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Brush Management-

The Ball and Chain

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INTRODUCTION

Brush management through brush clearing or removal, usually in conjunction with a brush burning program, may involve several types of operations, each of which is best done by particular types of tools. Heavy, brushland disks may be used to knock down or incorporate low stands of material; dozing with the straight blade and brush rake in limited situations may be used to crush, clear, and pile brush; the chain or ball and chain equipment may be used to tear out and crush brush stands. For information on your particular needs, see also:

Brush Management—The Brushland Disk, leaflet 2921.
Brush Management—Modified and Smooth Chains, leaflet 2922.
Brush Management—Straight Dozer Blade and Brush Rake Clearing, leaflet 2923.

Controlled burning or "prescribed" fire is the most frequently used method for brushland management. Burning's effectiveness is increased when brush is mechanically treated or crushed, then allowed to dry 12 to 18 months.

One effective method of mechanical treatment for tearing out and crushing brush is the ball and chain. Ranchers and land managers in California who have used this method report:

- better burns
  . . . fuel is concentrated on the ground.

- safer burns
  . . . crushed brush is drier than untreated vegetation and can be burned when wildfire hazard is minimal. This increases the possibility for summer burns if favorable weather occurs; summer burns produce ash seed beds that are not disturbed by rain.

- cleaner burns
  . . . most of the fuel is consumed and no blackened stems remain.

Ball and Chain

On steep slopes mechanical brush treatment with disks, anchor chains between two tractors, or dozer is not feasible. The ball and chain technique of crushing brush was developed to fill this need. One end of the chain is attached to a tractor and the other to a ball — a 5-foot diameter marine net float or buoy weighted with water or other dense material. The tractor operates near the top of the slope. The chain is held in its working position down the face of the slope by the weighted, rolling ball that replaces a second tractor on slopes that are too steep. As the tractor works along the contour or follows a ridge crest, the ball drags behind and below the tractor, frequently rolling forward and down, pulling the chain through the brush. The scalloped swath of crushed brush thus created is about one-third to two-thirds the chain length. (Swath width depends on size of brush and the drag it creates, steepness of slope, and chain weight in relation to weight of the ball.)

Tractor size. A variety of tractors has been used for ball and chain operations, but the most efficient are in the D7 to D8 category with 180 to 270 net engine horsepower. (For those using drawbar ratings, drawbar horsepower equals 75 to 81 percent of net engine horsepower.) Most operators agree that tractor weight is probably more important than horsepower, and that tractor weight must more than balance the downhill pull of the ball and chain to provide adequate traction.

Equipment. A ball and chain setup uses a light-to-heavy anchor chain attached to a steel, 5-foot diameter marine net float or buoy. Chains and buoys are generally available for purchase only through Navy surplus; chains come in 90-foot lengths or "shots." In some areas the California Division of Forestry has this equipment available for private landowner use. Chains frequently are modified by having steel bars welded across the links to increase crushing effects (see L2922). In operation, the float or ball is generally filled with water. This adds weight for more effective crushing and helps prevent denting and rupturing the ball.

Various lengths of chain have been used, from 50 to 200 feet. Typical lengths are 120 or 150 feet.

Chain weights range between 10 and 80 pounds per foot. The weight used must be proportionate to ball weight and chain length: too heavy a chain will keep the ball from rolling down the slope and being effective, especially on gentle slopes. Heavy chains can be used in short lengths, however. Long chains are most effective when light, although chains that are less than 20 pounds per foot may be too light and ride up and over heavy brush.

Recommended weights and lengths of unmodified chain used with a 5-foot, water-filled buoy are:

Length of chain	Chain weight in lb./ft.
60 - 90 feet	50 - 60
90 - 130 feet	35 - 50
130 - 180 feet	20 - 35

(Steel cable, 7/8 inch to 1 1/8 inch in diameter, has been used to drag the ball but the cable is easily damaged and does not do an adequate job of crushing and uprooting brush.)

The ball is constructed of high tensile 3/16-inch steel plate and is 58 inches in diameter. Unmodified buoys filled with water have developed leaks after some use. This problem can be reduced by cutting up a second buoy and welding it over an intact one as an armor plating. Check the buoys for leaks before use and before armor plating.

Because water does not compress, filling the buoy *completely* with water further helps to prevent severe denting that can lead to leaks, and prolongs the life of a buoy considerably.

An empty ball weighs about 600 pounds. Filled with water, and armor plated, it weighs about 5,000 pounds. Balls have been filled with gravel, sand, or a combination of the two. The gravel-sand filled buoy weighs more than one filled only with water, and adding water to this porous filler increases the weight still further to about 6,700 pounds. One filled with concrete will weigh 9,000 to 10,000 pounds, depending on density of the concrete.

Use of sand and gravel makes filling and emptying balls for transport more difficult. Balls filled with concrete are very difficult to transport.

Operating techniques. A number of techniques for using the ball and chain are effective. Choice generally depends on individual evaluation of the management problem.

There are different opinions on how to attach the ball and chain to the tractor. Some operators believe the chain should be attached directly to the rear drawbar. Others feel safer attaching it to the cable winch. Some have welded hitches onto the ripper bar or onto both sides of the tractor.

When the chain is attached to the rear drawbar the center of gravity is kept low, the operator has good control, and the tractor direction can be changed without unhooking. However, there are disadvantages: when working from a road the low chain setting can do considerable damage to berms, fill, revegetation on fills, and overside drains and aprons. Also, moving the ball up and down the slope can be done only by moving the tractor.

Using a side-hitch hookup, the center of gravity still is kept low but the disadvantages associated with the rear drawbar remain. In addition, with this attachment one must unhook and re-hook the chain when changing tractor direction.

Attaching the chain to the cable winch allows the reach of the ball and chain to be extended. Once some cable has been let out the operator can adjust the ball up or down a slope simply by winching. When working from a road, the higher point of the winch attachment can keep the cable and chain above the berm and some overside drains. It does raise the center of gravity, but most operators do not consider this a serious problem. When a modified chain is used, this method allows the tractor to change direction without unhooking — a definite advantage.

Attaching the chain and ball directly to the cable does result in considerable wear on the sides of the winch drum case because the drag weight pulls the cable sideways off the drum. However, most operators have not expressed concern. The problem might be remedied by attaching heavy roller guides to the sides of the drum.

By using a hitch welded to the hydraulic ripper crossbar, the operator can adjust the center of gravity. When working from a road, he can prevent some damage to berms and fills by raising the ripper bar. Also, the tractor direction can be changed without unhooking. However, when using the ripper bar it is impossible to use the winch. This is too important a sacrifice for most operators because, regardless of the hookup used, there is definite need for a cable winch. Often, the ball or chain gets caught and the winch is the most effective method of freeing them.

A single swivel 20 to 25 feet from the tractor increases the effectiveness of the ball and chain. As the ball moves across a slope, it rolls and turns the chain. The rolling chain effectively crushes and breaks brush. A second swivel used at the ball may help prevent twisting the chain. However, a modified chain between two swivels will slide over the brush and be less effective.

When a modified chain is used, there should be 20 to 25 feet of smooth lead chain between the tractor and the swivel. This allows the tractor to back up and turn on the smooth chain without damage to the swivel or to crossbars on the modified chain.

On California Division of Forestry projects in mixed chaparral along the central coast, in western Fresno County, and in Mariposa County, two swivels were used with smooth chain. One swivel was situated at the tractor drawbar attachment and the other at the ball. This combination worked well: it prevented the chain from becoming tangled and riding up and over the brush. The rotating chain also reduced potential for creating brush windrows that may require individual burning when prescribed fire is used.

The ball and chain is used occasionally on flat ground and gentle slopes of less than 30 percent. Here the ball is used as an anchor while the tractor drives around it in a circle. The best results have been in old chamise. Heavy brush stands with tough species do not crush well. Most operators believe this technique is inefficient, that the disk or a chain between two tractors should be used instead.

Capabilities

Vegetative types. If the project objective is to uproot and mulch brush, the ball and modified chain should be used. This combination can be effective in light brush of less than 15 tons per acre or in dessicated brush. But even in light fuels, follow-up burning is usually considered necessary to reduce fuel concentrations to safe levels. In medium-to-heavy brush of 15 to 45 tons per acre, the ball and chain has been very effective as a crushing technique to prepare brush for controlled burning. Table 1 classifies brush by type and volume.

TABLE 1. BRUSH CLASSIFICATION BY TYPE AND VOLUME.

Vegetation type[1]	Vegetation loading[2]		
	Light	Moderate	Heavy
	tons/acre (estimated)		
Light to medium chamise (2.5'-5' high)	—	7-15	16-25
Low brush mixtures including combinations of big sagebrush, California sagebrush, California buckwheat, white sage, black sage, coyote brush, chamise, and sumac (2'-5' high)	—	7-15	16-25
Mixed brush (4'-6' high) and scrub oak	10	11-25	—
Heavy pure chamise, manzanita or buckbrush (4'-8' high)	—	20-30	31-40
Heavy mixed brush (6'-8' high)	—	20-30	31-45
Heaviest mixed brush with toyon, oaks, big manzanita and madrone on north slopes at higher elevations and latitudes (8'-12' high)	—	30-45	46-60

1. Adapted by Clive Countryman and Lisle Green, U. S. Forest Service, and T. E. Adams, Cooperative Extension, from *Fireline Handbook*, U. S. Forest Service.
2. Prepared by Clive Countryman and Lisle Green, U. S. Forest Service.

One ball and chain pass, or two passes in opposite directions, usually prove adequate. Additional passes increase the costs and do not significantly improve burning conditions. Prescribed burning usually is planned as a necessary follow-up measure to ball and chain treatment.

Ball and chain treatment in southern California using the modified chain has been most effective during low fuel-moisture conditions from summer through early winter. During this period the brush is more brittle and easily broken, and a large quantity of dead and dry fuels will result from treatment.

In brush areas along the San Joaquin Valley, operations using a smooth chain with the ball were most effective in mid-spring. Soil moisture in the spring permits uprooting of shrubs. Shrubs that are not uprooted will have low food reserves, be physiologically weak, and will produce fewer sprouts.

Slope. The ideal location for a ball and chain operation is a long straight ridge with side-slope gradient greater than 30 percent. Efficiency increases as the side-slope gradient increases because the weight of the ball pulls the chain taut.

Ridges perpendicular to the working ridge are a problem. Frequent finger ridges, rocky points, draws, and small drainages cause the ball to trail back up the slope behind the tractor and areas of brush may be missed. However, the ball usually will roll back but if lodged, can be pushed back down the slope by the tractor and the operation continued.

Edging. The ball and chain tends to swing in a pendulum-like fashion: it "snakes" upslope due to brush drag or terrain, then swings down, creating an irregular edge to the crushed strip. The scalloped edge is aesthetically pleasing and its shape enhances the transition from standing brush to treated area, a great benefit to wildlife.

Rocks and trees. Large boulders and trees larger than 12 inches in trunk diameter (measured 4.5 feet from the ground) create problems for the ball and chain. When the ball catches on them, it must be pulled up the slope until it clears and can roll back down. Where there are many rocks and trees a winch is very helpful.

Roads. Care must be taken when working from or across roads. Whenever possible, such work should be avoided. The chain will damage berms, overside drains, and road fills. In some cases well-vegetated road fills have been stripped and the project manager forced to apply erosion control techniques to the denuded slopes.

Production Rates and Costs

In light brush of less than 15 tons per acre, production rates for the ball and modified chain have averaged from 1.2 to 1.5 acres per hour on U.S. Forest Service projects in southern California. In heavier brush of 15 to 30 tons per acre, production has averaged 0.6 to 1.2 acres per hour. Where brush volume exceeded 30 tons per acre, production dropped to 0.5 to 0.7 acres per hour. All rates are for two or more passes. The lower rates in each case occurred on slopes of 50 percent or less. Higher figures reflect rates on slopes greater than 50 percent, where the pull of the ball maintained maximum chain extension.

In three regions of the California Division of Forestry, excluding southern California, crushing with the ball and smooth chain has produced rates of 5 to 12 acres per hour for a single pass. The average rate has been 8 acres per hour in moderate to heavy brush on moderate to steep slopes.

Rates of 10 to 15 acres per hour have been achieved on ridgetop slopes in the Central Coast Region, using a D6-C tractor of 120 net engine horsepower, and a chain 150 feet long. The chain was composed of 50 feet of medium chain at 45 pounds per foot, attached to the ball by swivel, and 100 feet of light chain at 20 pounds per foot, attached to the medium chain by swivel.

Differences in production rates between U. S. Forest Service projects in southern California and projects in other areas result from composition of the brush, operating techniques, differences in topography, and more completely crushed brush in U. S. Forest Service projects.

Cost of tractor operation can be calculated from data in "Farm Machinery Costs," L2263, Division of Agricultural Sciences, University of California. To the cost of tractor operation should be added cost of transportation, support equipment charges, and pay for the tractor driver and swamper.

On-site costs to the Forest Service in southern California, through 1973, have varied from $22 to $50 per acre in light brush and from $40 to $70 per acre in heavier brush for three to four passes.

Computation of current costs will require adjustments for inflation.

General Recommendations

Soil disturbance. In general, the ball and chain disturbs soil less than any other clearing or crushing method. Some important exceptions are: (1) near the tractor where the chain digs relatively deep, especially along road berms or wherever there are small knobs and outcroppings; and (2) ball tracks created where the ball is lowered down a slope and then where it is pulled back up. Where disturbance occurs erosion control may be necessary. In the case of ball tracks, correction can involve hand crews to construct water bars and plant seed.

Transportation problems. The bulk and weight of the ball and chain pose special handling problems. The best equipment for transportation is a large flatbed truck with a high capacity hoist or A-frame. This allows one man to load, drive to the job site, and unload. Or, the ball can be chained to a tractor blade for loading and unloading. As noted earlier, material used to fill the ball can make handling and transportation difficult.

For short hauls it is possible to drag the ball and chain behind the tractor or pick the ball up with the tractor blade. However, when dragged, the ball and chain may cause damage that must be repaired to prevent erosion.

Cutting each "shot" (90-foot length) of chain in half and inserting a Navy master connector link makes it possible to lengthen or shorten the chain by 45-foot increments. This flexibility makes the chain easier to handle and use.

Swivels. For safety, most operators recommend swivels with a 20- to 30-ton capacity, depending on the weight of the ball. Because most swivels have a built-in 40 percent safety factor, this appears to be a safe capacity range.

Special hazards. Several balls have broken loose. In all known cases, loss was due to a broken swivel, a clevis pin working loose or unscrewing, or a clevis spreading apart. All swivel pins and clevis pins should be threaded or fastened in place with a heavy-duty cotter key, or heavy bolt and nut secured with a cotter key. All pins and cotter keys should be checked several times during a day's operation.

Because a loose ball presents a hazard, use of the ball and chain above heavily used roads, trails, campgrounds, and residential areas is not recommended.

There is severe hazard to the swamper or observer who gets below the ball and chain: a ball that is snagged in trees or rocks can jerk free suddenly and drop quickly down the slope along with dislodged rocks and trees.

The chain can move unpredictably too. There may be a whipping action in a slack chain as the tractor moves forward. Here, the chain moves much faster than a man can. In addition, when the ball and chain are attached to a winch line, the cable sometimes becomes twisted in spite of the presence of a swivel. This develops torque stress in the line. When the tractor moves the chain, even slightly, the cable may suddenly untwist and injure anyone standing nearby. Fortunately, this does not happen often because swivels usually do their job. Nevertheless, observers should stand clear of the moving ball and chain.

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Major advantages and disadvantages of ball and chain crushing:

Advantages	Disadvantages
Can be applied to steep slopes, eliminating or reducing need for expensive hand labor.	Not very maneuverable, difficult to leave specimen trees or clumps.
Except near the tractor, disturbs soil very little.	Removes few roots and root crowns; sprouts are numerous.
Allows varying degrees of clean-up depending on number of passes and desired aesthetic effects.	Ball and chain are difficult to load and unload.
Effective for creation of irregular edge effect — scalloping — which enhances wildlife habitat and aesthetics.	Efficiency limited by boulders and large trees.
Treated brush can be burned when surrounding brushfields will not burn readily.	The remote chance of losing a ball must be considered, particularly above traveled or occupied areas.
	Little debris incorporated into the soil.

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