game, upland gamebird, and livestock ranges; disturbed sites; sites with high erosion potential. It is also widely used in high esthetic value recreational areas, windbreaks, shelterbelts, and riparian sites.

Bareroot stock, wildings, container-grown stock, and cuttings can all be transplanted successfully using a transplanter (McKenzie and others 1981; Stevens 1979, 1980a,b; Stevens and others 1981b). Generally, bareroot stock and wildings are the most economical, producing the most established plants for dollars expended.

For best results, transplanting should occur in the early spring when soil moisture content is high and chances for spring storms are greatest. Fall transplantings are less successful, primarily due to frost heaving and drying. Care must be taken to ensure that packing wheels firmly pack soil around the root system.

Transplanters can consistently plant 1,000 to 1,500 plants per hour. Transplanters are restricted to soil at least 18 inches (45.5 cm) deep that is free of large rocks, roots, and stumps. Transplanters must be built heavy enough to meet adverse site conditions.

Transplanters equipped with automatic pickup and placement fingers have not proven practical with transplants that have multiple or fibrous root systems (McKenzie and others 1981).

Survival rate varies with species. Species with fibrous root systems survive much better than those with a single or few taproots.

Roller Chopper

Roller choppers are used to (1) push over, uproot, and chop up trees and shrubs with the main trunk at ground level less than 6 inches (15.3 cm) diameter, (2) create seedbeds, (3) cover seed, (4) create water catchment basins, and (5) to stimulate shrubs by pruning to 12 inches (30 cm) above ground level.

Roller choppers consist of a steel, 5 ft by 12 ft (1.5 m x 3.7 m) diameter drum with 12 grader blades evenly spaced and welded vertically around the outside of the drum (fig. 35). Intake and drain plugs are installed to allow the drum to be filled with 800 to 900 gallons (3,000 to 3,400 L) of water. Steel frames, tongue, and hitch are attached to both ends of the drum.

Primary Areas of Use—As the roller chopper is pulled forward, the weight, combined with the cutter blades, tips over, uproots, chops up, and kills trees and shrubs with main stem diameters of less than 6 inches (15 cm). When pinyon and juniper have invaded grasslands, shrublands or chained areas, the roller chopper has been used successfully to remove them.

Broadcast seeding can occur ahead of, or simultaneously with roller chopping. Seeds are pushed into the ground and covered with soil and litter. Water and snow catchments are created by the action of the cutter blades. Creation of a good seedbed, seed coverage, litter for seedling protection, and moisture retention and increased water infiltration all combine

Figure 35—Roller chopper being used to kill and cut up pinyon and juniper trees, create a seedbed, and cover seed.

for good germination and seedling establishment. Serviceberry, curlleaf and true mountain mahogany, bitterbrush, and cliffrose have all been stimulated by pruning with the roller chopper.

Dozers and Blades

Dozers and blades are widely used in range improvement projects. They are used to remove trees and shrubs, pile brush and slash, scarify areas, construct roads, and dig trenches, firebreaks, and other excavations.

Dozers are used in a standard configuration; a straight concave blade solidly mounted to a crawler or rubber-tired tractor (Larson 1980). They can also be modified as follows:

1. As a three-way dozer with multi-purpose dozer blade that is adjustable for height, tilt, angle, and pitch hydraulically (fig. 36) (Larson 1980).
2. As a brush, or forest rake with a special blade that consists of vertical teeth generally with replaceable tips, or a vertical toothed implement that is attached to a standard or three-way blade (Larson 1980; Roby and Green 1976).
3. As a hula dozer with a standard dozer blade with hydraulic side tilt and pitch that is often equipped with four removable digger teeth spaced along the blade (a hinged push-bar attachment is available for mounting above and in front of the blade).
4. With a shearing or clearing blade, a straight or V-shaped solid blade with straight or sharpened cutting edges along the bottom (Larson 1980).

Primary Area of Use—Blades are used to uproot, cut off, move, pile, and windrow trees and shrubs; build or clean roads, fences, and fire lines; construct trenches, basins, and terraces; move and pile rocks and debris; prepare seedbeds and planting sites; and grade and carry out general excavation.

Figure 36—Three-way dozer reshaping a streambank.

Trenchers, Scalpers, and Gougers

Trenchers, fireplows, gougers, and furrowers are used to construct trenches, scalps, depressions, and furrows for the purpose of intercepting runoff, collecting snow and precipitation, preventing erosion, removing competing vegetation and seed, creating a seedbed, and promoting plant establishment and growth.

In the case of double-disk contour and Rocky Mountain trenchers, one or two large disks are mounted on a crossbar or shank. Disks rotate hydraulically to allow for operation in two directions. Disks and crossbars are hydraulically controlled and will adjust to the contour of the site and depth and width of the designed trench (Larson 1980, 1982). Broadcast and dribbler seeders can be attached to these trenchers, allowing for seeding to take place concurrently (Stevens 1978).

Another piece of equipment in this category is the fireplow, a V-shaped lister share with large disks located on each side of the share (plow) (fig. 29A) (Larson 1980). Where needed, a coulter can be attached in front of the lister share. A moldboard wing may be attached behind either disk allowing for the trench berm to be moved away from the trench edge. Browse seeders or thimble seeders can be connected to the fireplow, allowing for seeding to occur simultaneously (Monsen 1984, 1979; Stevens 1979).

Gougers consist of three to five half-circle blades attached to solid arms that are spring loaded. The blades are raised and lowered automatically, scooping out depressions in a cyclic manner. Seed is broadcast into the depression from a seed box mounted above the blades and arms (Knudson 1977).

Principal Areas of Use—Contour and Rocky Mountain trenchers, fireplows, and gougers are used to construct trenches and scalp areas in a variety of shapes, widths, and depths, depending on the positioning of the disk, plow, or gouger. These implements are used to reduce competition, remove unwanted seed, and create water and snow catchment basins. Scalped areas can be seeded or have grasses, shrubs, forbs, and trees transplanted into them. Monotypic stands of annual and perennials can be improved by removing unwanted seed and vegetation, and at the same time seed desirable species. Shrub density can be reduced and desirable species can be seeded or transplanted into the depressions or scalps. The amount of vegetation and seed removed depends on the width and size of scalps and depressions. Width and depth of scalps or depressions can affect seedling establishment and growth (Stevens 1985a,b). This equipment is well adapted to smooth, nonrocky soils, but it can also be used successfully on uneven, semirocky range sites (Moden and others 1978b; Stevens 1978).

Fire Ignitors

Fire ignitors are used for: (a) vegetation control, (b) fire management, and (c) control of fire. Aerial, handheld, and vehicle-mounted types are available.

Aerial ignitors are connected to or suspended from helicopters. The most widely used is the flying drip torch (helitorch) (fig. 37). The helitorch consists of an oil drum, solenoid valve, electrical fuel pump (gel models), glowplug, and controls. The oil drum holds the gel or gasoline-diesel mix. Fuel flow is by gravity or pump and is controlled by a solenoid. The glowplug ignites the fuel as it leaves the torch. The helicopter pilot controls fuel flow and ignition, and can jettison the complete torch if necessary.

Another aerial ignition system is the ping-pong ball injector (Larson 1980, 1982; Ramberg 1977). Ping-pong balls are loaded with potassium permanganate and when fed through a ball dispenser they are automatically injected with ethylene glycol and dropped. The chemical reaction produced by the two chemicals coming together produces a flame. Ping-pong ball dispensers are mounted on helicopters, and are electrically operated. They can be jettisoned by the pilot, and will dispense up to four ping-pong balls a second. Distance between balls on the ground varies with air speed, altitude, and rate of ejection.

Backpack, handheld, vehicle and trailer-mounted teratorch, and drag-type drip torches are available. These consist of a fuel tank, wand, stem or boom to direct the flame and a fuel ignitor. Fuel is generally a gel, but can be a diesel-gas mix.

Flame throwers, depending on size, are hand operated or mounted on a vehicle or trailer. Pressurized tanks, hose, and a nozzle are the major components of a flame thrower. Fuel can be diesel, kerosene, or liquid propane gas.

Fuse backfire torch or flares are commonly used. Plastic bags or milk carton type containers filled with a gel or diesel-gas sawdust mixtures are placed in areas to be burned and are ignited by a torch or flame thrower.

Principal Area of Use—Ignitors are dispersed aerially from ground rigs or by hand to ignite fires in fire management, slash clean up, and range improvement.

The helitorch and teratorch are used extensively to start and manage prescribed burns, start backfires and burnouts, and make fire lines. The helitorch can be used in otherwise inaccessible areas as well as in extensive accessible areas. Large areas can be ignited in relatively short periods of time with these ignitors, allowing for better fire control and decreased costs.

A number of hand operated and vehicle- or trailer-mounted drip torches, and flame throwers are available. The main drawback to these has been that small crews have difficulty firing large areas in the short time that favorable burning conditions are present. Large crews are generally uneconomical. Small, irregularly shaped burns, backfires, and burnouts are sometimes best managed with hand and vehicle operated equipment.

Herbicide Sprayers

Liquid herbicides are most commonly applied on rangelands by broadcast spraying. Application is by ground rigs, fixed-wing aircrafts, helicopters, and hand sprayers (Ekblad and others 1979; Larson 1980; Vallentine 1989).

There are two types of ground rigs, boom and boomless. Boom sprayers are mounted on tractors, trucks, all terrain vehicles (fig. 38), trailers (fig. 39), or self-propelled chassis. A boom sprayer consists of a

Figure 37—Helitorch used to start a prescribed burn in a mountain big sagebrush community.

Figure 38—Boom sprayer mounted on an all-terrain vehicle.

Figure 39—Rangeland boom sprayer. Booms must be mounted high enough to clear tall shrubs.

tank, pump, pressure gauge, and spring-loaded boom with nozzles spaced along each boom. A boomless sprayer has no booms, but has one nozzle or a cluster of nozzles at one location.

Fixed-wing monoplanes, or biplanes may be equipped with boom sprayers mounted along or near the lower wings. Special equipment required includes cutoff valves, diaphragm check nozzles, and pumps designed to avoid pressure buildup. Helicopters are equipped with boom sprayers up to 40 ft (12 m) long with hydraulic nozzles spaced along the entire length (fig. 40). Helicopter spray units require lightweight tanks, special pumps, and positive shut-off valves. Booms have been specifically designed for helicopter sprayers. Hand-operated sprayers are pump pressurized tanks equipped with a hose and a handle. A cutoff valve is located in the handle.

Primary Area of Use—Boom and boomless ground sprayers can spray only those areas that their transport power unit can traverse. Height of woody vegetation cannot extend above the height of the boom. These sprayers can provide even application of herbicide with little drift. Boom sprayers are superior to boomless on areas where precise application is desired. Boom sprayers have less drift and are less affected by wind. Boomless sprayers are generally less expensive, and less restricted in their areas of use as they are able to travel over rougher terrain and work in larger brush. Boom and boomless sprayers can be used to apply herbicide to selected areas, such as strip spraying followed with broadcast or drill seeding (fig. 41A,B).

Figure 40—Helicopter equipped with a boom sprayer.

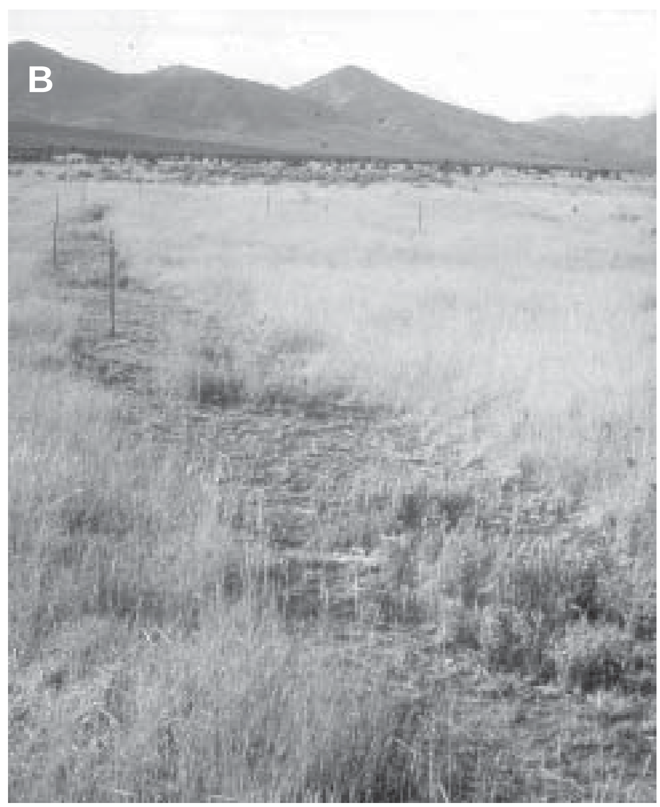

Figure 41—(A) Strip of intermediate wheatgrass sprayed with Roundup in June. (B) Shrubs and forbs established by broadcast seeding in October within the sprayed strip 3 years following seeding.

Figure 42—A helicopter with a boom sprayer spraying mountain big sagebrush on the Manti LaSal National Forest, UT.

Application of herbicide by ground rigs has several advantages over aerial application: small acreages can be sprayed, no landing strip is required (fixed-wing only), there is less drift, application is not restricted by fog or wind, equipment is generally less expensive, and applicators are safer.

Aerial application does have some advantages over ground rigs: application rate (acres per hour) is greater and large areas can be sprayed during short periods of time when conditions are ideal. For this reason, aircraft are commonly used to spray large acreages (fig. 42). Aerial application is also well adapted to spraying wet, rough, steep, and rocky terrain. Cost of application is less, vegetation and soil are not disturbed, and dense, tall brush stands can be treated more effectively.

Steep-slope Scarifier and Seeder

The steep-slope seeder was designed to seed steep slopes and inaccessible sites. It is primarily used to plant roadways, mine sites, and similar disturbances. However, it can be modified to seed range and wildland sites.

The machine consists of a tubular constructed frame with: (1) front- and rear-mounted reversible spring-loaded scarifier tines, (2) soil drags, (3) four spring-loaded press wheels, and (4) two electrically powered rotary seeders or spreaders. The capacity of the seed hoppers is 2 ft^2 (0.57 m^2) (Larson 1980). The machine can be mounted on a telescoping-boom crane or gradall. The seeder is bolted to the end of the crane by a knuckle joint, and can be turned in any direction or angle. The machine can be operated to run horizontally across a slope, or up or down a roadcut or fill surface. Seed and fertilizer are dispensed separately through the two spreaders. The equipment operator is able to start or stop seeding and adjust the seeding rate through electrical lines connected from the seeders to a control box mounted within the cab. The machine can be easily converted to a three-point attachment and towed by a wheel tractor to seed the less steep sites.

Principal Areas of Use—The seeder was initially developed to seed steep roadcuts and fill surfaces where conventional equipment is not able to operate. Steep, inaccessible sites are normally broadcast seeded without any seed coverage, and poor plant establishment usually occurs. The steep-slope scarifier seeder is not only able to operate on uneven terrain, but seeds are planted in the soil.

The front scarifiers or tines loosen the soil. Seed and fertilizer are broadcast directly onto the loosened seedbed. The rear-mounted scarifiers, drags, and press wheels cover the seed and compact the seedbed. The seeder operates on extremely rough surfaces with an abundance of rock or debris. Larson (1980) reports the machine has a production capability of 2 acres (0.8 ha) per hour. Seeding rates can be adjusted to vary between 5 to 60 lb (2.3 to 27.2 kg) per acre (Larson 1980).

The steep-slope seeder is not capable of reducing existing competition, but can be used to seed areas without damage to existing plants. When mounted on a gradall or crane, the machine has limited reach, and can only be operated within the reach of the crane.