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Editor's Note: This article brings together into one place historical and technical information to date relative to chaining for brush control. It is valuable for present use as well as for future reference.—**D. Freeman.**

Chains for Mechanical Brush Control

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During a large portion of the 20th century, range managers have been trying to develop and implement technologies for manipulation of plant communities to enhance forage and browse production. The vastness of rangelands dwarfs the manipulator and negates labor intensive practices. Rocks, steep slopes, and accumulations of woody plant material on rangelands blunt, twist, and bend agricultural implements into impotency. The relatively low productivity of rangelands in comparison to intensively cropped farmland has produced scant returns in payment for expensive range improvement technologies. Within these constraints of high productivity, durability, and low cost has evolved the unique rangeland implement—the chain. The process of using the chain for rangeland rehabilitation is called chaining. Chaining is accomplished by dragging heavy, navy anchor chains in a U-shaped, half circle, or J-shaped pattern between two crawler tractors traveling parallel in the same direction.

Evolution of the Chain

The idea of dragging a strong line between tractors to down brush and small trees has existed as long as the have been tractors with sufficient power to pull the line. Early lines usually consisted of a twisted cable. B.W. Allred reported in 1949 that cabling, the process of pull a cable between two tractors traveling in the same direction, had been used in Texas and Oklahoma to reduce mesquite *(Prosopis glandulosa)* for a number of years. Similar comments have been made by C.E. Fisher of the Texas A&M Agricultural Experiment Station.

Simon Wolff of the Soil Conservation Service (SCS), U.S. Department of Agriculture, reported that in 1945 it cost $4.00

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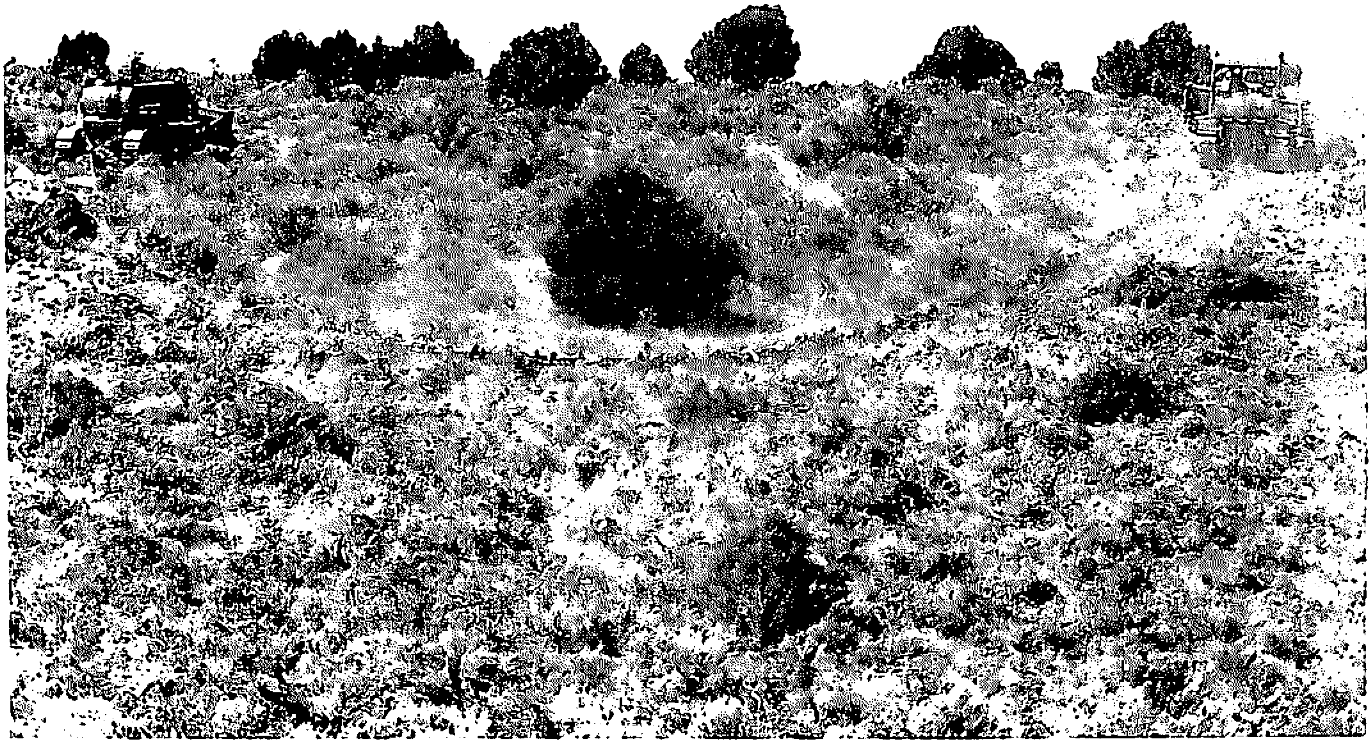


Chaining.

per acre to treat junipers in Val Verde County, Texas, with 250 feet of 1-1/2-inch-diameter cable pulled between two tractors. He suggested that weights were sometimes attached to the cable to help keep it on the ground.

Vernon Young and his associates at Texas A&M University reported in 1948 that cabling and railing were common ways of attempting brush control. He considered these methods inefficient because the more supple and resilient trees and brush simply bent over without being broken or uprooted.

After World War II the spread of large tractors around the world encouraged a proliferation of brush and tree control and site conversions to grazing lands. Individual range managers began experimenting with mechanical control methods in such diverse geographical areas as Australia, Kenya, and South America.

The Interagency Range Seeding Equipment Committee [now known as the Vegetative Rehabilitation and Equipment Workshop (VREW)] reported in 1953 on trials located in the Southwest (Region 3, U.S. Forest Service) where a 1-1/8 inch cable pulled by two large track-laying tractors was used to control junipers (*Juniperus* spp.). According to the report rooting out medium-sized trees was fairly successful. The cost was $1.00 per acre on level ground and $4.00 over steep, rocky terrain.

The next cabling trial was reported in 1955. Sagebrush (*Artemisia* spp.) rangeland was cabled for $0.35 per acre and juniper for $1.00 to $2.50 per acre. The sagebrush cabling was accomplished with a so-called necklace cable consisting of 1,000 feet of drilling cable with the center 600 feet of it weighted with railroad rails. The necklace cable gave fair control of sagebrush with two passes. Cabling of uneven-aged or young stands of sagebrush or juniper was not recommended.

Chain Drag

Allen Johnson, manager of the Kapapala Ranch on the island of Hawaii, may have been the first person to use an anchor chain to control brush on rangelands. Johnson first began developing the chain drag in 1945. This was not chaining in the modern sense, but the use of multiple loops of anchor chain attached to a beam towed by a single tractor.

In the Arizona-New Mexico area the first chaining was probably done on the Colorado River Indian Agency at Parker, Ariz., to control mesquite in 1948. The same year 150 acres of juniper were cabled in the Kaibab National Forest near Williams, Ariz. Both cabling and chaining were being used at the Kaibab National Forest in 1949.

During 1949 there was a host of juniper control operations undertaken in the Southwest. At the Fort Apache Indian Reservation, 200 acres of juniper were chained and 400 acres were cabled. Juniper was also cabled at the San Carlos Indian Reservation at Point of Pines, Ariz. At Mescalero Indian Reservation in New Mexico 4,500 acres were treated in 1949. The land managers used a light 3/4-inch cable and a 1-7/8-inch heavy cable and reported the need for swivels. Mesquite was chained near Sells, Ariz., on the Papago Indian Reservation. Ranchers cabled juniper on private land north of Ashfork, Ariz., in 1949.

Between 1950 and 1961 in Arizona about 1.2 million acres of pinyon/juniper woodlands were treated for control of trees. This is about 10% of the pinyon/juniper woodlands in Arizona. About 55% of the pinyon/juniper controlled in

Arizona during this period was done by cabling or chaining. Ranchers and land managers often used the terms cabling and chaining interchangeably in describing treatment no matter which implement was actually used. This makes it difficult to be sure of the acreage that was actually chained. Of the total treated area, about 48% or 580,000 acres of deeded and state land was treated about equally by cabling and chaining. On Indian lands 340,000 acres were treated, about 28% being treated by chaining. Forest Service personnel treated 216,000 acres, mostly by pushing trees with bulldozers or by cabling. On National Resource lands administered by the Bureau of Land Management, about 77,000 acres were treated by pushing and cabling. Most of the areas suitable for treatment by chaining or cabling in Arizona were treated by the mid 1950's. In New Mexico treatments continued into the early 1960's.

The Forest Service in Region 3 apparently preferred cabling to chaining because it was faster, less power was required, the whipping action of the cable jerked trees from the ground, the equipment was readily available, and there was less soil disturbance. During the 1960's on Forest Service lands, pushing juniper trees with bulldozers became more popular than cabling or chaining. Pushing was selected because most of the areas left to treat on U.S. Forest Service lands were not suited for chaining.

The Interagency Range Seeding Equipment Committee in cooperation with the Bureau of Indian Affairs - USDI, Fort Apache Indian Reservation, White River, Ariz., sponsored a field test of chaining and cabling in 1957. Two large tracklaying tractors were used to pull the 1-3/4-inch-diameter bar anchor chain (about a 30-pound chain) in combination with a cable. The double loop combinations were judged not to be a success.

A great deal of brush was chained in Texas from about 1954 through 1967. Robert Darrow estimated in 1962 that 28% of the Rio Grande Plains had received some brush control and that about 80% of the treatments involved chaining. After the early 1960's there was a shift to other methods such as root plowing or herbicides.

In 1966 Perry Plummer of the Intermountain Forest and Range Experiment Station, U.S. Forest Service, suggested to the exploratory subcommittee of the Range Seeding Equipment Committee than anchor chains could be im-proved to make them more efficient in eliminating undesirable brush and tree competition. A trial was proposed in Cave Valley, Nev., to test an anchor chain with teeth welded across the links.

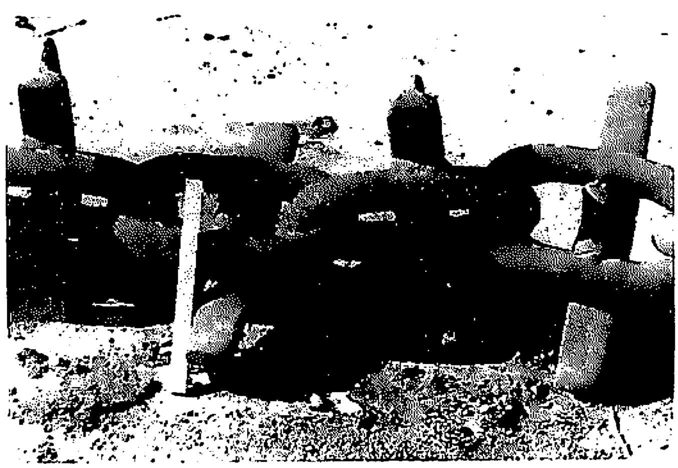
At the 1967 meeting of the Range Seeding Equipment Committee, John K. Chambers reported on the evaluation of chaining of mesquite stands previously sprayed with herbicides. Fifty to 60% of the shrubs with stem diameters greater than 3 inches were uprooted. For unsprayed mesquite only 20 to 30% of the shrubs were uprooted. For juniper species in stands 3 or more inches in diameter 30 to 50% were uprooted by chaining. The uprooting of smaller trees was 30% at best. The committee found in Texas and Oklahoma that resprouting after chaining often resulted in more plants than existed before treatment. In certain cases, subsequent treatments were cheaper because of chaining.

The results of chaining performed by the Utah Department of Wildlife up to 1967 indicated that large tractors (at least 200 hp) were required. The best combination of chain proved to be one with approximately 220 feet of length with the 90 to 100 feet center section made up of 70- to 90-pound links. A lighter chain consisting of 30-pound links was suitable for the ends. They had experimented with welding car axles across the links to add teeth to the chain.

The Forest Service in New Mexico chained 1,000 acres of juniper stands with an average of abour 400 trees per acre. They used 250 feet of 70-pound-per-link chain. Results indicated the chain was better than cable. Little damage was done to smaller trees.

Modified Chains

John K. Chambers of the Ely, Nev., district of the Bureau of Land Management, tried welding 3-inch malleable angle irons into the 50 center feet of a 190-foot chain consisting of 90-pound links. Later the entire chain was modified. About 50% of the big sagebrush *(Artemisia tridentata)* plants were uprooted with one pass with this chain and an additional 20 to 30% with a second pass. The angle iron teeth deteriorated rapidly, reducing the effectiveness of the chaining.



Ely chain link.

The Bureau of Land Management reported in the Range Seeding Committee Proceedings for 1967 the results of tests involving 160 feet of 90 pound per link chain. Various improvisions such as welding angle irons to the center 50-foot section and several types of teeth were tested. Pulling patterns were also varied. Swivels were used on the ends of the chain to allow the chain to rotate where it attached onto the tractor.

These BLM tests in Nevada indicated a reverse J pattern was the most efficient configuration for the chain. Approximately 50 to 70% of the big sagebrush was controlled with two passes (i.e. opposite directions) of the modified chain, but wear of the angle teeth was excessive. After this trial the chain was modified by welding 30-pound railroad rails across the links on the outermost 40 feet of each end of the chain. With this chain 70% of the sagebrush was removed by the straight portion of the chain and about 45% in the loop of the J. In 1967 dollars, the cost of this treatment was estimated at $3.50 per acre.

Swivels

The need for swivels was reported for cabling treatments carried out on the Mescalero Indian Reservation in New Mexico in 1949. The switch from cables to chains intensified the need for swivels.

Swivel made from crawler tractor track roller.

Jack Crowder was chaining big sagebrush on the Jacarilla Apache Indian Reservation in northwestern New Mexico in 1967. He noticed that a rolling chain was more efficient in pulling up sagebrush plants without disturbing grass plants. He equipped his chain with swivels made from oil well tool joints. These swivels were not lubricated and soon overheated and seized. Crowder fabricated swivels from track rollers with lubricated bearings.

Don Cain at the BLM became chairman of the Anchor Chain subcommittee of the Range Seeding Equipment Committee in 1968. The major chaining development in 1967-68 concerned the development of adequate swivels so the chain could rotate. The Ely, Nev., district of the Bureau of Land Management experimented with commercially manufactured and handmade swivels for anchor chains. The commercially manufactured units failed after less than 4 hours' use. The most successful swivels tested were those manufactured by Jack Crowder.

Ball and Chain

A ball and chain system was developed for brush control in steep terrain where it is impossible to operate large tractors in parallel positions. This modification of chaining was probably first developed in the rugged mountains of southern California. The ball is usually made from a surplus anti-submarine net buoy with a 5- or 6-foot diameter. The steel-walled buoy is completely filled with water, sand, or concrete, and attached to one end of a chain. The waterfilled ball weighing 1-1/2 to 2 tons is supposed to hold one end of the chain down slope while a tractor drags the other end along ridge tops. A concrete-filled ball weighs about 5 tons and becomes a problem to transport.

Frederick Full and Waldon Vincent made a ball and chain for treating mixed oak and pinyon/juniper communities on the Spanish Fork Ranger District of Uinta National Forest. Their experiment was judged a success, but they experienced difficulty keeping the ball at the correct downslope angle. There are a lot of hazards in using a ball and chain. Balls have been known to break loose and roll downslope. The chain is often temporarily snagged on trees or rocks and when it breaks loose the ball can suddenly drop downslope.

Dixie-Sager Chain

The Dixie National Forest, located in southwestern Utah, was faced in the late 1960's with thousands of acres of degraded and big sagebrush-dominated rangelands and limited funding for range improvement. Hoping to develop a less expensive brush control implement than the brushland plow, range managers initiated a program in 1967 to improve existing chains.

The materials used were a worn chain, railroad rail, and two rebuilt track rollers. The modified chain produced was 250 feet long and weighed 20,000 pounds. There were 235 links with 6-inch pieces of railroad rails welded lengthwise on the outfaces of the links to act as digger teeth and 15 smooth links on each end. In operation the chain twisted like a giant rototiller. This modified chain was named the Dixie-Sager.

After the chain was tested in different vegetation types and terrain, changes were made in the digger teeth by cutting off the "foot" of the railroad rail. Thus the teeth became "T" shaped with the top of the T welded lengthwise to the chain link. This change provided for a pointed digger tooth which scarified the soil better than before and allowed the teeth to clean themselves of debris, because there was no flanges as the chain twisted and rolled in its forward motion pattern. The need to have digger teeth that will clean themselves of debris is very important in using modified anchor chains.

The Dixie-Sager, like all modified anchor chains, uproots brush and scarifies the soil more when it is pulled in a narrow swath than in a wide swath. Thus, it is pulled in a U pattern with the tractors no more than 75 feet apart. If a higher degree of scarification is required on a particular area, the swath is narrowed to 50 feet.

In contrast to the 1967 cost of $3.50 per acre, the 1982 price for double (twice-over) chaining in big sagebrush was $14.00 per acre.

Ely Chain

As an outgrowth of the chaining experiments sponsored by the Range Seeding Committee in Nevada, the Ely District of the Bureau of Land Management developed a modified chain named appropriately, the Ely chain.

The Ely chain differed from the Dixie-Sager in the direction that the railroad was welded across the links and stuck out on each side of the link-like diggers. In this chain modification, one piece of railroad rail was welded perpendicularly across both bars of a link.

The specifications for the Ely chain called for 210 to 300 feet or 62 to 110 pound per link anchor chain with 18 inches of 70 to 90 pound per yard railroad rail welded across the links. Swivels were required to allow the chain to turn. Tracklaying tractors exceeding 200 hp were recommended for pulling the chain.

Operation patterns recommended for the Ely chain varied with the vegetation being treated. For maximum churning action from the chain, a J form was recommended. The greatest amount of brush control occurred along the straight portion of the chain and the least in the loop portion.

By pulling the Ely chain in a J pattern, the maximum control obtained of big sagebrush was 70 to 85% with double chaining in opposite directions. A U-shaped pattern resulted in 50% brush control.

The cost of brush and tree control with the Ely chain was reported in 1971 as $4.00 to $7.00 per acre for pinyon/juniper depending on the age classes of trees present and the terrain. For big sagebrush the cost per acre ranged from $2.00 to $4.00 per acre. It is not clear whether these were contract costs of actual costs figures and, if they were actual cost figures, it was not apparent that the cost of transporting the chain and tractors to the site was included. The rate of production for the Ely chain in pinyon/juniper stands was estimated at 200 acres per day for one-way chaining and 150 acres per day for the second chaining over the sameground. Production rates for big sagebrush sites were given as 300 to 320 acres per day.

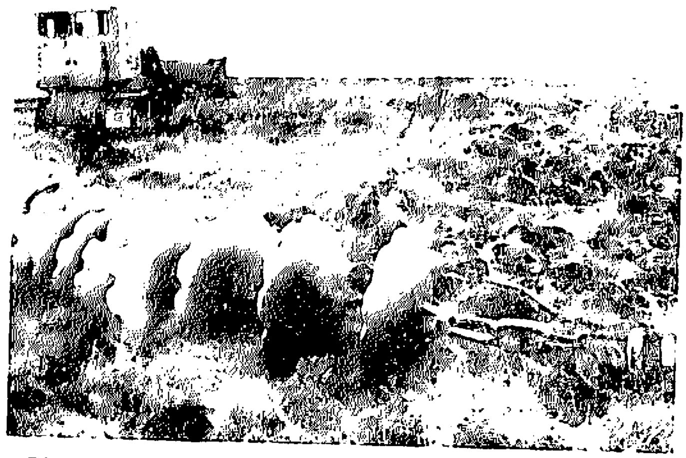
The Intermountain Forest and Range Experiment Station developed a small chain (35 feet long) for creating openings in oak (*Quercus* sp.) brush fields. Pulled behind a single tractor, this chain must have been remarkably similar to the original Hawaiian chain.

Testing of Modified Chains

The modified chains developed for pinyon/juniper and sagebrush vegetation were widely tested by the Soil Conservation Service in diverse vegetation types in Texas and the Southwest. The results of these tests were included in the report of 1975 of the anchor chain subcommittee of the Range Seeding Equipment Committee. The report concentrated on means of fabricating modified chains and hard-facing surfaces to limit wear. Chain swivels were a problem and various lubricating methods were developed to prolong their life. Drawings of the Dixie-Sager chain, Ely chain, and swivels are available from the USDA/Forest Service Equipment Center, Missoula, Montana. Drawing number is MEDC 568.

Disk Chains

The idea of a disk chain originated in Australia where a 100-foot-long chain with disks on every other link was used on lands operated by the King Ranches of Texas. The latest development in disk chains is in the state of Texas. Chaining was generally not proven highly successful as a control treatment for most brush species occurring in Texas. Tillage obtained from disking with an offset harrow after rootplowing produced consistently better stands of seeded forage species than treatment with chaining. However, the use of offset disk harrows was often limited by woody trash accumulations and large stumps. Large, heavy disk blades (24 by 0.5-inch blades) are welded to a heavy anchor chain. This chain requires different pulling techniques from those used with conventional chains. The cost of using this implement on Texas rangelands is projected at $6.50 per acre compared

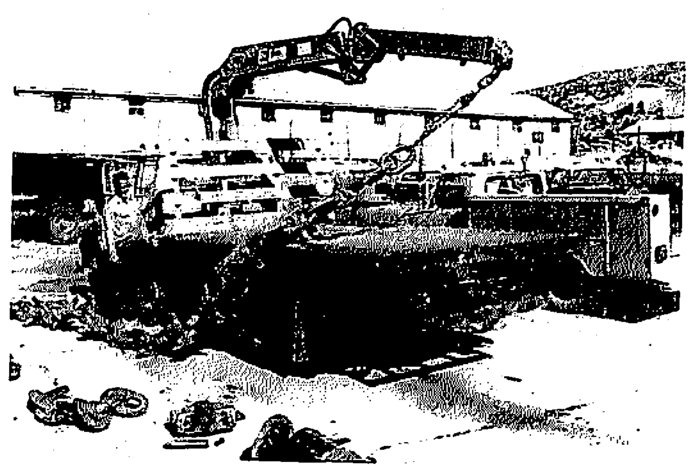


Disk-chain.

with $14 to $25 per acre (1982 dollars) for conventional disking.

Analysis of the Use of Chains

Probably the use of chains as range improvement implements has raised more controversy than any other land management practice. Much of this controversy deals with the



Loading chain.

philosophy of including the physical changes in what individuals perceive as the natural environment. Such considerations are extremely important in implementation of a range improvement program, but we will confine our analysis to the weed control and seedbed preparation characteristics of chains. George Roby and Lisle Green summarized the results obtained with chaining as follows:

Advantages:

1. *Low cost per acre compared with alternatives.*
2. *High production rate in suitable terrain and vegetation.*
3. *Minimum ground disturbance (this depends on type of chain).*

4. Enough debris left on surface to help reduce erosion potential.
5. In certain vegetation types, it facilitates burning.

Disadvantages:

1. Selectivity poor because of restricted maneuverability.
2. Application limited by slope, irregular terrain.
3. Age and type of brush or trees can severely limit usefulness; supple woody plants bend under chain.
4. Crown- or root-sprouting species are not controlled.

The practical land managers who developed and modified anchor chains as range improvement devices have always stressed their limitations. For example, the original publication on the Dixie-Sager chain stressed that if complete control was desired on deeper, relatively rockfree soils, the brushland plow should be used. The Dixie-Sager chain was adapted for sites with more rugged topography and rocky terrain where plowing was not readily feasible.

The key to understanding the use of the chain as a brush control implement is that the chain produces partial brush control. In terms of some management goals, especially wildlife habitat enhancement, this appears to be an advantage rather than a drawback. However, it has been a long established biological fact of life that partial brush control will lead to a dynamic increase in brush species unless the environment potential released by controlling the brush is preempted by desirable forage species.

The chances of establishing desirable forage and browse species to compete with brush seedling dynamics is directly related to how good a job of seed coverage is obtained in the chained seedbed. Besides seed coverage, the amount of herbaceous weed competition in the seedbed from a weed such as cheatgrass *(Bromus tectorum)* also limits the chances of seedling success.

Factors in the Success of Chaining

Probably for no other range improvement implement is there a greater discrepancy between the quality of results obtained in general practice. Chaining fulfills the requirements of a rugged, fast, and low-cost implement, but this does not mean it is simple to operate.

The first error in application of chaining technology is site selection. Big sagebrush stands with an abundance of young supple plants or shrubs containing many root-sprouting species are not suitable for chaining. The same applies to pinyon/juniper sites with tree seedlings and many saplings in the stand. Big sagebrush stands with dense cheatgrass understories are also examples of sites not to chain. Sprouting species such as snakeweed *(Gutierrezia)* or rabbitbrush *(Chrysothamnus)* should not be chained.

The second level of error in chaining involves technology transfer from those who know how to use the implement to those who want to apply the technology. The size and cost of chains and the tractors necessary for their operations has precluded their use by most research/educators. Few students get their hands-on experience with chaining from qualified instructors. This lack of experience is a fundamental problem that land management agencies are trying to address through training programs.

The success of many chaining projects could be enhanced by integration of weed control technologies. The control of seedling and sapling pinyon/juniper whips with herbicides is an example of such integration. ●