Wildlands Workers' Handbook

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Chapter 14

Water Pipelines

Pipelines are used to convey water from a source to a lower point where water is needed. Pipelines are more efficient than conveying water in an open ditch.

All springs have some pipeline laid from the collection box to the trough. Since springs normally occur on mountains, water is often piped to the valleys.

Where well water is available only at great depths (500 to 1,000 ft.) drill one well and pump the water up to a tank on a hilltop from which the water can gravity flow by pipeline to the several pastures.

The natural flow of water is subject to several limitations:

(a) Water will flow only downhill unless under pressure.

(b) Only so much water will flow through a given sized pipe.

(c) Water flowing through a pipeline creates friction, which slows and eventually defeats the flow of water.

These limitations are the reason for planning and designing a pipeline.

For a short simple pipeline, a design chart is unnecessary. If running a pipe from a spring collection box to a trough a few hundred feet away, select a pipe size that seems reasonable from Table 14-1 on page 92 and lay the pipe in a downhill ditch to the trough. But if a pipeline is planned that goes downhill, then up over ridges and down into gulches, design the pipeline before investing in pipe and incurring other expenses.

The full chart is shown in EXAMPLE on page 87. For simplicity, this exercise will use just the first columns.

(1)	(2)	(3)	(4)
Stations in hundreds of feet	No. of feet between Stations in feet	Elevation at Station	Difference in elevation of Station from previous Station in feet

0+00

The first station on the list is always 0+00, which means 0 hundred and 00 feet. 257 would be written 2+57. Stations are so listed because friction is computed as so much per 100 feet of pipe. Station 0+00 is *always* at the bottom end of the pipeline.

The information for the columns can be derived in several ways.

(1) Map Method

If topographic maps are available with 20 feet (or less) contour intervals, the proposed pipeline can be plotted on the map to determine probability of success. See Figure 14-1 on page 85 for the concept. Note that distances and elevations are recorded only where slope changes.

If the pipeline computes favorable on paper, always check the topography by going to the field to see if there are small unmapped hills or rock ledges not shown on the map.

(2) Engineering methods. Always measure the distance and elevations at least twice to avoid errors.

(a) Survey. The most intensive and accurate method is to measure distances with a steel tape (measure slope distance) and determine elevations with a dumpy level and surveying rod. At least three people, but preferably five are needed.

(b) Determine elevations with a dumpy level and distances by stadia. This method needs two persons.

(3) Less intensive, one person methods.

(a) Derive distances by pacing and use an Abney level (with a rod holder) to determine elevations.

(b) Derive distances by survey odometer in a truck, which will measure distance to the nearest 50-feet and can be extrapolated to the nearest 5 feet. A large aneroid barometer (6 in. dial) is used for elevations or an electronic item, like Brunton's Sherpa™ (a hand-held weather station that measures elevation to the nearest 3 feet) may be used. This machine costs about $200. This method is the fastest one-person and is accurate enough for plastic pipeline computations.

Begin at one end of the pipeline. It is easier to drive or survey downhill than uphill and measurement of water flow is necessary, so normally begin at the source. Time the flow into a gallon container with a suitable watch. The amount of flow determines pipe size. Record the measurement in gallons per minute with the date and time of day. A spring may vary in flow by season and some springs vary by time of day. For this exercise let's assume that the spring flows 3-gpm. Write this down.

After measuring the water, begin survey. Set the survey odometer at zero. Open the lid of the barometer box, let it sit a minute to stabilize the needle, then read and record the elevation. Only differences in elevation between two points are needed so don't correct the barometer to actual ground elevation. The barometer reflects atmospheric pressure changes as storms come and go, so complete readings in 3 hours or less.

If starting from the upper end of the pipeline, add a column at the left side. These figures will have to be reversed for computation because 0+00 is always at the trough (lower) end. If the pipeline is measured to be 48+40 long, then the first downhill station of 8+20 will, on the final form be, 40+20. Record from which end of the pipeline work was started in case others do the computation.

Drive across country, on the exact route of the proposed pipeline to the first slope change. This may be a flattening of the slope, a steeping of the slope, or where the slope reverses. Stop and record the odometer reading and barometer reading, again letting the barometer needle settle before reading. Then go on the next slope change .Do not take readings at stated intervals like every 100 feet or every 500 feet. Place stakes along the route so construction crews can follow. Flagged steel posts are highly visible and the posts can be used to hold the pipeline risers.

If a deep impassable ditch is found, pace to the bottom and read the barometer hand-held. It is better to detour such a place, and if so, change the last stake (if needed) and proceed.

When at the bottom of the line, fill in the chart then and there. There may be obvious errors that can be corrected on the spot.

Sample computation from Figure 14-1. Remember 0+00 is the bottom end.

(1) Station	(2) 100's of ft. Between sta.	(3) Elevation	(4) Difference in Elevation in ft.
0+00	------	4725	-----
3+70	3+70	4710	+15
8+40	4+70	4730	-20
10+00	1+60	4745	-15
17+50	7+50	4740	+5
19+80	2+30	4750	-10
41+10	21+30	4752	-2
53+80	12+70	4762	-10
Add columns	5380	37	-37

And they check out.

After re-running the line to be sure figures are correct, turn to Table 14-1 on page 92. This table has information on velocity and friction losses per 100-ft. of flexible plastic pipe. Rigid plastic and steel pipe will be discussed later.

First, determine friction loss. Enter the gallons per minute column at 3-gpm and go across the 1 in. pipe size. The column 'pressure drop, pounds per square inch' reads .29, which means for every 100 ft. of 1 in. pipe, there will be a loss due to friction of .29 pounds per square inch. Now look under the 1½ in. pipe for 3-gpm; the friction loss is only .08 lbs. The larger the pipe the less friction with a given head of water.

Compare friction loss of 3-gpm, 1 in. pipe with friction loss of 10-gpm from the same sized pipe. As the amount of water in the pipe increases, the friction increases dramatically from .29 to 2.73.

Friction increases pressure, so if there is a problem with excessive pressure, this can be relieved by going to a larger pipe size or decreasing the amount of water.

The box on Table 14-1 titled 'Factors for conversion of pressure' states: "Pressure, feet (head) of water to pounds per square inch = .4331 X feet."

So what is 'head'? Head is the elevation in feet the water is running from as compared to the elevation it is running to. A storage tank containing 12 feet of water has 12 feet of head. One foot of fall in the pipeline will nullify .4331 pounds per square inch of friction. When friction equals or exceeds the head, no water comes through the pipeline.

To illustrate this, find 1¼ in. pipe and 5-gpm. Pressure loss is .2 psi per 100 ft. of pipe. If there is 100 ft. of head, how far can the water be run before friction reduces flow?

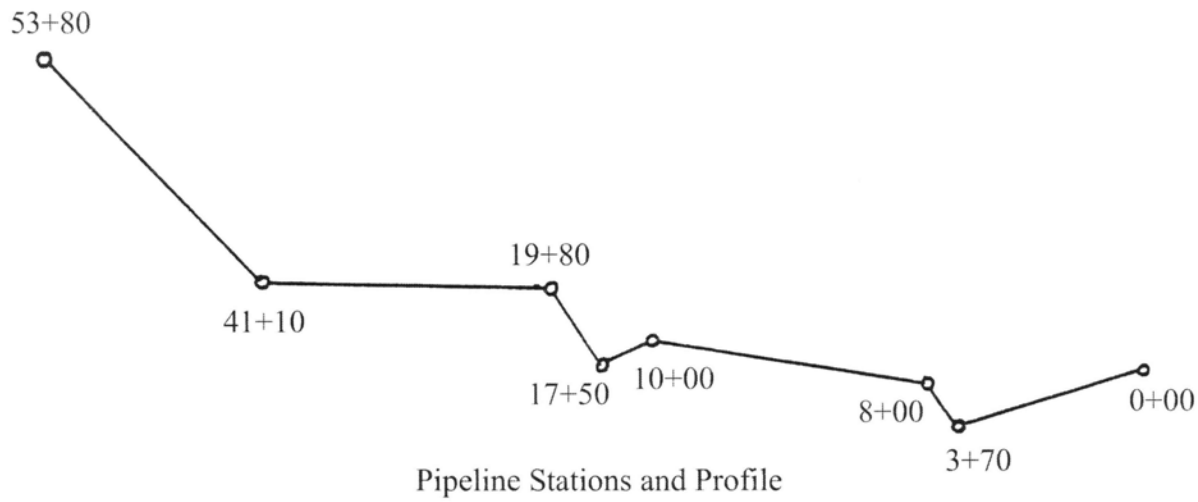


Figure 14 - 1

100 feet of head X .4331 = 43.3. Divide by .2 (psi loss per 100 ft.) and the quotient equals 21.6 stations (21,600 ft.) or about 4.1 miles. If using 20-gpm and the same sized pipe, the answer is about .3 miles.

Back to the chart, Column 5. Only Columns (1) and (4) are duplicated for simplicity.

(1) Station	(4) Difference in Elev. in feet.	(5) Elev. in head ft., Converted to psi. (Col.4 x .4331)
0+00	------	--------
3+70	+15	+6.495
8+40	-20	-8.66
10+00	-15	-6.495
17+50	+ 5	+2.165
19+80	-10	-4.331
41+10	-2	-0.866
53+80	-10	-4.331

Remember that a minus sign means downhill and a plus uphill.

Now add Column (6). Again, only the needed columns are duplicated. In real life, use legal-sized paper and make a spreadsheet with all columns on it.

(1) Station	(2) Distance between Stations in feet	(6) Headloss in psi from friction.(1 ¼ Pipe @ 5gpm (Col. 2 x .2), all +.
0+00	------	-------
3+70	3+70	+0.74
8+40	4+70	+0.94
10+00	1+60	+0.32
17+50	7+50	+1.50
19+80	2+30	+0.46
41+10	21+30	+4.26
53+80	12+70	+2.54

These figures are for friction in the pipe itself. Plastic pipe is joined with insert couplings, which restrict flow and add friction (Table 14-1, Chart 2). Each coupling adds (in effect) 2.75 ft. of length to the line. Rolls of plastic pipe come in lengths of 100 to 1,000 feet.

Now, on to Column 7. Add algebraically columns (5) and (6), plus or minus the figure in Column (7) of the previous station. That is, for station 8+40, add Columns (5) and (6) (-8.66 plus +.94), then from station 3+70 add (+7.235) = +0.485.

(1) Station	(5) Elev. Head/ft.	(6) Friction loss	(7) Pressure Converted to psi Algebraic sum of (5)+(6)+/–(7)
0+00	--------	-------	--------
3+70	+6.495	+0.74	+7.235
8+40	-8.66	+0.94	+0.485
10+00	-6.495	+0.32	-7.750
17+50	+2.165	+1.50	-4.085
19+80	-4.33	+0.46	-7.955
41+10	-0.866	+4.26	-4.561
53+80	-4.33	+2.54	-6.351

Remember station 0+00 is the trough. The large positive figure there means that 5-gpm will not flow through 1¼ in. pipe. Options are to decrease the size of the input, or increase the size of the pipe from about station 10+00 to the trough, or re-route the pipeline to eliminate that last rise, or shorten the pipeline to about station 3+00.

Second problem: A spring flows 3-gpm., split the flow 100 feet below the spring box to put 1-gpm into a trough and send 2-gpm down the pipeline. The line is 5 miles long and has a trough at the spring, one in the middle, and one at the lower end. Use 1-in. plastic pipe rated at 80-psi in 300 ft. rolls.

EXAMPLE
Spring Flow - 3 gpm — Pipeline Length - 5 miles
1in. Plastic Pipe — 80 psi —300ft Rolls

(1) Station	(2) No.ft. between stations in hundreds of feet	(3) Elevation of station in feet	(4) Difference in elevation of station from previous station in feet	(5) Elevation in head feet converted to psi (col. 4 x .433)	(6) Head loss in psi from friction (col. 2 x .26)	(7) Pressure algebraic sum of (5)+ (6)+ previous station (7)	(8) Pipe pressure. algebraic sum of (5)+(6)+ lower station
0+00	0	4721	---	---	---	---	---
4+80	4+80	4731	-10	-4	+2	-2	-51
5+10	0+30	4722	+9	+4	+1	+3	-49
7+80	2+70	4805	-83	-36	+1	-32	-54
23+50	15+70	4852	-47	-21	+5	-48	-19
93+20	69+70	4923	-71	-31	+19	-60	-3
143+10	49+90	4961	-38	-17	+13	-64	+9
198+70	55+60	4982	-21	-9	+15	-58	+13
264+00	65+30	5005	-23	-10	+17	-51	+7
	264+00	284	284		73		

Measure the spring flow and find it does flow 3.1-gpm. If a tourist shuts off the trough valve, the full 3-gpm will go down the line, so design for that figure. Using just Columns (1), (2), and (3) in the EXAMPLE, complete the rest of the chart without reference to my work. Round the figures upward to the next whole number to take care of insert fitting friction and to speed the process. Note a Column (8) 'Maximum pressure'. Compute this column as for Column (7), BUT start at the source end of the line.

There are two kinds of pressure damage; explosion and implosion. Explosion blows the pipe out and implosion collapses it. Implosion occurs when an upper valve is turned off (where there is no riser below the valve) and as the water runs on down the pipe, a strong suction effect occurs causing collapse of the pipe. To avoid this, *ALWAYS PUT A RISER BELOW AND ADJACENT TO ANY VALVE IN THE MAIN LINE.*

Should Column (8) pressures be found to be above 100-psi (the highest rated flexible plastic pipe), use rigid plastic or steel pipe for the portion of the line where pressures are excessive.

After the pipeline is designed, order the pipe and fittings. If several pipelines are planned, it is convenient to standardize on one size pipe rather than maintaining an inventory of various sizes of pipe and fittings.

Trenches

Plastic pipe must be covered with dirt. A ditch may be opened and the pipe placed in it or a chisel-tooth layer behind a crawler-type tractor may be used to lay and cover the pipe in one operation.

The pipe is covered to protect it from the elements, such as hot sun, freezing temperatures, or mechanical damage from herbivores, vehicles, or floodwater. On a rocky hill where it was impossible to bury the pipe, it was found that water will seldom freeze in the pipe if velocities exceed 1-ft. per second, assuming temperatures of -10 degrees F or higher.

If water is to be shut off during the winter, the lower places where there is reverse grade will freeze and break the pipe. Place a stop-and-waste valve at these points.

The pipe may be covered in various ways. A moldboard plow can cut a shallow trench, or a set of border discs can pile dirt on top of the pipe. Or dirt can be pushed from the side onto the line with a bulldozer or maintainer. A fairly short line can be placed in a backhoe trench.

For longer lines, rip the ground first with a large chisel behind a crawler tractor, and then use a road maintainer with the blade set at a high angle to clean the dirt from the trench. Two men can finish a five-mile-long pipeline ditch in reasonable soil in about three days.

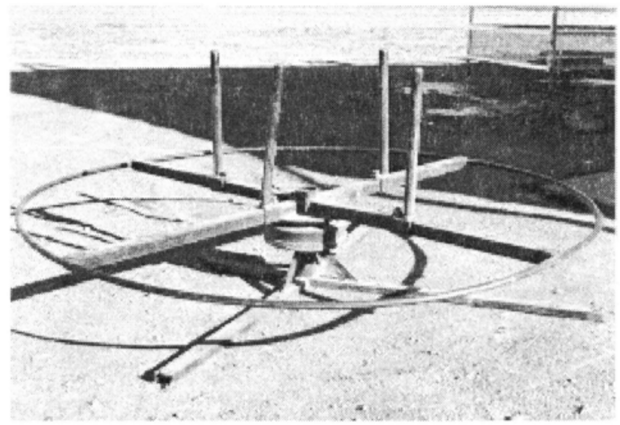
Opening a ditch with a blade. Line was first cleared with the bulldozer. Cutting blade is outboard at an extreme angle.

On steep side slopes, a crawler-type tractor works best. First a rough road is built around the hill on the staked line. Then the pipe is laid in this road on the uphill side. A second road is built just above the first road, letting the dirt spill onto the pipeline. If the sideslope is very steep, put a walking tooth on the bulldozer blade to hold it on the slope. This big chisel tooth that bolts onto the blade also does a nice job of making a trail that can be finished by hand.

Laying the Pipe

Plastic pipe comes in rolls of from 100 to 1,000 feet in length. The smaller rolls are easier to handle, but require more couplings and time to lay. Using short rolls, unroll the pipe by rolling the roll down the ditch like a hoop. Or grab an end and walk off, unrolling it, like a spinning fishing reel. On a stake-bed truck, wire a steel pipe across the rack and use this as a spindle, with the addition of an empty barrel for a hub.

It is suggested, if there is much pipeline to lay, that a pipe-laying reel be constructed such as shown in photo at right. With this reel two men can lay up to ten miles of pipe a day. Using other methods, four men can lay about four miles a day. Plans for the reel are available in Equip-Tips from the Bureau of Land Management's Denver Service Center.



Plastic Pipe-Laying Reel

The top spins freely on an old automobile front wheel and bearing. The upright posts on the square arms are adjustable to fit the inner circumference of the roll of pipe. This reel can be used for 100 to 1,000 foot rolls of pipe.

Longer pipe rolls are very bulky; a large truck is needed to transport them. A 6-wheel drive, 2½-ton truck is proper, since it can drive the line without excessive detours.

Begin laying the line at the source. Tie the pipe into the source when laying begins and put a valve with a riser below the valve, but leave the valve open. Placing a 'T' fitting in the line with a 4 to 6 foot piece of pipe extending vertically tied to a steel post for support makes a riser. The valve permits stopping the flow of water in an emergency or if water is to be cut off during the winter. It also may be needed to choke the flow to get water into a nearby trough. Almost always a trough is placed near the source, but never run the pipeline from the overflow of the trough because the pipeline will clog from leaves and trash that blew into the trough. Instead, place a 'T' in the main line and run a pipe to the trough location.

The water will begin to flow into the roll of pipe. The cold water will stabilize the shrink of the pipe and a break or leak is immediately evident. This is called 'laying the pipe wet'.

Drive down the line at a prudent speed while the reel lays the pipe. One person drives the truck and the other tends the reel. If more help is available, one person can police the pipe into the ditch. The pipe must not be laid tight and straight, it must have slack. It should look like a tired snake on a hot day. If it is laid taut, when temperatures drop at night, the pipe will shrink more and pull some of the insert couplings out. If the pipe is laid dry and taut, by next morning , ***all*** the insert couplings will be pulled loose by the shrinkage of the pipe.

At the end of the first roll, stop and drive an insert coupling into the wet end of the pipe with a rubber mallet and put on a clamp, screw the clamp tight with a screwdriver. If the water has not appeared yet, wait until it does. If the water does not soon arrive, that means there is a break or kink above, so go fix it. Cut out any kinks and splice the pipe with an insert coupling, else someone will be out soon digging up the line to fix the leak.

If the weather is cold, the plastic pipe will not be flexible and it helps to gently heat the truck end of the next reel before pushing the pipe onto the insert coupling. Use a blowtorch or propane torch. Lay the wet end on the ground and warm the pipe end with the torch. Pick up the wet end quickly and press the coupling into the warmed end before the water starts flowing again. Tighten the clamp with a screwdriver and begin driving again. It should take about one minute to splice two rolls. Note: Take extra screwdrivers, they are easily misplaced.

On every ridge or hilltop, put in a 'T' fitting and a riser. Air is lighter than water and is compressible. It will go to the high spots and remain there, preventing the water from flowing by forming an 'airlock'. Usually an airlock forms 2 to 3 days after the pipe is covered. If pressure in the line is high enough to squirt out the tip of the riser, add length to the riser, or place several insert couplings to increase friction. If these measures fail to stop the water, use a commercially available pressure cap. These are special couplings into which a pressure cap screws.

The design chart will show how much pressure to expect so the proper sized pressure cap can be used. Keep some 25-lb. caps and fittings in the truck for emergency use.

Place 'Ts' for the troughs as the line is laid, with a short line and closed valve as earlier described. Any valve in the main line must have a riser placed just below the valve.

After the line is laid and checked for leaks and kinks, dirt is placed on the pipe. This is a two-person job. One polices the pipe into the ditch, makes sure there is slack and removes large or sharp rocks that might collapse or cut the pipe. As dirt flows onto the pipe it pushes the slack out, so the pipe tender will shovel dirt onto the pipe to hold it down at about 100-ft. intervals. The other person operates the machine that moves the dirt.

Don't work under the blade of a bulldozer, the operator can't see or hear the person. *STOP* a heavy equipment operator by holding up one or both thumbs. The same signal used to tell an airplane driver to *GO*.

Several passes are needed to fill the ditch and make a berm on top. No berm is left at a road crossing. All trash is picked up on the last pass and usually the bare area is drilled with grass/forb seed to prevent erosion.

Chisel-type Layers

Since about 1970, because of the high cost of digging the ditch, several one-step pipe layers have been developed. These use a large crawler tractor with a tool bar and a 4 to 5 ft. long chisel. To the back of the chisel a 4-in. diameter heavy wall steel pipe is welded for about the top 2/3rds of the chisel length, then it is bent back away from the chisel in a smooth curve to nearly 90 degrees. The plastic pipe is nearly parallel to the ground surface before it is released from the protection of the steel guide.

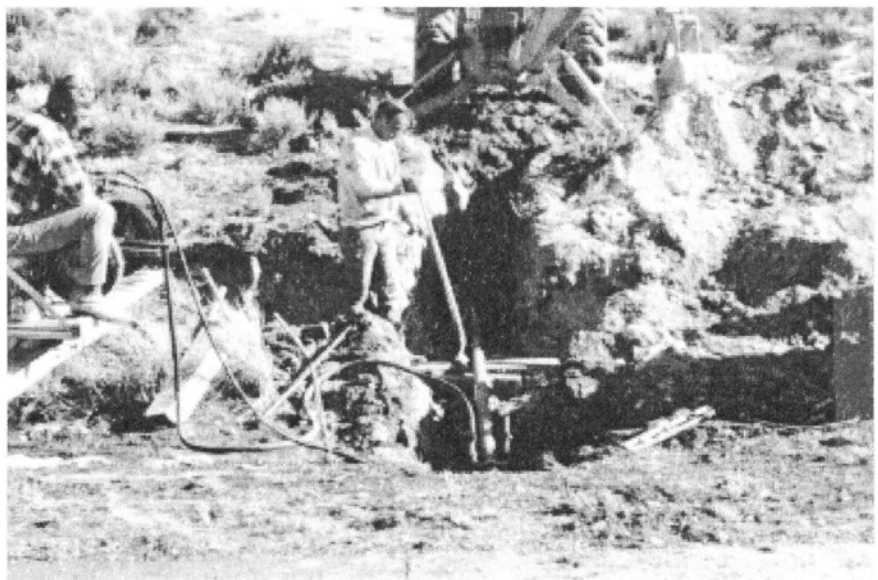
The line is chiseled before laying the pipe, sometimes two or three passes, to open the ground and remove any rocks or boulders. Then, using some type of pipe reel to hold the roll of pipe, the pipe is threaded through the steel pipe on the chisel, tied firmly to a water trough or a pickup and the chisel is lowered into the ground. The tractor is driven along the pre-chiseled line and the pipe is fed underground. If the pipe is laid wet, to stabilize shrink, and placed four feet underground, there is still a splitting problem not encountered with ditch-laid pipe.

The problem seems to be that chisel-laid pipe is laid taut, which causes splitting of plastic pipe in a few years. Even so, it may be cheaper to replace a chisel-laid pipeline every five years than to open and close a ditch.

Paved Highway Crossings

Consult with the local Highway Department engineer as to how to cross a paved highway. Sometimes the pipeline can be threaded through an existing culvert, but only as a temporary measure. If this is done, any detour of the line to reach the culvert will be included in the design figures. Opening a ditch across the paved road is always vetoed, so the option left is to push conduit under the highway. Find a contractor with the equipment to hydraulically push heavy-wall steel pipe. This equipment is easily carried in the bed of a half-ton pickup or on the trailer that a carries the backhoe.

Start by backhoeing a T-shaped trench near the highway, usually at the base of the fill slope. The long part (10-ft.) is perpendicular to the highway; the short part is on the end away from the road and is parallel to the roadway. If crossing in highway fill, the ditch need only be deep enough to hold the equipment: if crossing at a level point, the ditch must be three to four feet deep. The machine is placed into the ditch perpendicular to the highway; bridge timbers, for backing, go into the short ditch. Park the backhoe with the scoop against the timbers for added strength.



Pushing conduit under paved highway, using hydraulic pressure. Cross-T backing is where hand shovel rests. Pipe is on carrier in trench. Motive power is provided by a small gasoline engine in the pickup bed.

Weld a flat plate over the end of the conduit pipe so it won't fill with dirt while being pushed. The conduit is hooked onto the carrier, and is hydraulically pushed forward using a small gasoline engine to power the hydraulic system. When the first 21-ft. joint of conduit is pushed in, weld or couple on another joint and continue pushing. Usually about three joints (63-ft.) of conduit are needed to span a two-lane highway.

In soft fill dirt, it takes about 15 minutes to push the conduit through. In rocky fill, the conduit may hit a rock and go off in another direction, hopefully not up through the pavement. It may take several hours and several T-trenches to push conduit through a rocky fill. The conduit ends are then trimmed with a cutting torch, the plastic pipe is threaded through the conduit, and couplings are placed to hook this segment of the line into the main line previously laid, or to be laid. Bury the pipeline and the conduit. Do not let the conduit extend above the ground since it will wreak havoc with mowers, rakes, and maintainers.

Use a horizontal well-drilling machine if one is available, it should work quite as well as a hydraulic outfit. See Chapter 4, Springs.

Mark the location of the conduit with a short post in the highway fence or on the edge of the highway right-of-way so it can be located in future years.

Steel and Rigid Plastic Pipe

Where pressures exceed allowable limits for flexible plastic pipe, use steel or rigid plastic pipe. These types of pipe come in 21 foot-long sections, called 'joints'. Standard fittings are available for coupling two pieces of pipe and for bends of 90, 45, and 33 degrees. The ditch bottom must be flat and straight and below frost line.

Professional pipeliners use steel pipe and cut and weld the pipe at bends, rather than rely on standard fittings. These types of pipe are time consuming to lay and join. They require much more ditch preparation than for flexible pipe.

In the Wildlands, steel or rigid plastic pipe is used to bridge short distances where pressures exceed those allowable for flexible pipe. Rigid plastic pipe has about the same friction coefficients (Table 14-2), as does flexible pipe.

Steel pipe rusts, corrodes, and attracts precipitants from the water. In hard-water areas, steel pipe will accumulate so much rust and scale in 20 to 30 years that it is almost completely clogged. To compensate for this corrosion and precipitants, steel pipe flow capacities are computed on the basis of 15-year old pipe, not on the capacity for new clean pipe. Table 14-3 contains data for design of steel pipelines.

Friction Loss Characteristics
POLYETHYLENE (PE) SDR-PRESSURE RATED TUBE
PSI Loss Per 100 Feet of Tube (PSI/100 ft)

POLYETHYLENE (PE) SDR-PRESSURE RATED TUBE
Sizes 1/2" thru 6" Flow 1 through 600 GPM

SIZE	1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"		4"		6"	
ID	0.622		0.824		1.049		1.380		1.610		2.067		2.469		3.068		4.026		6.065	
Flow G.P.M.	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss
1	1.05	0.49	0.60	0.12	0.37	0.04	0.21	0.01	0.15	0.00	0.09	0.00								
2	2.10	1.76	1.20	0.45	0.74	0.14	0.42	0.04	0.31	0.02	0.19	0.01								
3	3.16	3.73	1.80	0.95	1.11	0.29	0.64	0.08	0.47	0.04	0.28	0.01	0.20	0.00						
4	4.21	6.35	2.40	1.62	1.48	0.50	0.85	0.13	0.62	0.06	0.38	0.02	0.26	0.01						
5	5.27	9.60	3.00	2.44	1.85	0.76	1.07	0.20	0.78	0.09	0.47	0.03	0.33	0.01	0.21	0.00				
6	6.32	13.46	3.60	3.43	2.22	1.06	1.28	0.28	0.94	0.13	0.57	0.04	0.40	0.02	0.26	0.01				
7	7.38	17.91	4.20	4.56	2.59	1.41	1.49	0.37	1.10	0.18	0.66	0.05	0.46	0.02	0.30	0.01				
8	8.43	22.93	4.80	5.84	2.96	1.80	1.71	0.47	1.25	0.22	0.76	0.07	0.53	0.03	0.34	0.01				
9	9.49	28.52	5.40	7.26	3.33	2.24	1.92	0.59	1.41	0.28	0.85	0.08	0.60	0.03	0.39	0.01				
10	10.54	34.67	6.00	8.82	3.70	2.73	2.14	0.72	1.57	0.34	0.95	0.10	0.66	0.04	0.43	0.01				

Table 14 - 1

Friction Loss Characteristics
PVC SCHEDULE 80 IPS PLASTIC RIGID PIPE

(1120, 1220) C = 150
PSI Loss Per 100 Feet of Pipe (PSI/100 ft)

PVC SCHEDULE 80 IPS PLASTIC PIPE
Sizes 1/2" thru 6" Flow 1 through 600 GPM

SIZE	1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"		4"		6"	
OD	0.840		1.050		1.315		1.660		1.900		2.375		2.875		3.500		4.500		6.625	
ID	0.546		0.742		0.957		1.278		1.500		1.939		2.323		2.900		3.826		5.761	
Wall Thk	0.147		0.154		0.179		0.191		0.200		0.218		0.276		0.300		0.337		0.432	
Flow G.P.M.	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss
1	1.36	0.81	0.74	0.18	0.44	0.05	0.24	0.01	0.18	0.01	0.10	0.00								
2	2.73	2.92	1.48	0.66	0.89	0.19	0.49	0.05	0.36	0.02	0.21	0.01	0.15	0.00						
3	4.10	6.19	2.22	1.39	1.33	0.40	0.74	0.10	0.54	0.05	0.32	0.01	0.22	0.01						
4	5.47	10.54	2.96	2.37	1.78	0.69	0.99	0.17	0.72	0.08	0.43	0.02	0.30	0.01						
5	6.84	15.93	3.70	3.58	2.22	1.04	1.24	0.25	0.90	0.12	0.54	0.03	0.37	0.01	0.24	0.00				
6	8.21	22.33	4.44	5.02	2.67	1.46	1.49	0.36	1.08	0.16	0.65	0.05	0.45	0.02	0.29	0.01				
7	9.58	29.71	5.18	6.68	3.11	1.94	1.74	0.47	1.26	0.22	0.75	0.06	0.52	0.03	0.33	0.01				
8	10.94	38.05	5.92	8.56	3.56	2.48	1.99	0.61	1.45	0.28	0.86	0.08	0.60	0.03	0.38	0.01				
9	12.31	47.33	6.66	10.64	4.00	3.09	2.24	0.76	1.63	0.35	0.97	0.10	0.68	0.04	0.43	0.01				
10	13.68	57.52	7.41	12.93	4.45	3.75	2.49	0.92	1.81	0.42	1.08	0.12	0.75	0.05	0.48	0.02	0.27	0.00		

Table 14 - 2

Friction Loss Characteristics
SCHEDULE 40 STANDARD STEEL PIPE

PSI Loss Per 100 Feet of Pipe (PSI/100 ft)

SCHEDULE 40 STANDARD STEEL PIPE C = 100
Sizes 1/2" thru 6" Flow 1 through 600 GPM

SIZE	1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"		4"		6"	
OD	0.840		1.050		1.315		1.660		1.900		2.375		2.875		3.500		4.500		6.625	
ID	0.622		0.824		1.049		1.380		1.610		2.067		2.469		3.068		4.026		6.065	
Wall Thk	0.109		0.113		0.133		0.140		0.145		0.154		0.203		0.216		0.237		0.280	
Flow G.P.M.	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss	Velocity F.P.S.	P.S.I. Loss
1	1.05	0.91	0.60	0.23	0.37	0.07	0.21	0.02	0.15	0.01	0.09	0.00								
2	2.10	3.28	1.20	0.84	0.74	0.26	0.42	0.07	0.31	0.03	0.19	0.01	0.13	0.00						
3	3.16	6.95	1.80	1.77	1.11	0.55	0.64	0.14	0.47	0.07	0.28	0.02	0.20	0.01	0.13	0.00				
4	4.21	11.85	2.40	3.02	1.48	0.93	0.85	0.25	0.62	0.12	0.38	0.03	0.26	0.01	0.17	0.01				
5	5.27	17.91	3.00	4.56	1.85	1.41	1.07	0.37	0.78	0.18	0.47	0.05	0.33	0.02	0.21	0.01				
6	6.32	25.10	3.60	6.39	2.22	1.97	1.28	0.52	0.94	0.25	0.57	0.07	0.40	0.03	0.26	0.01				
7	7.38	33.40	4.20	8.50	2.59	2.63	1.49	0.69	1.10	0.33	0.66	0.10	0.46	0.04	0.30	0.01				
8	8.43	42.77	4.80	10.89	2.96	3.36	1.71	0.89	1.25	0.42	0.76	0.12	0.53	0.05	0.34	0.02	0.20	0.00		
9	9.49	53.19	5.40	13.54	3.33	4.18	1.92	1.10	1.41	0.52	0.85	0.15	0.60	0.06	0.39	0.02	0.22	0.01		
10	10.54	64.65	6.00	16.46	3.70	5.08	2.14	1.34	1.57	0.63	0.95	0.19	0.66	0.08	0.43	0.03	0.25	0.01		

Table 14 - 3

Chapter 15

Water Troughs

Water troughs are metal or wood containers to store livestock drinking water. If made of dirt, they are called tanks or reservoirs and are dealt with in Chapter 18.

The size of the trough depends upon the numbers of livestock and wildlife using it and the amount of water flowing into it. Plan a trough large enough to hold:

(a) A 24-hour flow from a spring.

(b) A 3-day supply for the herd from a windmill, since the wind may not blow for several days.

(c) A one-day supply for the herd from a catchment tank, which will have a float valve.

(d) A 2 to 5 day supply from a motor-pumped well. This latter size will depend upon how often the well can be pumped with personnel available.

Trough size may vary from the above. In cool weather, desert cattle may water about every third day and then drink 30 to 50 gallons per cow, not the normal 10 gallons.

There are two kinds of troughs in general use:

(1) a rectangular prefabricated trough of sheet steel which holds about 500 gallons.

(2) A circular steel trough constructed of pre-cut pieces or sheets of corrugated steel 2 to 4 ft. high and 10 ft. long. These sheets are bolted together to form a circle. A concrete bottom is poured with the steel set 3 to 6" deep in the concrete. Almost anything that will hold water can be used as a trough, from old bathtubs to tractor tires. Cost is the major consideration, not beauty.

Redwood staves were once widely used to form a trough, using techniques used making barrels. Metal bands held the staves in place. Due to the labor involved, these are seldom found nowadays.

Tub Troughs

These troughs are ordered from a local supplier. If 500 gallons is not sufficient capacity, put several troughs in tandem. These troughs are light enough that two men can handle them. The site must be leveled for each trough. Since fill dirt tends to shrink unevenly, it is best to excavate to level rather then fill to level.

Once the trough is leveled, the pipeline is extended underground to the inlet. On the inside of the trough place a short nipple, a 90º elbow, and a 2 to 3 foot length of steel pipe to bring the inflow up so humans can get a drink of clean water. The outlet end of the end trough of the series is plumbed for an overflow pipe, elevated to near the top of the trough. Excess water goes out of the trough into an underground pipeline that runs 50 to 100 ft. from the trough and is released into a small dirt pool where calves and wildlife can get water. Place a steel post at each end of the trough to guard these fittings.

If troughs are placed in tandem, connect the outflow of the first trough directly to the inflow hole of the next trough with a straight piece of radiator hose. If steel or plastic pipe is used, the connection will break as the troughs settle unevenly. The outflow hole of the second trough will be plumbed with a riser to retain the water in both troughs to a height of 2 inches below the top of the troughs. Place a steel or wooden post between the two troughs so a cow won't walk in between and break the connection.

Circular Troughs

The circular sided, concrete floored trough is more complicated to install.

To calculate the capacity of the trough in gallons, use the formula Pi (3.1416) times the radius squared times the depth (in feet), times 7.48 (gallons in a cubic foot.) A sheet steel trough with sides 3-ft. tall, set 3-inches into the concrete and less 3-in. freeboard to keep the wind from blowing water from the trough, will be computed as 2.5-feet. Trough walls should be low enough that livestock can drink when water is low in the tank (to avoid a lot of dead storage). Usually, wall heights are between 2 and 3 feet tall, especially if there are calves that will need to drink there. If sheep are grazed, about 1-ft. is proper height for walls.

Capacity of a circular trough 20-ft. in diameter, with 2.5-ft. tall walls is computed at Pi x R squared x depth x 7.5 = 5887.5 gallons, rounded to 6,000. Is this the right size for the need?

If so, compute the amount of steel needed, multiply Pi x diameter for a 20-ft. diameter trough, this would be 62.8-ft. in circumference. There will be about 2-inches lost to overlap where the sheets are bolted together, so six sheets will end up with about a 59-ft. circumference trough. Earlier it was decided how much water the trough must hold; go with that figure, even if one sheet must be cut to length.

Begin construction by clearing and leveling the site. Always cut to level, since any fill dirt will shrink and throw the completed trough out of level. Choose a level site; it requires less concrete than a sloping one. Once the site is leveled, reinforcing bar (called 'rebar') is laid in checkerboard pattern on about 8-inch centers and tied at most intersections with bailing wire or 14-gauge tie wire. The rebar extends into the apron. Use ½-inch diameter rebar, it is small enough to cut with bolt cutters, which method is much faster than a hacksaw and cheaper than using a cutting torch. An alternative is to use net wire, doubled, in place of rebar. Lay the first layer in one direction and the second layer at right angles to the first layer then tie the two layers together with tie wire. Assemble the metal sheets into a trough with gaskets and bolts and set it on the rebar. The trough walls should set about 3-inchs into the concrete and a goal is to pour no more than 6-inches of concrete, so arrange to pave the trough area plus a 2-foot wide apron around the trough with small rock (under 3-inch size).

Next, level the trough Use a dumpy level or a water level. The latter is a piece of garden hose with a clear plastic tube on each end. Fill the hose with water until it is visible in the plastic tubes. Hold this machine to the tops of the steel across the tank site and move the steel until both ends of the water level are equal. Check in both north-south and east-west. Then recheck. Once the steel is leveled, block it securely.

Build a berm of dirt around the outside of the apron to hold the concrete when it is poured. The apron is essential to prevent trampling erosion and leaks in the water trough (Figure 15-1).

The inlet and outlet plumbing are placed and measured to assure proper freeboard. These pipes should be within arms' reach of the edge so a person can get a drink of clean water from the inlet or clear debris from the outlet riser. The overflow should be piped 30 to 50 feet away from the trough using buried plastic pipe. Use only steel pipe inside the trough.

Finally, drive 5-ft. long, 3-inch steel pipe (posts) firmly into the ground every 8 to 10 ft. around the rim of the trough, either inside or outside. After concrete is poured and cured, place boards, poles, or steel cable on the posts to exclude cattle from the trough. Wooden posts will soon rot unless creosoted and creosote is poisonous, so if wood posts are used, place them outside the rim. Don't use smooth or barbed wire for this barrier, nor steel posts since these items are too flimsy. Cattle wade into the pool, drink, and then relieve themselves, which quickly and thoroughly contaminates the water. The tank must have a threaded steel plug outlet so the tank can be drained and cleaned.

The concrete may be mixed on site, if labor is available. It is better to use ready-mix concrete, trucked to the site. Arrange for all the concrete to arrive on schedule, since cracking can occur if there is a long wait for the second load to arrive. Most trucks will carry 5-cu. yds. in the Wildlands, but some daring drivers will bring up to 7-cu. yds. Add local rock sufficient that one load of concrete will complete the floor of the tank, but don't use over 2-cu. yds. of rock.

Compute the amount of concrete needed by the formula Pi x radius squared (in feet) x depth in feet (usually 6-in. = .5-ft.) divided by 27 to find cubic yards. Concrete is bought by the cu. yd. For a 20-ft. diameter trough, about 5.8-cu. yds. is needed, so order six.

Level and screed the concrete as it is poured and slosh around the edges of the metal sides to insure a good bond. Keep fresh concrete covered with wet gunnysacks for 2 to 3 days after pouring. Don't pour in freezing weather unless using a special mix of concrete.

To control mosses and algae in troughs, place a few copper sulfate crystals in a 35mm film can, punch a hole in the lid, and fill the can with water, replace the lid and drop the can into the trough. Copper sulfate in quantity is poison, but the hole in the can will release the few parts per million needed to control algae. Renew crystals annually.

Wildlife Considerations

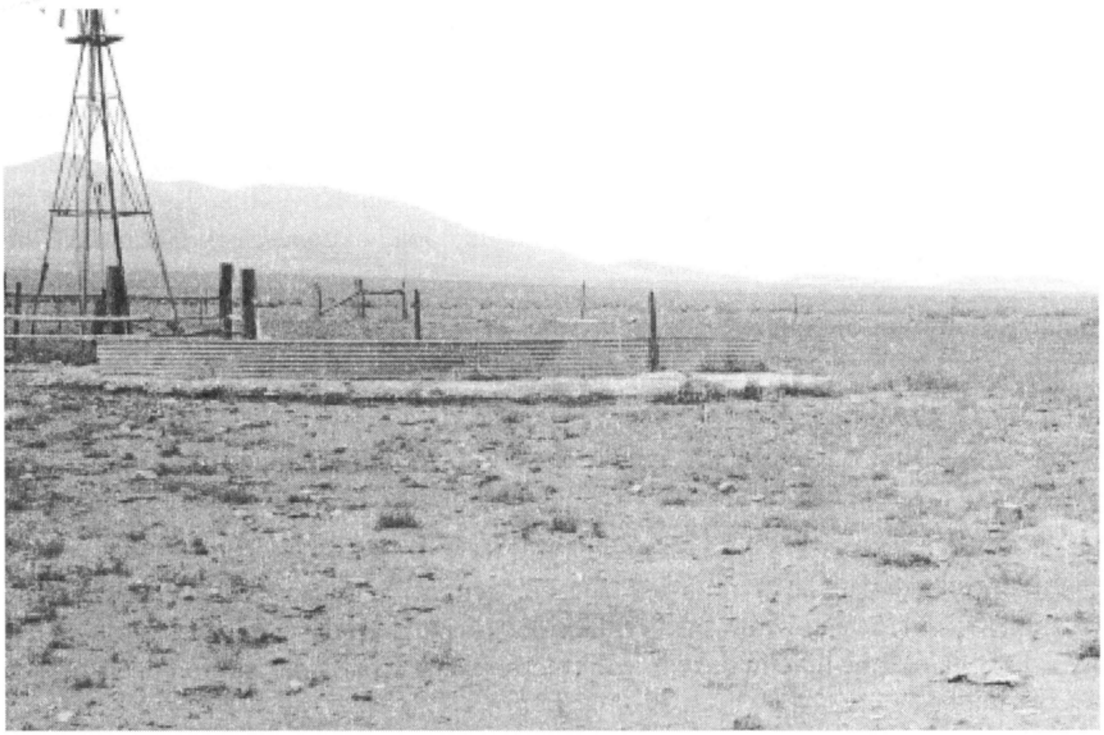
The dirt overflow pool near the trough will serve small wildlife, if the trough overflows daily. Always place a floating board or boards in a trough for a bird perch, unless a bird-ramp is installed. A bird-ramp is made by welding heavy steel mesh (like airplane landing field steel sheets) above the water level at one end of the trough and sloping to the bottom of the trough at an angle of about 45 degrees. The ramps obviously reduce the drinking area of the trough. The livestock will soon tear out wood ramps. For tub-type troughs, use a 1 x 12-inch board of the right length with cross-cleats of 1"x 2"x 4', the latter to prevent the larger board from drifting to one side of the trough. Paint 'Bird Lifesaver' on the board so tourists will not destroy it.

When trough overflow is not dependable, lay a short pipeline from the trough or from the supply line to a place near cover for wildlife. See Chapter 12, Springs Development, for details.

If the wildlife water is intended solely for big game animals, install a suitable trough, fenced to exclude livestock. Deer and elk will jump a pole fence that is 40 to 42 inches high; the enclosure should be about 20-feet on a side so there is room to jump out. Bighorn sheep will not jump a fence, so build rock pyramids at the corners which the sheep will walk up. Antelope will pass under a pole 16-inches off the ground. The larger animals will drink as much as 10-gal. per head per day, so trough capacity should be ample.

Storage Tanks

Storage tanks are used to even out the flow to a trough or pipeline. A storage tank always has a top, bottom, and sides; in most areas of the West, about ten vertical feet of water is lost annually to evaporation. Check the records at the nearest Federal Dam to you; they will have a record of open-pan evaporation losses to guide you. You may collect water from several small springs and pipe them to a storage tank, then run one pipeline from the storage tank. If pumping water at a high rate from a well, pipe it to a storage tank so



A circular windmill trough. Note erosion around the concrete lip that would have washed out the tank had the lip not been there.

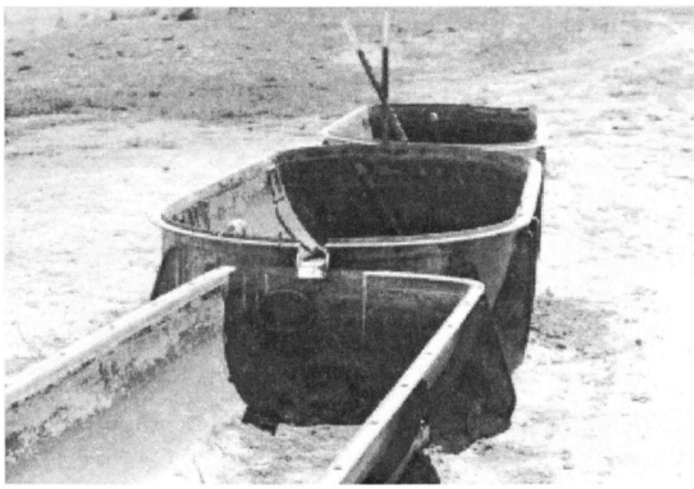
Figure 15 - 1

normal sized pipelines can be used to distribute the water. Or pump water uphill to a storage tank on a hill from where water can run thorough gravity in pipelines.

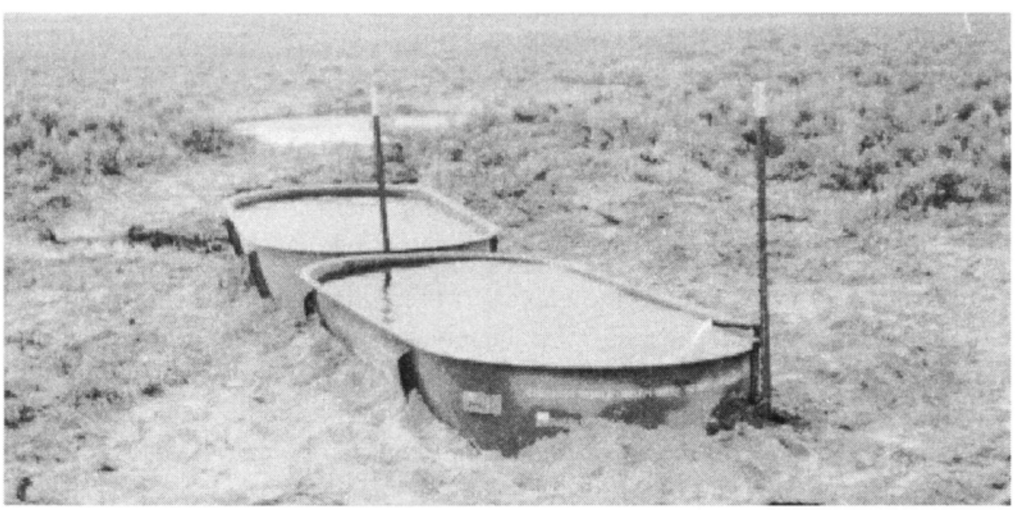
Storage tanks are normally placed on a hill or ridge and may cause 'visual pollution'. A tank may be buried or painted to lessen the impact. Consider this in planning stages.

Float Valves

Where there is a limited supply of water and none to waste through overflow of a trough put a float valve in the trough. See Chapter 16, Catchments.



Tub-type troughs. The pipeline enters the center trough and is conventionally piped to the far trough. The near trough is filled by an overflow lip from the center trough.



Water Troughs in tandem, with guarded inlet and underground overflow to a pool for wildlife and calves.

Figure 15 - 2

Chapter 16

Catchments

Catchments are precipitation collectors, consisting of an impervious apron onto which precipitation falls. The water flows off the apron into a storage tank and from there into a drinking trough.

Catchments are expensive to construct and annual maintenance is required. They are used only where:

(a) There is no more economical way to get livestock or wildlife water in that area and provision of water is necessary.

(b) The land slopes are gentle, under 5%. Since precipitation falls vertically, the effective apron area is measured on horizontal distance, not slope distance.

(c) The site is free of trees, large boulders, and gullies.

(d) There is an environmentally acceptable access route for tractors and trucks.

Designing the Apron

The first step is to design apron size. Look up National Oceanographic and Atmospheric Agency (NOAA) records for the state. Will the site receive mostly rain or mostly snow? During which months? What is the average annual precipitation at the site? What is the probability of 'average precipitation'?

If the site is in northern Nevada, about 80% of the annual precipitation falls as snow in late December, January, and February. Precipitation records show an annual average of 5½-inches on the valley floor (5,000 to 6,000 ft.), whereas the catchment is at an elevation of 7,500 feet.

Make a graph, plotting average annual precipitation against elevation, using all available local weather data. Some stations will be USGS stations in remote areas. This information is available from NOAA and from the Agricultural College in each state. Once the points are plotted, mark the long-term stations (30 years or longer) in a contrasting color. Draw a smooth curve through or near the long-term points. An S-curve should develop fairly flat at lower elevations, increasing sharply between 4,000 and 6,000 ft. elevation, then decreasing in slope at the highest elevation. From this graph you can make a reasonable estimate of the annual precipitation to be expected at the catchment site.

Make another graph plotting annual precipitation against years. Use a station near the catchment site with at least a 30-year record and plot the most recent 30-years. The low year may be about 2-inches and the high year about 12-inches. It is not economical to design the catchment for the lowest precipitation year, so count the years below and above average and find the percent of years for each.

For example, at 7,500 ft. elevation, the elevation precipitation graph shows about 8-inches for an annual average. The 30-year graph shows a 75% chance of getting at least 6-inches of precipitation at the catchment site for any year. Then examine the daily records for the three wettest months of the year and discover that about 85% of the precipitation comes in heavy storms and the rest comes in .01-in. to .10-inch amounts, which would just blow off the apron and be ineffective for water yield. The Weather Bureau once made probability charts for each state; try to find these.

Don't use the 8-in. average figure for the site for design, use the 6-in. (75% probability) figure times 85% effective moisture (heavy storms) which equals 5.1-inches, rounded to 5-inches. This is the design figure for expected precipitation.

How much water will need to be harvested? Estimate the numbers of animals that will use the water for what time periods and then derive a total demand figure. An open drinking trough will lose water to evaporation so compute the surface area of the trough times the number of feet of evaporation expected for the months the trough will be in use. Evaporation data can be extrapolated from NOAA data.

Examples:

100 cow/calf units for 90 days (15 gal./day)...................... = 135,000 gallons

20 elk for 120 days (5 gal./day) .... = 12,000 gallons

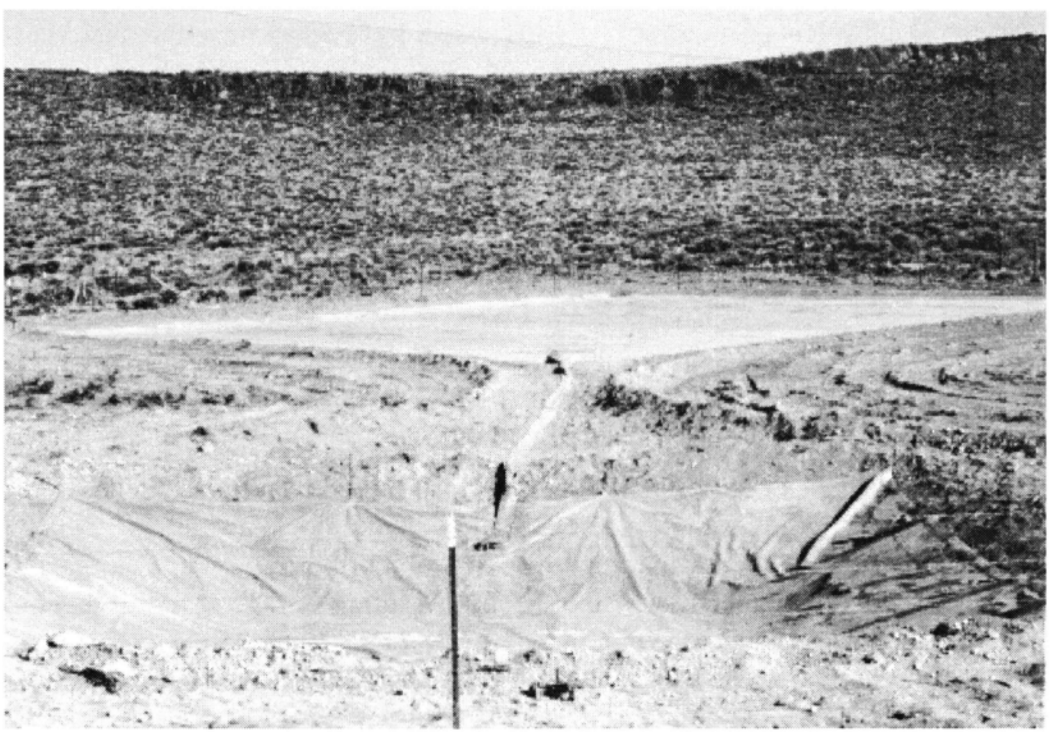
10 deer, 120 days (1 gal./day .... = 1,200 gallons

80 sage-grouse, yearlong. (1 tbsp./day) .... ignore

Evaporation, for 40 sq.ft. trough, 120 days, in summer .... = 1,800 gallons

Need a total of about 150,000 gallons

Divide gallons needed by 7.48 gallons per cubic foot to get 20,053-cu. ft.. Round to 20,000. Now compute the size of the apron needed. 5-inches of precipitation equals about .42-feet. 20,000-cu. ft. of water needed divided by .42 of water expected per square foot of apron equals about 47,600-square ft. of apron needed to collect this much water. The square root of 47,600 is about 218. The apron should be about 218-feet. on a side, if square.



Catchment, newly constructed. View of apron and the tube leading to storage bag. Note berm along lower edges of apron.

Figure 16 - 1

Go to the area and seek a place to build this sized apron with a storage tank just below and a drinking trough site below the storage. At this Nevada site, almost all of the precipitation will fall during the winter when the cattle will be on the ranch feedlot. If the site was near Tucson, Arizona where 50% of the annual precipitation falls during the winter and the other half during the summer, a very different design and much less storage would be needed.

Inspect the area, preferably while some snow is still on the ground. Choose a site on a south-facing slope where the snow will melt rapidly and run into storage. On a north-facing slope, the snow may evaporate in the spring with little or no runoff.

Do not consider the infrequent summer showers as a water source in northern Nevada; monthly averages are under one inch. Carefully determine which are the heaviest precipitation months and use only this in design.

Construction

Clear the sites for the apron, storage tank, and water trough down to mineral soil. Smooth the apron site carefully. Normally a bulldozer will be used. Vegetation sprouting under the apron will disrupt it; so use a soil sterilent such as borate on the apron site. It comes in powder form and can be spread by hand or with a lawn fertilizer spreader.

Aprons can be made of a variety of materials. Black plastic sheets (4 to 8-mils thick) are a favorite as it is cheap and easy to handle. Snow melts quickly on it and it can be repaired or replaced by one or two persons. But plastic is short-lived under a hot sun, and deer hooves puncture it. The high winds that occur annually create a venturi effect on a flat surface and can tear loose an apron. Other materials that have been used are wood, sheet steel, and sheet aluminum and all are subject to high wind damage. Consider 2-in. of concrete or asphalt for an apron. This type of construction must be fenced only against livestock, not wildlife. Livestock tend to loaf on an apron if it is open to them, so aprons are fenced to avoid contamination of the water.

Several different types of apron construction have been used. On heavy clay soil, salt worked into the topsoil can seal the surface. Or cement can be raked into the soil to mix it with the dirt and then wetted and smoothed to form a seal. Some soils can be oiled to waterproof them. In a 1980 report, a silicone seal worked well. There may be rock outcrops that will serve as an apron. A hundred yards of paved abandoned highway may serve as an apron. Any type of apron will produce litter, soil and sand along with the water, so design of the storage tank must allow debris to be safely cleaned from it with a minimum of effort.

After the apron is laid, place berms of dirt on all sides to exclude run-on water that would carry dirt and debris to the storage. The berm also holds the edges of the apron down against the wind. Normally, use a diamond-shaped configuration, with water running off a corner of the apron into storage. Use a large pipe or conduit 8 to 12-inches in diameter between the apron and the storage tank to accept high flows. The conduit should be coarse-screened at the mouth to prevent rodents from drowning in the storage tank.

A peak flow from the apron may exceed of the conduit's carrying capacity, or it may rain after the storage is filled. Spill any excess water over a spillway in the berm (where it has been reinforced with concrete) near the conduit and ditch the excess water around the storage tank to a safe release place.

There are several types of storage tanks. Huge rubber bags are used, but they weigh over a ton and are difficult to clean .A steel storage tank, whether steel-floored or concrete-floored, must have a top to avoid losing 5 to 13 vertical feet of water each year to evaporation. Arrange a drain, locked to prevent vandalism, and provide manholes at top and the side for cleaning access.

From the storage tank, lay a pipeline to the water trough that is equipped with a float valve. See Chapter 14, Pipelines and Chapter 15, Troughs, for details on these items.

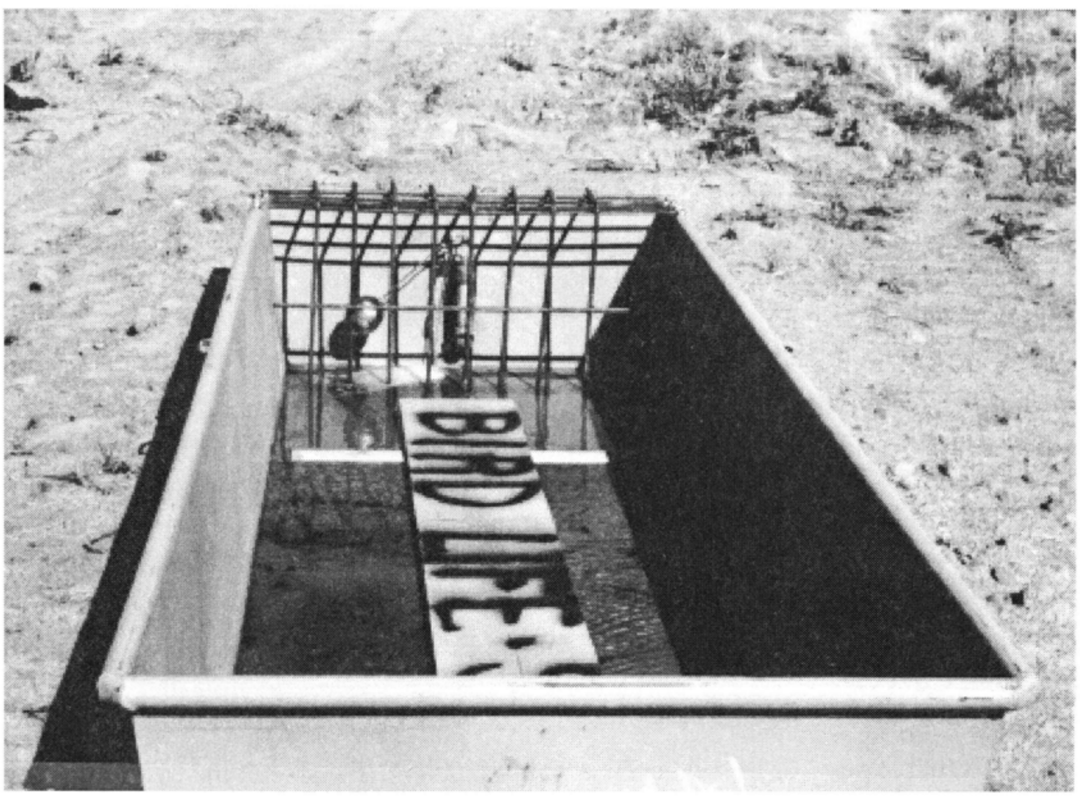
The apron should be fenced. See Chapter 9, Fences.

Schedule at least annual maintenance of the apron, clean the storage tank as needed, and monitor the float valve several times a week while livestock are using the water.

Float Valves

These valves operate like the one used in a toilet to let water flow in until the trough is full, then close. The plumbing is simple, just an inlet pipe to the valve and a float on an arm. These valves are fragile and must be protected with a steel cage, perhaps made of rebar and welded in place. It must be hinged to be accessible for adjustment and repair and the lid must be locked.

Use a cowbell shaped sheet metal guard around the lock so it cannot be shot off. (Fig.15-2, Chapter 15, Water Troughs).



Water trough with float valve. Note welded guard around float mechanism. Also note "Bird Lifesaver" board float in trough to permit birds to safely drink.

Figure 16 - 2

Chapter 17

Hydraulic Rams

A hydraulic ram is a small gadget that uses the power of falling water (such as in a flowing stream or a pipeline) to pump water uphill.

The water is led into the hydraulic ram by a pipe laid in the stream, parallel to the flow of the stream. The water must have a downhill fall within certain limits, with a minimum of two feet of fall per hundred feet of steam. The force of the water flowing down the pipe to the hydraulic ram is used to pump a fraction of the water passing through the ram. A hydraulic ram cannot be used except where there is sufficient water for a full intake pipe and there is some way to let the excess water from the ram pass safely back into the stream.

Table 17-1 includes design data. Begin by figuring how high the water must be lifted. Choose a point above the stream for a water trough or storage tank and then measure the vertical distance from the stream to the top of the trough. See Chapter 14, Pipelines, for ways to determine this distance. The vertical distance is called Elevation (E). Divide E by 6, then divide E by 12. These two figures give a range for the proper stream fall for the hydraulic ram to operate properly.

If the water is to be lifted 20-feet, then E=20. 20 divided by 6 = 3.33 (round to 3), and 20 divided by 12 =1.66 (round to 2). Choose a place where the Fall (F) is at least 2-feet and not more than 3 -feet per hundred feet of stream.

Another constraint is that the length of the drive pipe must be not less than the fall of the stream times five. Here are two examples: First, a stream of a fall of about 2-ft. per100-ft. of stream (the minimum allowable fall). The formula for the length of drive pipe is (E+2) x (E-F) over F. When numbers are plugged in, it becomes (20+2) (20-2) divided by 2 = 198 feet. The proposed project falls within the 2 to 3 fall ratio and is larger than the FX5 constraints of the length of drive pipe.

The second, will deal with a fast flowing stream. Lift is 100-ft, and the fall is 17-feet. This computes to 498-ft. of drive pipe. This stream is on the verge of too much fall (E divided by 6 = 16.6) and if the fall was 20-ft. we could not use this segment of stream to lift the water 100-feet. Choose a site that is more amenable to using the hydraulic ram, or place it on the bank of the stream or find a different spot for the trough.

Using the numbers from the second example continue the design computations. Calculate how much water can be pumped to the trough. The E to F ratio: 100 divided by 17 = 5.88. With interpolation of Table 17-2 on page 105 (rounded to 6), we find the efficiency is a healthy 61-percent. The right hand column of Table 17-1 gives maximum discharge in gallons per minute. For a 2-inch drive pipe and ram, the range is from ¼ to 5½-gpm or a 5¼ difference. We should get 61% of 5¼ or 3.2-gpm plus the ¼ from the lower end of the range for a total of nearly 3½ gpm.

Going back to our first example, we would expect an E/F ratio of 20 divided by 2 = 10, which would yield an efficiency of somewhere around 45%. With a 1½-inch drive pipe and ram, the yield would be about 1-gpm.

In either case, if that is more or less water than needed, change the size of the hydraulic ram to suit the need, or seek a more favorable E/F ratio.

The intake pipe is usually laid in the stream for its entire length and firmly blocked and staked so it will not wash away during the spring flood. Should the stream be a small crooked one or has too much fall, place the inlet under water and the hydraulic ram on shore at a point where the fall is proper. Ditch the overflow from the ram safely back to the stream.

Where the fall of the stream is not sufficient to operate a hydraulic ram, sink a caisson in the stream to get the proper amount of fall. If the caisson is dug on the bank, the excess water from the ram can be siphoned or pumped with a venturi pump back into the stream. The ram will work perfectly well under 5 or 10 feet of water.

The intake end of the drive pipe is screened with a coarse screen to keep fish and trash out of the hydraulic ram. The ram is installed with a proper sized outlet pipe. If the hydraulic ram is in the stream, usually the outlet pipe is buried in the streambed to prevent damage since it is normally at about right angles to the stream flow and is thus more subject to damage than the inlet pipe.

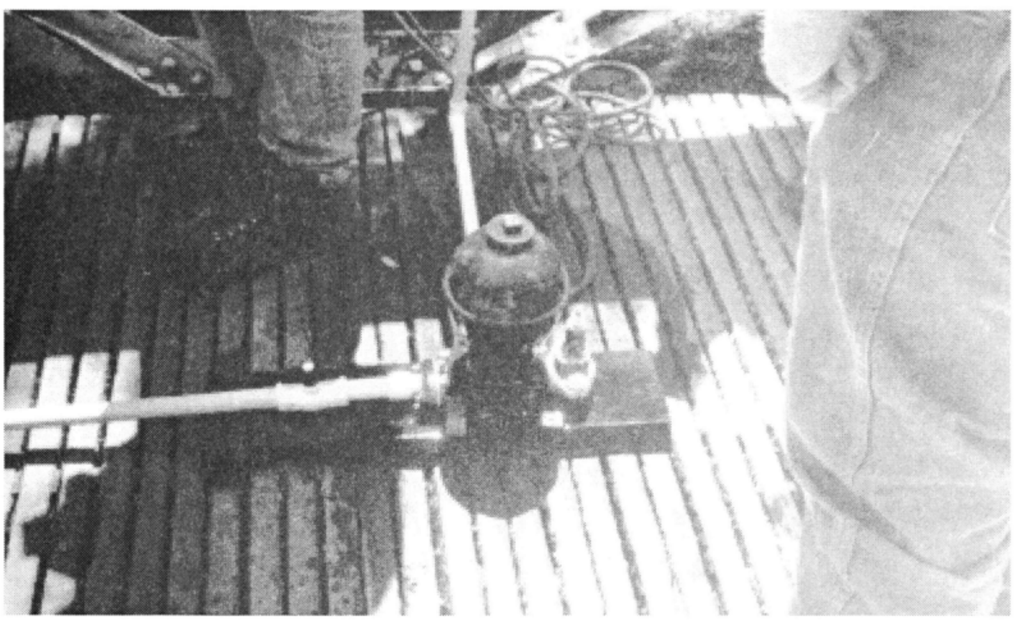
Steel pipe is used for the inlet or drive pipe and for the portion of the outlet pipe that is in the stream. Flexible plastic pipe may be used to continue the outlet line up the bank to the trough, if pressures permit. See Chapter 16, Table 16-4 to find pressures for the size of pipe and head. For 100-ft. of head, the pressure is 43.3 lbs./sq. in.; since standard plastic pipe is rated at 80 lbs./sq., special heavy-duty pipe is not needed.

A hydraulic ram may be placed into a pipeline. Usually the ram is placed in the inlet to a trough so the overflow is spilled in the trough, while additional pipe is run to a higher spot to which water is pumped by the ram.

There are many ways to adapt stream or pipeline flow to the use of a hydraulic ram. Consider this method whenever is its necessary to raise water.

A hydraulic ram should be kept clean of silt, trash, and leaves. There are instances of a hydraulic ram working for 20 years without maintenance, leading to the belief that constant maintenance is not required.

Now, let's get practical about using a hydraulic ram. The fall of the stream is not important, it is the fall from the inlet to the ram. This is infinitely variable since the ram needn't be under water, it can be on dry land.



A Hydraulic Ram. It will work equally as well below 10 ft. of water.

Figure 17 - 1

Or it can be in a caisson sunk into the ground beside the stream or even in the stream. Develop the proper fall and don't worry about turns and angles of the inlet pipe. You can use flexible plastic pipe to go into the caisson wherein resides the hydraulic ram.

I once saw a demonstration where a pump (looks like a torpedo with a propeller on the rear) was tethered in a flowing stream, the water of which turned the propeller and pumped water up to the floor of a bridge, into a 55-gallon drum on a holder of angle iron, laying flat wise. One end of the drum was cut out so it overflows if more than half full. A flexible plastic pipe siphon goes from the water in the barrel about 4 feet over and down two feet to the hydraulic ram. The outlet of the ram is a plastic clear pipe flung up into a tree and from the end of the pipe flowed a constant stream of water from the ram. Here, E was about 8 feet. Length of drive pipe was 4 feet, Fall was about 2 feet. Go figure.

Table 17-1

Hydraulic Rams

Sizes and Capacities of Hydraulic Rams

Drive pipe diam, inches	Delivery pipe diam. inches	Minimum gpm to operate	Maximum discharge, gpm
1	½	4	1/16 to ¾
1½	¾	8	1/3 to 2¾
2	1	15	¼ to 5½
3	1½	25	5/8 to 16
4	2	45	1 to 35
6	3	90	3 to 65
9	4	200	7 to 140

Drive pipe should be nearly straight. Length of drive pipe in feet should equal at least $\frac{(E+F)(E-F)}{F}$

And should not be less than F x 5.F

E = elevation in feet water is to be lifted.

F = fall of stream in feet/100-ft. of stream.

Table 17-2

The Efficiency of Hydraulic Ram

As a pump depends upon the ratio of elevation to fall, generally:

Ratio (E to F):	4	6	8	12	16	20	24
Efficiency:	.71	.61	.53	.37	.25	.15	.04

The hydraulic ram is a true impulse pump. Certain limitations must be known if it is to operate properly.

The fall from the source of supply must be 2-ft. or more.

The elevation to which water is to be raised should be at least six times greater than the fall, but not more than 12 times greater than the fall.

With the great versatility of placement of the ram, it is difficult to imagine conditions under which it would not work.

Chapter 18

Reservoirs

Reservoirs are large holes dug into the ground in which to store drinking water for livestock or wildlife. A dam built across a waterway to impound water always washes out unless built to strict and expensive engineering standards. The water for a reservoir is usually derived from precipitation, but may be from a spring or a well. If a small hole used to serve as a wildlife-watering trough, call it a dirt trough.

Reservoirs are generally dependent upon an unpredictable supply of precipitation and lose water from both evaporation and seepage; they are the least reliable of watering places.

The ideal reservoir has a clay bottom (or a bottom sealed with clay or plastic), is 12 to 14 feet deep below ground level, is fenced and water is piped from the reservoir to a water trough. Dimensions of the hole, at ground level, are traditionally 200-ft. on a side and capacity is about two million gallons or 10,000 cubic yards. The sides and front slopes are about 2:1 and the rear slope (whence comes the water) is 4:1. Plan to lose the top six feet of water to evaporation and the bottom 4-ft. to seepage, leaving a couple of feet in the middle for livestock and wildlife.

Designing the Reservoir

Begin designing with a U.S. Geological Survey map of the area. Locate the pasture on the map where the reservoir would be placed and pencil in an approximate site. Then pencil in on the map the watershed boundaries. Count the acres in the watershed above the proposed site.

Runoff figures or yield of precipitation per acre will be needed. If there is a State Water Engineer-U.S. Geological Survey water report for the water basin, find the yield figures there. These will give a yield per acre from certain elevation spans; e.g.: 2,000 to 4,000-ft. elevation is a deficit zone. 4,000 to 5,000-ft =.02-inch, and the like. By estimating the acres in each elevation zone within the watershed, compute a reasonably accurate figure in acre-feet of water of total runoff, which is called 'Q'.

If there is no other way to get a number, derive one. Follow the procedures in Chapter 16, Catchments, for average and effective precipitation determinations. If most of the precipitation is from snow, consult the state Natural Resources Conservation Service Snow Survey team for yield figures. If most of the precipitation is from rain, check the heavy precipitation months only. Any showers of less than about .25-inch will be ineffective in producing overland flows. Very sandy soils will further inhibit flows, so if the watershed is mostly deep sands, forget the reservoir and drill a well.

When considering soils, be aware of a condition called a 'vesicular layer' in the surface of a silt or clay soil. It occurs on Lake Lahontan silts and probably on Lake Bonneville silts. Where there are erosion pavements it is almost always found. It has an infiltration rate of .00012-inch per hour. Thus, in this 'tin roof' country, much more water than expected will come off the bajadas. Look for a vesicular layer in the surface of the soil. Flip up a crust with shovel or pocketknife. If it is plated and shows air bubbles under a 10x magnifying glass, it is a vesicular layer.

In addition to average precipitation and percent effective rainfall figures, derive an average infiltration rate for the watershed above the reservoir site. The infiltration rate is determined during a soil survey. This cannot be an exact figure since it will vary with amount of moisture present when a precipitation event begins and whether the soil is frozen and other variables. Use a number from an adjacent soil survey or from a NRCS soil scientist.

Also needed is a figure called 'Manning's (n)'. It is the coefficient of roughness of land surface, or the friction to running water. The number explores the theory that water running across a smooth surface, like slick rock or concrete, has less friction to overcome than water running across a rough surface, such as a boulder pile.

The NRCS has books of pictures with a measured 'n' for each cover type such as short grass, tall grass, rough rocky places, and so forth. Since the longer the water stays on the land, the more sinks into the soil, an increase in 'n' is wholly beneficial to the vegetation, but detrimental to water runoff into the reservoir. Consult the nomograph, Figure 18-1 (page 109) to aid in determining this number.

Once this information is amassed, seek out a local engineer who can compute yields using his handbooks.

The engineer can also compute Time of Concentration (Tc) of the peak flow. This is an estimate of how long it takes, after rain starts, for the peak flow to reach the reservoir site. Involved in the calculation is average slope of the watershed, distance from the site to the top of the watershed, and the average Manning's (n) for the main watercourse. This computation is used to determine the force with which the water will strike the diversion dam or reservoir.

If the total 'Q' figure indicates the reservoir will barely fill on an average flow, move the site downstream to increase watershed size. Should the yield estimates indicate that the average flow is more than five times the capacity of the reservoir, move upstream to decreases the problem of excessive flows. Or plan to use an off-channel reservoir.

Water Flows at the Site

Another method of determining how much water arrives at the site is to look for high points of trash deposition. The very highest points are generally considered to be either 50-year storm or a 100-year storm, depending on which school was attended. Other trash points will be found below the high points. Stake the high points. They should be nearly the same elevation, but because of the way floodwater flows, the two points are not exactly the same in elevation on both sides of a stream.

Trash is deposited just after the peak flow is reached and velocities are usually slower on one side of the flow than the other. Figure the square-feet of the cross-section of the channel by measuring with a tape and some string. From the stakes at high water marks, stretch a taut string across the watercourse. Using a level-rod, measure depth from the ground to the string at intervals where the ground changes elevation.

Plot the figures on cross-section paper and count the square feet. Engineers use a level and rod to do this. Multiply the square feet of cross section by 6 (the velocity of storm water in an arroyo is usually 6-ft. per sec.) to find cubic feet/second yield. There are about 450-gallons of water per cubic foot, to convert to gallons. This will give a reasonable estimate of the amount of water passing this point on a real flood. This can help in determining where to dig the reservoir and whether a real dam is needed for the settling basin or merely a few boulders in the watercourse.

If things look OK so far, get a more accurate figure of the flow. First, measure the wetted perimeter, which is the distance from high flow stake to high flow stake along ground level, measured at right angles to the stream flow. Use a survey-rod and Abney-level or dumpy-level to get exact depths across the waterway. Plot this wetted area on cross-section paper and count the number of square feet that is wetted on the high flow (R).Next compute the velocity of the water using this formula: V= 1.485 x (R divided by WP2/3) x s1/2 all divided by n.

V, is velocity in feet per second.

n, is Manning's coefficient of friction of flowing water.

R, is the wetted area in square feet divided by wetter perimeter in feet to the 2/3rd power.

s, is the slope in feet per foot of fall (to the ½ power).

Find an engineer with logarithm books or use a nomograph (Fig.18-1) to estimate V. Once V is derived, it is multiplied by the cross-section area of the channel and one has a good figure for the flow at peak flood. Look for the lowest trash piles and use this cross-section to compute the amount of water for an average flow. This work determines if there is the proper amount of watershed for the planned reservoir.

Types of Reservoirs.

(1) The Cross-channel reservoir.

Using modern dirt construction methods, the site is first cleared, then core-drilled to rock, and if possible, the dirt is excavated down to bedrock. If not possible to excavate this deep, dig a core-trench in good solid soil and fill the trench with clay soil. This core is extended up into the dam fill as the fill is made. The fill is compacted and wetted, then compacted and wetted. An engineer trained in dirt construction is needed to supervise the work. He will have the tools necessary to determine the proper clay fraction of the fill dirt, when compaction is sufficient. A lot of heavy equipment and water trucks are used. The engineer will always core-drill to check compaction.

This type of construction is quite expensive and there must be an engineer on the ground supervising whenever the contractor's machines are working.

(2) Charco-type tanks.

In the Southwest, dig a damless tank in the channel. The soil is stacked along the sides of the hole. Then, if a very high flow occurs, it will go right across the hole and not drop too much silt and boulders in the charco. These are often used near the center of a dry lake and this it probably the best site for such a tank.

A charco can be built with a team of horses and a slip (Fresno) or with a bulldoze or some other type of machinery. The downstream slopes and side slopes are steep, while the upstream slope is about 4:1.

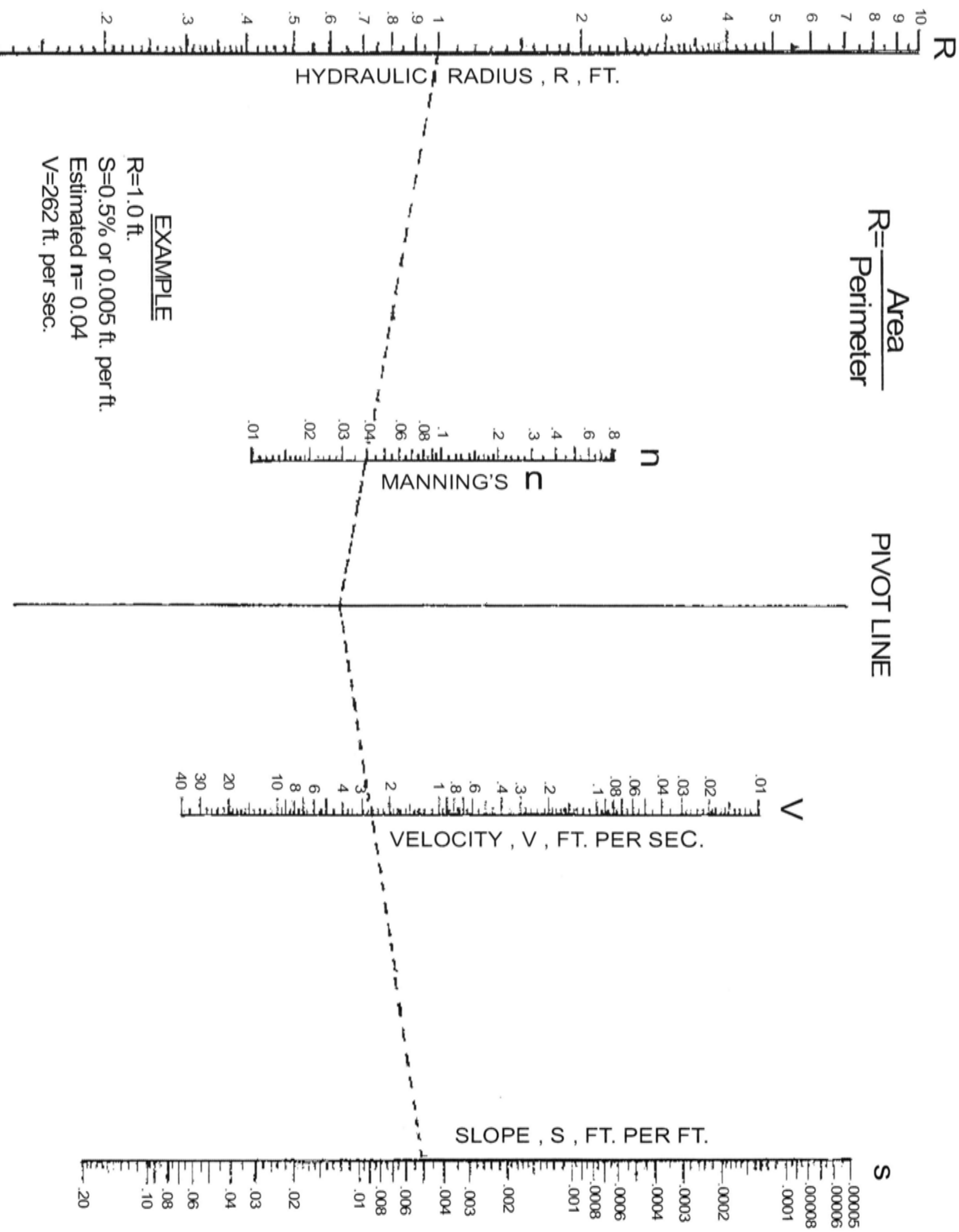
(3) Rock Tank.

An innovation in the Southwest where evaporation can suck the top twelve feet of water from a reservoir, is the Rock Tank. Construct a hole on channel, just as if building a reservoir. It is built like a charco, with dirt spilled to the sides of the tank. The depth is between four and five feet.

It is cheaper to dig only 5-ft. deep rather than 12-ft, although the hole will be wider and longer to make up for the shallower depth. Once completed, the tank is lined with plastic sheets or good clay is mixed into the top few inches of soil in the bottom of the tank. Then a 2 to 4-inch steel pipe siphon is installed from the lowest point inside the tank to a safe place of lower elevation, for a watering trough below the tank. The reservoir is then filled with rock.

When water enters the tank, it seeps down among the rocks and is not subject to loss by evaporation. It is siphoned or pumped from the hole.

Much of the capacity of the hole is lost to rock, but if 12-feet of capacity is lost to evaporation in an open tank, then about the same amount of water is harvested for use.



SOLUTION OF THE MANNING FORMULA: $V = \frac{1.486}{n} R^{2/3} S^{1/2}$

USDA Conservation Service
Research Project OK-R-3

Figure 18-1

A smaller scale version of a rock tank was used to water bighorn sheep in southern Nevada. A rock wall about 8-ft. high was built in a slick-rock area. Luckily, a pipe was placed through the bottom of the wall during construction, because the first rain filled the reservoir to the brim with loose rock. So the wildlife specialist piped the water from the (now) rock tank to a trough. He even claimed he did it on purpose.

(4) Rock Dam

In some mountains the terrain obliges with a narrow gorge where ranchers have built rock dams, using flat rock and concrete. The dam may not be higher than 10-ft., and is generally about 5-ft. tall. It must be nearly to the top of the mountain to reduce the size of the watershed. These reservoirs will fill with silt, therefore they will be cleaned out with persons and shovels periodically, and the 5-ft. dam makes this possible.

(5) Off-channel Reservoir.

This is the normal type of reservoir built to conserve water for livestock and wildlife.

Silting is a problem in reservoirs. Some reservoirs fill to the brim with silt on the first flow. Avoid this by having some kind of a settling basin to slow the water before it reaches storage. When the speed of the water is doubled, its silt carrying capacity is increased by 33 times. The silt forms a kind of slurry with a high specific gravity, so it will 'float' boulders nearly as large as the slurry is deep. Since the converse of 2 V = 33 is also true, if a site is chosen where the water naturally slows before coming to the reservoir, a lot of silt will be dropped before arriving at storage.

To slow the water above the reservoir, build a shallow reservoir just above the main reservoir and then ditch the water to the off-channel reservoir. The shallow reservoir is properly called a settling basin. It should be shallow, so the silts it traps will dry quickly to allow a bulldozer to clean it out before the next big flow. A dragline may be used to clean out a settling basin.

The ditch from the channel to the reservoir should leave the main channel on a straight stretch or the inside of a bend. Stream flow on the outside of a bend increases in velocity, and a ditch placed here may, once the settling basin is full, cause the stream to divert down the ditch and fill the new reservoir with silt. Place the dam of the settling basin well below the ditch to the reservoir. This 'dam' is made by rolling some big rocks into the channel to slow the water and raise its level so it can flow into the ditch to the reservoir. Don't try to put all the water in the channel into the reservoir. The ditch should be on a non-erosive grade, which means a fall of about 0.1-ft. of fall per 100-feet of ditch in most soils.

If the slope of the waterways leading to the reservoir is not excessive (under 5%), consider fencing an area above the settling basin and/or reservoir and let the vegetation grow. This will slow down the water and make it drop its silt load. This won't work where the water comes down the draw deep enough to overtop the brushy vegetation.

Evaporation

Reservoirs lose water to evaporation. There is no way to correct this in a large reservoir (10,000-cu.yd.). The one-molecule thick films are pushed by the wind to one side of the reservoir so evaporation is almost unchecked.

It is prohibitively expensive to try to roof over a 200-foot square reservoir with wood, metal, or plastic. Wind tends to wreck even small covers. The only options to fight evaporation are to dig a deeper tank, or use a rock tank.

Evaporation figures can be procured locally so expected losses can be computed. The NOAA people have evaporation pans, which are constantly monitored. These pans will lose more water than a reservoir because they are set above ground so the temperature of the water is the same as that of the air. Use lake evaporation figures as a guide, these figures are available for almost every big lake or reservoir in the West from the U.S. Bureau of Reclamation or the Corps of Army Engineers.

Seepage

Seepage is a problem that can be solved in part. Bentonite or a good local clay raked into the bed of a reservoir will help seal against seepage. Salt raked into the soil will help seal the bottom of certain clays. An older method was to put salt blocks in the bottom of the new dry reservoir and let livestock trample the bottom as they came to lick salt. Sheep can also be used to pulverize the soil in a new reservoir and let the fine particles separate and sink.

Spraying a slurry of bentonite on the surface of the water with a livestock sprayer sealed one small reservoir. The currents in the pond carried the slurry to the leaks and sealed them. When the reservoir goes dry, the clay liner tends to crack, and unless raked back into the dirt, this creates channels for the next run to water to leak out.

In places where the soil is basically unsuitable for reservoirs, such as gravels and decomposed granites, a plastic lining of the hole will slow the seepage. A foot or so of soil is backfilled onto the plastic to protect it from sun damage while the hole is dry (Sometimes a rancher waits for two or three years before the first rain comes to fill the reservoir). The reservoir must be fenced to protect the plastic from the hooves of livestock and wildlife. The water is piped or siphoned over the dam to a safe place below the reservoir to water troughs equipped with float valves. See Chapter 15 -Troughs, Chapter 14 - Pipelines, and Chapter 16 - Catchments.

Chapter 19

Revegetation

Pre-planning the Seeding

General Information

Seeding is the planting and establishment of (usually) a mixture of several species of grass seeds, at least one species of forb seeds, and one or more species of browse seeds on an area where protective nutritious perennial plants make up a minimal percentage of the vegetation complex. 'Establishment' is the key word in the definition. Pre-Planning determines certain criteria that must be met as a step preliminary to planting the seed.

(1) If there is really a need for such an expensive and time-consuming effort as seeding.

(2) If the site is capable of supporting the seeds planted.

(3) What method and the cost of the operation may be.

Pre-Planning is done in the field. Use all available maps, including range survey, range site, watershed data, and soils maps. Include a sharpshooter shovel and a pH test kit.

Step One

Walk over the land and list all the plants growing there. Look under half-shrubs and weeds. Are tiny native grass plants growing in the shelter of the plant? Sometimes the grasses have been heavily grazed for so long that only a few apparently dead clumps are left. Dig up a clump and check to see if all the roots are dry and dead or if some live roots remain. If there are live roots, the plant can recover if grazing pressure from livestock, wildlife and insects is reduced or eliminated. You are determining if there are enough good native plants that can recover to repopulate the site. If resting the land will recover it, you are trading time for dollars. Which is in surplus in your economy?

Add Step Two

Step 2 of Pre-planning is done concurrently with Step One. It determines if the soil and vegetation will permit the growth of soil-protective nutritious vegetation; and if competition control is needed.

Considerations

Another phenomenon is that growing plants try to eliminate competition. They may out-compete other plants for sunlight or water, but more frequently plants (especially aromatic brush plants and some grasses), use chemical warfare. Chemical inhibitors to competitive growth are broadly called allelopathic (al-LEE-lo-pathic) substances; those emitted by leaves are terpines and those from roots are saponins. This chemical may inhibit the radicle (root) growth of the competing sprouting seedling, so the new root is deformed and small. Other chemicals may operate within a species to prevent additional seeds from germinating; this has been shown in cheatgrass (Bromus tectorum) and tumble mustard. The first seeds to germinate emit these chemicals and prevent other seeds from germinating to prevent so heavy a stand where none of the plants could mature. The remaining seeds may germinate at a later date, should fire or drought kill the first sprouted plants. It is safe to guess that almost all plants can have this capability. Since these chemicals are water-soluble substances held by adhesion to soil particles, unusually heavy precipitation can wash them away, temporarily. They can be destroyed by fire or by tilling the soil. Tilling improves infiltration so the chemical is washed away or is buried. This is one reason why tillage is so important to seeding success.

Try to not trade bad for worse.

Nature is said to abhor a vacuum. Once competition of the overstory species is reduced, a subdominant plant may spread rapidly, for instance, the increase of low rabbitbrush when big sagebrush is burned. This is trading one problem for another with no benefit to the Wildlands. Or will the invader be cheatgrass? This possibility can be foreseen and may well dictate what kind of competition control is used. After competition is controlled, seed good plants as soon as possible but at an optimum time of year.

Seeding after a large wildfire may be difficult since prior plans have not been made for rehabilitation. Experience shows a certain acreage will burn each year in a given area and plans to rehab should be made well before fire season. Remember fire makes some soils hydrophobic so plan to drill the seed on these sites, not broadcast. When seeding into ash the seed is placed into an acid environment, so use seed that can tolerate those conditions.

Pre-Planning

An essential step is to sample the soil by digging holes 12 to 24-inch deep with a shovel. Check the various soil layers. Soil depth is critical; it must be at least 12-inches deep without inhibiting layers. If shadscale occurs on the site, don't dig, just walk on, shadscale indicates an effective soil depth of about 6-inches. Black sagebrush usually indicates a lime hardpan at 6 to 10-inches. Other plants are indicators, too, and learn these for your area. Hopsage or robust sagebrush indicate good deep soils. Bitterbrush loves decomposed granites or other well-drained soil. In some cases the parent rock from which the soil is derived may be too salty to grow grasses, or it may be an area covered with water during Lake Lahontan or Bonneville times and is yet too immature to grow grass.

Dig holes frequently and where elevations change. Look for a soil color change and a white layer or white particles in the profile. The white material is generally a calcium precipitate and indicates the average depth of moisture penetration in that soil from precipitation. Sometimes the white layer is a deposit of lava ash that is too acid for grasses. Take a slice of dirt with the shovel from a side of the hole and carefully extract said slice while still on the shovel. Lay the shovel down and gently tap the handle. The profile will break at each hardpan layer. Check the pH and soil texture at each level. Use an agency supplied meter or a pH kit from a supplier of school chemicals.

Checking for Alkali

To check pH, take a pinch of soil and put it on the spot plate and add a few drops of drinking water, then add a drop of reagent to the runoff. Consult the color chart to learn the pH. (If you are colorblind, use a meter.) The range of pH for good grass growth is 6.5 to 7.5. If readings are outside of this range, the site isn't suitable for grasses normally available. If revegetation is needed, consult your extension agent or state college for tips of how to plant what seeds.

Soil textures aren't as simple. Basically, there are clays, loams, silts, and sands. Frequently they are mixed. Ask a soil scientist how to determine which is which. Lacking another source of information, take a small handful of soil from a certain place in the profile; dampen it with water from a canteen. If it makes a ball when molded with the closed hand, it is sufficiently wet. If water drips, it is either too wet or the soil is coarse sand. Take a chewing gum sized wad of moist soil on a finger and wipe it across the palm of a hand. If the soil shows a slick shiny surface, call it clay. If it won't form a ball, it is sand. Very fine sands will ball, but will break if tossed a few inches into the air and caught gently. Loams and silts are medium textured soils and one way to distinguish between them is to wipe a wad of soil across the palm. When it dries partially, flick it off with a fingernail. If there is a black-brown residue, it is a loam (color due to organic matter). If no color is left or it is tan, it is silt. Check texture below each color change in the profile.

The above is a horrendous example of over simplification, but it will give an idea of soil texture. An ideal rangeland soil has a layer of sand on top, which aids infiltration and inhibits evaporation. This grades into moderate loamy clay and is underlain at 18 to 24-inches by tighter clay. Tight clays will hold about 3-inches of water per foot of depth; coarse sands will hold ½-inch .Fine sands, silts and loams will hold intermediate amounts of water. The amount of grass that can be grown is directly related to soil texture since it takes about 500-pounds of water to grow a pound of grass. Brushy plants require twice as much.

Some clays are not good sites for seeding. Bentonite or kaolin absorb precipitation so slowly that they become wet only on snow melt and hold the water so tightly that few plants can extract it. If the soil surface cracks into 5-sided slabs, beware, it is probably montmorillinite clay (alkali sagebrush grows here) and is not suitable for seeding. Record all information for future use. It will help those who will follow.

Vesicular Layers

Before covering the hole, check a slice of dirt from the top few inches for a vesicular layer. These are silty crusts of ½ to 6-inch thick that, probably due to soil chemistry, are shot full of tiny pore spaces and thus repel water because the surface tension of water is too high to enter such small places. The pores are visible under a 10X magnifying glass. Infiltration rates on these soils were measured at .00012-inch per hour. Not enough water can enter the soil, except on snowmelt, to support vegetation. Native vegetation will be plants that grow in early spring and then are dormant until the next spring.

Vesicular layers are found on silts located a few hundred feet (vertically) above Lake Lahontan or Lake Bonneville playas and on areas worldwide with erosion pavement. (These are desert areas where small rocks cover the ground in a near solid mat). Where the layer is only an inch or so thick, disking or plowing will disrupt the vesicular layer, which reforms naturally from wet-dry cycles. *IF* the area is seeded promptly and *IF* the seed germinates on the first moisture and becomes established, the organic matter and roots will eliminate the vesicular layer. This is a large gamble.

Other Considerations

Recognize that some areas cannot be successfully seeded and some will be marginal.

Consider the numbers of livestock and wildlife that make a living here, the benefit-cost ratio of the proposed work, and environmental considerations. The latter may include visual pollution or downstream water yields (a seeding will soak up most all the moisture that falls, so there will be little runoff to the village water supply tanks below the seeding).

In summary, answer these questions:

a) Are there enough native grasses to recover naturally in 2 to 3 years? What steps must be taken to permit this?

b) Is the soil of proper pH? (6.5 to 7.5)

c) Is the soil deep enough? (At least 12")

d) Is the soil texture proper for grass growth and establishment? (No coarse sands nor heavy clays.)

e) What seedbed preparation will be needed?

f) What species can be successfully planted here of the seeds available?

g) Can livestock be kept off the seeding for two growing seasons? Some grazing might be permitted during dormant seasons, but don't count on it. The grass may not be firmly rooted enough to withstand grazing by cattle.

h) What other herbivores are present, such as wildlife, grasshoppers, etc.? (Will control be needed? What kind of control?) If pests are at a peak of population cycle (infestation) delay seeding for a few years until the population crashes.

When to Seed

Mixtures of adapted seeds are planted. There are many guides on what species to plant in a given locality, so this Handbook will not attempt to define what species to plant, but how to plant.

Seasonal precipitation patterns determine when to seed. In the Intermountain Basin, for instance, there are usually enough summer showers to germinate the planted seed, which then die during the ensuing hot dry periods between showers. In the northern Intermountain Basin, it is best to seed in September-October, just before the snows. The seed will lie dormant under the snow until spring when temperatures and moisture conditions are excellent for seed germination and establishment of the seedling.

In west Texas and New Mexico (Chihuahuan Desert) the heavy rainfall period is July-September, so it is best to seed in May-June. The Sonoran Desert rainfall period is split with a late winter (February) monsoon period and another in July-September. In the Mojave Desert and the Pacific Northwest, precipitation occurs in winter. And yes, it can rain in other months, but probability is abysmally low.

Competition control is done during the annual dry season. Plant the seed just before the annual wet period.

Understanding Seed

Seed for large scale plantings are grown for seed harvest on farms. It is usually cleaned to a purity of 90-98% and 90% germination. Wildland-collected seed seldom runs over 50% purity and 50% germination. A seed-testing laboratory determines the purity and germination. Most government agencies buy seed on a "pure live seed" (PLS) basis. PLS is determined by multiplying purity times germination. 98% purity times 90% germination equals .882 pounds of pure live seed per pound of material. 50% purity times 50% germination equals .25 pounds of PLS per pound of material. Seed is always tested before being offered for sale and all government agencies insist on retesting the seed after it is delivered. Payment is made on the basis of the retesting.

When taking seed samples from a burlap bag, use a seed probe for quick easy sampling. This pointed probe is pushed through the burlap near the tie at the neck of the sack and a small amount of seed is extracted. Ideally, a small sample should be taken from each sack in each lot of seed. If there are several hundred sacks, all stacked the warehouse, sample the sacks than can be reached without excessive moving of sacks. Take twice as much seed as needed for the test. Put it all in a bucket and mix it thoroughly. Then send half of the seed to be tested. If the seller contests the test, the buyer and seller agree on another test by a different seed-testing laboratory. It is embarrassing if the auditor asks for another sample and all the seed has already been planted. Retain one sample in a dry place against this eventuality.

Small slick seed, such as blue panic-grass, alfalfa, or Lehman's lovegrass come in canvas sacks and these must be unwired to take a sample.

A tag on the seed sack gives germination and purity and also the origin of the seed (where it was grown). Auditors know about dollars but they don't know about the ecospecific inheritance of seed unless someone tells them. Do homework with the auditor so the origin of the seed is not a surprise. The tag will also list whatever else is in the sack besides pure live seed. There may be seeds of other plant species, some defined as noxious weeds for the state where the testing was done. Each state has its own list of noxious weeds, which are prohibited for planting within the state. Check the state's list before ordering so the auditor can include this information in the request for bids.

If there is seed left over from a previous year, have it tested for germination before using it. Unfavorable storage conditions (moist heat) may have caused the seed to deteriorate.

Native Versus Exotic Seed

Native Species

A continuing discussion as to the merits of native species over exotic species still rages. Some preservationists always vote for the use of native species regardless of circumstances. The working field man who is responsible for planting and the establishment of a seeding is usually a bit more flexible. He recognizes that native plant seed may be well adapted to survive in the area but finding a supply of adapted native plant seed that has a high enough PLS to be worth running through a drill is seldom possible.

And what is an "adapted native plant seed"? There is an item called 'ecospecific inheritance' in seeds. This determines where the seed can grow and survive. For instance, if juniper seed is collected from a tree on the south face of a hill and taken to the north side of the hill and planted, the seed generally won't grow. It is programmed for higher temperatures, more sun, poorer soil, etc.

Sideoats grama (Bouteloua curtipendula), a good native grass in West Texas, was seeded near Marfa, TX. The seed was collected in South Dakota. The seed sprouted and made a beautiful stand the first year, grew fairly well the second year and vanished the third year. Why? Ecospecific inheritance of seed. How far can seed be moved and still have it adapted?

On a highway map, mark the location of the plot to be seeded. Then put a dot 50 miles north and another dot 50 miles south. Put dots 150 miles east and 150 miles west of the seeding location. Connect the dots with a smooth curved line. The oblong should be oriented to the flow of the jet winds in the U.S. In the West, the flow is northwest to southeast. The final lines should be properly oriented. In the mid-west it will be banana shaped, reflecting both the Western northwest to southeast flow and the Eastern flow which is southwest to northeast.

If planting native seed, it should come from this area to be truly adapted, particularly if it is collected from Wildlands. If there are elevation differences between the seeding site and the bulk of the surrounding area, scoot the oblong north or south to reflect this. For instance, if planting on a 4,000-ft. mesa and the surrounding country is about 2,000-ft elevation, move the oblong north to include an area where elevations are nearer 4,000 ft.

In the final analysis, no one can exactly prescribe other than 'near the seeding site'. On the Great Plains, blue grama seed moved 100 to 200 miles south show more vegetative growth than on the original site. When the seed was moved the same distance north, the plants formed seed earlier in the year, limiting plant growth. If possible, do a small trial seeding the year before the competition control, it may show how the particular seed source will respond locally. Network with other land managers to locate adapted seed.

Contact the seed company that furnished seed for a successful seeding and try to get that ecotype of seed for local use.

Exotic Plants

Exotic species are those which have been imported from another continent or area of the world. When seeds are moved this far, the ecospecific inheritance factor is rendered inoperative for several years. Examples of exotic species are crested wheatgrass (Agropyron cristatum) from Russia and Lehman's lovegrass (Eragrostis lehmanniana) from the Mediterranean. Both of these species perform admirably in the Western U.S. on proper sites.

However, both plants have been in the U.S. long enough that ecospecific inheritance is again becoming apparent. One seeding done in Nevada, using crested wheatgrass seed from North Dakota grew well, but plant height did not exceed 12-inches. The Nordan strain of crested wheatgrass, a selected strain developed at Mandan, North Dakota was also planted, but this seed came from an old stand in adjoining Utah. This latter seeding consistently produced plants over 24-inches tall. Better results are received if adapted seed is used, be it native or exotic.

Some government agencies have a policy prohibiting competition control until a pasture has been rested for one or two years, to see if mechanical methods are needed. Experience has shown that often grasses will recover with rest and a rotation system. Admittedly, though, it may be very difficult to sell to a rancher even if he is educated in ecology. He worries that there may not be enough grass to feed his herd if part of his land is off-limits. So maybe a fence can limit the area of rested land to a reasonable amount?

How to Plant the Seed

The goal is to have at least one established seedling per square foot of ground and to do this, plant about 20 PLS per square foot if broadcast or 10 to 12 seeds per foot of row if drilled. If the land has been plowed, there is an ideal seedbed for drilling the seed.

If chaining was used to eliminate some competitive plants, there is usually too much tree trash on the ground to permit the use of a seed drill. Drilling requires 1/10th as much seed, compared to broadcasting. There is also a much-enhanced probability of seedling establishment if the seed is drilled. The added cost of seed may be a factor in deciding whether to rake a chained area to permit drilling of seed. Visual pollution caused by the dead trees will almost always require piling and burning the uprooted trees.

Drilling the Seed

The drill should be set to plant one to four pounds of PLS. per acre depending upon seedbed conditions. If planting on a well-tilled, weed-free farmland, then one pound of PLS. per acre is sufficient. On Wildlands, plant from two to four pounds of PLS. per acre. This sounds like considerable overkill, but Wildland planting will be on a rough seedbed, with considerable trash on the ground that prevents some seeds from being properly planted. Some seeds will be planted too shallow, some too deep; some will germinate on the first shower and die due to an unexpected drought. Many vicissitudes face the seedling plant. It is best to apply a little more seed than needed to avoid the high cost of having to go back the next year and drill in more seed.

Grass Drills

When planting crested wheatgrass seed, smooth brome, and similar seeds, a standard grain drill is used. The drill seed box will contain agitators to keep the seed flowing but these need to be checked frequently to assure that the trashy grass seed is actually dropping to the ground and not bunching up in a drop tube or bridging in the seed box. Standard farm drills have disc openers, which make a furrow for the seed to fall into. A chain drag following will cover the seed.

Specially made grass drills have been developed to plant very trashy seed such as Rhodes grass or blue grama grass from the large box. Small slick seeds such a blue panicgrass are metered through small boxes, usually Planet Jr-type boxes, which are mounted on the rear of the large box. The large seed box has special agitators that force the seed from the box. These drills have depth-stops on the discs that prevent opening too deep a furrow. The Rangeland Drill, developed by the USFS, is a drill with oversized wheels that can be used to plant areas infested with tree stumps. A very accurate drill, it should be used if available.

The drills are always calibrated for a particular lot of seed. Set the drill openings for wheat seed using data on the chart inside the lid. Place a certain weight of seed into the seed box, generally one sack that has been weighed. It is best to ride the drill for a few hundred yards to be sure the seed is feeding through the tubes to the ground, the seed is falling into the furrow and being covered by the drag chains. All drills have an acreage meter. When the seed box is empty, read the acreage meter on the drill and divide it into the number of pounds of seed used. Then readjust the setting to a more exact planting rate.

If there is a small amount of expensive seed, set the drill openings correctly before planting. The standard calibration method is to park the drill on a piece of canvas, place a weighed amount of seed in the seed box and set the drill openings at a guess -estimated point. Measure the circumference of the wheel and the width of the drill. An area 8-ft. wide and one mile long equals about one acre. Jack-up the bull wheel (the one that drives the planting mechanism) and turn the wheel enough times to equal 1/10th of a mile. Then gather and weigh the seed the drill has disgorged onto the canvas. Calculate how much seed has been planted/per acre. Readjust the feed until the drill is planting the right amount. After actually drilling a sack, check the acreage meter to be sure the drill in motion is not planting more seed that had been calculated when it was sitting on the canvas. Record the setting for future reference. If the drill will not close down enough to reliably plant the proper amount of seed, mix the seed with oat-hulls or sawdust or some other inert material to increase the bulk. When planting very small seeds (over 1 million seed per lb.), add clean dust-free sand to make a one volume of seed per 9-volumes of sand. This dilution may be needed when using Planet, Jr-type boxes to plant Lehmann's lovegrass, or sand dropseed, for instance.

Drills tend to clog, so check each pass to be sure all the drops are feeding and all the drop tubes are in their brackets. If the tubes are out of their brackets the seed will broadcast outside of the furrows. A freshly planted row can be checked by gently uncovering the seed, if it is large seed. There should be 10 to 12 seeds per foot of row if using .8 PLS seed.

Drills are hooked in tandem so the widest possible swath is planted on each pass of the tractor. There are ways to hook drills together using tool-bars and dollies. The topography, tractor size, and turning room available will determine how many drills are used. Again, be sure welding equipment is available in the field to repair the hitches when they fail.

The seedbed is always rough and has litter on top. The tractor driver needs to be alert. If a drop tube clogs or jumps from its bracket, it should be promptly fixed. This means the driver must dismount from the tractor to go check the drills at least at the end of each run. He should clean the seed boxes at each filling to remove straw, dust, etc. Damp seed has a proclivity to jam in the drill or to bridge. A supervisor should check the drills to be sure the driver is drilling seed, not just driving up and down the field. When the seed supply is low in the drill's seedbox, driving on a side hill will bounce the seed to the downhill end of the box, so the uphill end is not planting. Tractor speed is important; it should be slow enough that it is possible to walk beside the drill as it operates. If tractor speed is too high, the dirt from the disc openers is thrown out of the furrow to fill adjacent furrows. If too slow, the dirt is not moved from the furrow.

Rarely will the drop tubes be removed from their holders to let them broadcast seed. Under certain seedbed conditions, where small areas of silt are powdered about an inch deep, this may be a proper way to plant these small areas. Silts flow like water so the disc openers cannot open a furrow. Since the seeds must be planted shallowly, broadcasting on top of the silt may work well as the seed will sink about ½-inch deep. Again, this is proper only on small areas of an acre or less.

Tests have shown that grass seeds and other small seeds germinate and establish best on a firm seedbed. If the seedbed is very loose (and with some silts the top 6" may be just a loose dust bed) wait for a shower to firm the seedbed before planting. The soil should be firm enough that a footprint shows clearly. If the footprint is over an inch deep, run a cultipacker ahead of the drill to firm the seedbed. A loose seedbed has too much air space so when wetted, the soil dries rapidly and the sprouted seeds die.

Ideally, a mixture of seeds is planted. Include from 1 to 3 species of adapted grasses plus at least one forb (legume) and perhaps a browse plant. The Range Extension Specialist or field agency (BLM, USFS) can provide a list of adapted species for the site. Finding a browse seed may be very difficult and/or too expensive. Most browse plants are very site specific, so be sure one has adapted seed; don't plant 4-wing saltbush on an acid soil, for instance, or bitterbrush except on decomposed granites or a similar well-drained soil.. Some subspecies of sagebrush are very palatable. If browse seed is not obtainable at planting time, plan to go back in a few years when it is available and plant it into the stand of grass. This is accomplished using a renovated cottonseed planter with two drop-tubes and two disc openers.

Broadcast Seeding

It may be necessary to broadcast seed on rough trashy seedbeds where a tractor and drill cannot be driven. Do not broadcast seed on an undisturbed soil. On farm land, one applies at least 40-lbs. PLS per acre. Small hand-held windmill seeders can be used for small area. A canvas sack or plastic box holds the seed and the seed gravity feeds through a variable slot to a set of horizontal vanes. Turning a crank spins the vanes that throw the seed ahead and to the left of the seeder. This machine is an improvement over hand sowing.

The helicopter may use a larger version of the windmill seeder suspended below the helicopter. Fixed wing planes have a seed box inside the fuselage with either a fan-driven or venturi-powered feed. The seed may be broadcast from a helicopter. With the newer computer controlled seeders, a much more accurate spread is possible.

Broadcast seeding requires calibration as an initial effort. This is very difficult since seeds falling on soft ground are hard to find and if falling on bare surface they tend to bounce around so there is no true idea of their original pattern. Ground speed of the plane will vary with wind speed and direction. The seed boxes are not large on a plane, so it is best to load a weighed amount of seed and fly a measured course (with flagpersons) and see how much seed was applied on the known area. Then adjust the seed flow to a more proper amount. There is no such thing as planting exact pounds per acre using broadcast methods. Touch up the ends where turns were made by flying seed in parallel to the edges of the seeding as a final act.

Apply from 10 to 20 (PLS) lbs. per acre, depending upon the species seeded. This is not enough seed to create a full stand, but it is sufficient to start a stand and is an affordable amount. When plants become established, their seed can fall to thicken the stand. Put livestock into the seeding for a few days at seed-ripe time to help knock the seeds from the plants and to press the seed into the ground, *PROVIDED* the plants are sufficiently rooted that they can withstand being gummed off by a cow. Pull some plants to check this before turning in the cattle.

There is no set formula for when the seeding is ready to graze, except that it will be after the plants have made seed one time. Most grasses use every bit of food in the plant to fill the seeds; only after seed-ripe is more food stored for next year's growth. Sometimes the plants are fully established in one season, other times it requires two growing seasons. The new seeding will require attention the first year or two. It may be necessary to control grasshoppers or rodents or weeds the first years until the stand established. Sometimes big game animals will camp out on the succulent new forage. If annual grasses invade, early spring grazing may be needed to control seed set of the annuals.

Do not give up on a seeding until three years have passed. Some years a cold dry spring will permit little germination. More seedlings will emerge the second year, with additions the third year. When the grasses start, they will extrude one tiny leaf about the diameter of a human hair; it is easier to see the shadow of the leaf than the leaf itself.

In summation, marshal all of the knowledge and intelligence, do a thorough job of planning, monitor the process of planting, and hope for proper moisture so the seedlings are established.

Using Livestock to Help a Seeding

When it became necessary to establish grass on old mine dumps, ingenuity came forward. It was found that if grass hay, with seed heads intact is scattered on the slope of the dump, cattle will go to the hay, and eat it. In the process the hoofs push the seeds into the ground and the area is also fertilized. In two years time, the bare slopes were covered with stabilizing grass.

It may be possible that some seeds will go through the animals' digestive system and emerge viable. Squirrel-tail is one that will do so. Sagebrush seeds apparently will not survive.

Where rough loose seedbeds are to be planted, a band of sheep can pack and firm the soil, leaving thousands of hoof-marks just right to receive and shelter a seed. However, a cultipacker is always available to use, whereas sheep may not be .

In summation, Pre-Planning consists of three steps. (1) It determines if there is really a need for such an expensive and time-consuming effort as seeding. (2) Determines if the site is capable of supporting the seeds planted. (3) Determines the method and cost of the operation.

Chapter 20

Revegetation

Competition Control

Competition control may be called "brush eradication"; this term is wishful thinking. It is almost impossible to eradicate a native plant from the Wildlands. Strive for a measure of about 80% control. If aggressive noxious weeds are the target plant, try for 95% control.

If the Planning data supports both the Need and Capability, proceed to determine the method to control competition to allow the seeded species to become established. You are recognizing that the present situation on the ground is a closed stand.

The three growth forms of plants are (a) annual plants such as cheatgrass, (b) half shrubs such as snakeweed, and (c) woody plants such as sagebrush, mesquite, and juniper.

Considerations

There is an ecological phenomena called a 'closed stand', where the existing vegetation is using all the (a) space, (b) sunlight, (c) nutrients, and/or (d) water available to the plants in that ecosystem. One item is usually limiting on a specific site. The addition of seeds to the area are futile since there will be none of whichever factor(s) are limiting, so the seeds will sprout and die.

To illustrate this, consider the Mojave Desert: an extreme example. Perennial plants occupy only about 4% of the ground surface. There appears to be ample room for more plants. And there was, in 1914, 1943, and 1972, when excessive moisture was received and annual plants filled the interspaces with a density as high as 60%, which is about the density of a Bermuda grass lawn. During normal dry years, only the perennials can be seen. Although there may appear to be ample space for additional plants in an undisturbed stand, this is seldom true. Competition control is almost always needed. Planting into a recent wildfire may be the exception.

Annual Plant Control

Annual plants generally emerge early in the growing season and make extremely rapid growth. Most go to head in 5 to 6 weeks from germination. The annual plant roots may emit allelopathic substances, which inhibit root radicle development of the seeded species. Annual plants produce enormous root systems that penetrate every square millimeter of the soil. By the time the annuals die, there is no soil moisture left for the seeded species. One annual barley plant will produce 90-miles of roots, rootlets and root hairs.

Check with the state Agricultural Research Unit at the University to learn if there is information on the particular species that must be controlled. Some weeds, such as tumble mustard and tumbleweed may have a beneficial effect of shading the grass seedlings. Young perennial grass plants will be killed by any chemical controls used on the annual plants.

Since annuals sprout from seed, heavy grazing of the green annual plants the year before seeding may help reduce seed set. Burning a stand of annuals in the fall before seeding may reduce the seed crop, but most dry annuals burn as if they were soaked in gasoline, so extreme caution is essential. There will be enough seeds left in the top inch of soil to produce a stand of annuals so one treatment of heavy grazing or burning may not be enough. Take a sample of soil from the top inch and germinate it to learn how much competition may be expected. Recognize that on some ranches, annual grass is a very important spring grazing plant, so don't try for large projects, leave some land for the cattle to graze.

Planting perennial grass seed in deep lister furrows will place the seed away from allelopathic substances and competing annual seeds, provides a safe, moist, low evaporation niche for the seed. Some chemicals, such Paraquat™, can reduce competition, but may not be legal in all states.

The chemical Oust™ is expensive, but a certain method of killing cheatgrass to permit seeding of a perennial grass. Other chemicals are coming along. A combination of chemical plus grazing plus fire may make seeding of perennial grasses a reasonable endeavor.

Biological control is also a very real possibility. Bugs have been imported that are specific on goathead, tumbleweed, St.John's wort, Klamath weed, and other spurges. Investigate the local research of these bugs.

You will not be able to eliminate noxious annual or perennial weeds completely, the best one can hope for is control. In most cases with cheatgrass, learn to graze the plant, if it is all you have and all you can reasonably expect to have.

Half-Shrub Control

Half-Shrubs should be controlled if they occupy the area in dense stands. While looking over the area while planning, look under the half-shrubs to see if grass seedlings are under the protection of half-shrub foliage. Are the half-shrubs helping or harming?

Recognize that humans want to do things in a hurry and with as much dust and noise is possible. The slower quieter process of resting the plants is hard to sell. Half-shrub populations are suited to the quieter process; every so often, a proper temperature/precipitation regime will occur and the bugs (a worm tunneling in the roots) will reduce the stand of half-shrubs. Then is the time to seed the area before the half-shrub can recover. It is also possible to reduce the population by using a spray such as 2, 4-D. Some half shrubs are poisonous to livestock, such as snakeweed, called 'slink'em weed' by ranchers because it causes abortion in sheep and cattle. Though, these shrubs are eaten in quantity only where other nutritious vegetation isn't available. No grazing animal is going to bed with an empty stomach; they will fill up with something in the way of vegetation, however unpalatable.

A wether band of sheep or goats can be used to graze down the snakeweed since they are not affected. It may be necessary to train them to eat this plant (See Chapter 5, Range Livestock).

A site not fully occupied by half-shrubs, such as small rabbitbrush, can be treated by excluding livestock during the growing season for a year or more to let grass recover and possibly set seed. Weak grass plants require one season to regain vigor and will set seed at the end of the second growing season. The pasture may be grazed during the winter. If the half-shrubs are sprayed and wiped out, the stand is open to invaders. Plan so the new plants are good ones, not a new crop of the half-shrub. This problem may occur where sagebrush was burned and the small rabbitbrush population exploded.

If, after suitable rest, there are not enough grass plants to seed the area naturally, it may be necessary to apply a mixture of grass, forb and browse seed. In the Southwest, on snakeweed areas, Lehman's lovegrass has been successfully established. This grass has several million seeds per pound and in growth form is much like black grama grass. A trip to the University to talk to the researchers will be worth every minute spent. Go look at their successes (and failures) and learn the method and species that may be successful on the site to be improved. This trip should be part of the pre-planning stages, as part of the 'determining methods' process.

Some half-shrubs can be controlled by burning. However, this can be destructive to the site. It is most instructive to be out in the Wildlands during a rainstorm. Watch the raindrops hit the bare ground and make craters, strike vegetation and become a spray. After the rain is over, dig a few holes. Under litter and trash check to see the water has penetrated several inches into the soil. Litter is old dead grasses and forbs, plus twigs from brush plants. These lie on the ground and protect the soil from erosion and excessive heat from the sun. Then check on bare ground, the water will have penetrated less than an inch. After watching this, the value of litter on the Wildlands becomes apparent.

In wetter climates, fire is a wonderful tool. In the semidesert where half-shrubs occur, there is little to carry fire from one bush to the next except red brome or cheatgrass which have successfully invaded the salt desert shrub.

Woody Vegetation Control

Chemical Control

Unwanted shrubs may be controlled using chemical means and this is a very convenient method. Lots of work, but for a short time. Some mixes of chemicals, such as 2, 4, 5-T (now proscribed) and picloram have shown good results on some plants. Check with the University to find which chemicals are legal for use in the area and which chemicals have proven worthwhile.

The old standby chemical for woody brush control is 2, 4-D. It comes in two forms, acid and amine. The acid form is absorbed by the plant and is translocated to the roots and kills them. The amine form is a contact poison, killing the leaves. Control is poorer and more difficult with the amine form, although it is cheaper.

Apply one to two pounds of active ingredient per acre. The chemical is normally mixed with water or diesel oil as a carrier because it is difficult to get coverage with small amounts of material if used pure; the droplets would be so small as to have an aerosol effect, without enough weight per droplet to be readily affected by gravity. The mixture, called 'goop', is sprayed on the target plants using a tractor or truck with spray booms or from an airplane (either fixed wing or helicopter).

The one absolute *MUST* for effective chemical control is that the plant *MUST* be growing vigorously. To be sure of this, check soil moisture prior to spraying. Dig 6 to 8 inches, get a handful of dirt. Wad it into a ball and toss it into the air, catch it in a stationary hand. If it shatters, cancel the spray project unless it is a sandy soil, and here, the ball should leave a wet spot on the palm. A better method is to take pictures using color infrared film. Have the film developed that day by a local photo shop or amateur photographer. If the vegetation shows bright red on the photo, go ahead with the spray. If colors are pink or gray, cancel the spray project, it will be a waste of time and money.

Some protectionists object to using 2, 4-D or 2, 4, 5-T because it will kill broadleaf plants other than the target species. This may be a valid point; during pre-planning list the occurrence of good plants that may be damaged by spraying. If good forbs such as mountain dandelion (Agoseris) or good shrubs such as bitterbrush or cliffrose (Purshia or Cowania) are present, choose a date for spraying that will cause the least damage to these plants. Sagebrush grows well on 55-degree days and 20-degree nights, while most forbs grow only after frosty nights are passed. If palatable browse plants are in 'deer form' (tall spindly plants with few leaves within reach of grazing animals) use the amine form of 2, 4-D so they will root-sprout and return to a normal bushy growth form.

Winter ends when the plants green up. This is not a fixed calendar date so it is difficult to project a year in advance what a good date for spraying might be.

Fixed Wing Planes

Most large spray projects are best suited to spraying from an airplane. Planes vary in capability as they do in size and type. A fixed-wing plane requires a landing field fairly close (within about 10-miles) of the spray area. A good dirt strip is suitable for small to medium sized fixed-wing spray planes. If there is no landing field in the area and one can't be built, then use either a ground rig or a helicopter.

Where there is a suitable landing strip, the fixed wing plane is faster, cheaper, and better than most helicopters. Ask a pilot if the field is suitable for the type of plane to be used. A field suitable for a little bi-wing spray plane may not be safe for a larger sized plane. Fixed-wing planes are usually cheaper than a helicopter by a factor of 10. A small fixed-wing plane carries a small load of goop, from 20 to 40 gallons, which is enough for 4 to 8 acres at the standard 5-gallons per acre. Compute how long it will take to spray the acreage planned with one plane, then how many planes are needed to complete the job in about a week. Larger planes carry much larger loads, so two of the old Navy Torpedo Bombers (Medium), can spray about 5,000-acres in a week. One acre is 8-ft. wide and a mile long.

The one week period is stated because that is about all a human wants, but figure 14 days are all a crew can take, mentally and physically. The crew is up at 4 a.m. at the landing field waiting for first light; ready to load and fly until the wind comes up or a temperature inversion occurs. Then the crew must again go to the spray area in late afternoon on the off-chance that winds will drop so spraying can be done that evening. Suppertime is 10 to 11 p.m. *EVERYTHING* that can go wrong or break, will. Nervous excitable persons should be someplace out of the way (monitoring the spray pattern is a good job), else they'll go berserk. With enough planes and equipment and material to do the job in 7 days, hopefully the weather will cooperate enough that the job will be completed within 14 days.

All spray pilots are a bit touched; they would have to be to contemplate such an occupation. Treat them gently. Pilots are never stupid; they just have a mental bent that makes them love danger. They are a cut above ordinary people and this should be recognized.

Generally, the planes and pilots, with their tanker trucks and ground crew show up a few days to a week late. Any broken equipment is then fixed. Most times, an advance man, or one of the pilots will drop in a few days ahead of time to look over the area and the airstrip and to confirm that all is ready.

Learn what arrangements they have made for airplane repair during the job. Have him phone the contractor and get something firm worked out. One outfit that sprayed owned only two planes and when one broke (pilot uninjured, but plane totaled) the job couldn't be completed. Another outfit, when a plane needed repairs, sent a light plane with a mechanic and parts within 2 to 3 hours of being notified. A radio link to an office is vital. Go over the contract with the head pilot so he understands the time limits, amount of spray to be applied, and all the rest of the fine print. Many times, the contractor sends the pilots and planes with only "Go spray some country for me.". Theoretically, the ground crew can fix the pumps and meters (which always break down) in the field. Check to be sure they have spare parts for the pumps and spare meters. The pilots have an uncanny ability to find the most obscure airfield. The ground crew is led to the strip.

The chemical comes in concentrated form and must be mixed with a carrier so it can be spread evenly over the plants. If you furnish the chemical, order it well ahead of time. If the contractor furnishes the concentrate, hopefully it will be in factory-sealed 5-gallon cans. If it is in bulk, take samples to be check to be sure it is really the chemical and not used diesel oil with a touch of 2, 4-D to make it smell.

Either water or diesel oil can be used for a carrier. In low humidity areas, water tends to evaporate in the air before reaching the ground, so diesel is a better choice. Too much diesel oil will harm existing grasses, so proper application amounts is critical. But it takes luck, too. Once we sprayed with diesel carrier, started about 4:30 a.m., finished about 8 a.m. Temperatures rose, the diesel volatilized and picked up some 2, 4-D and drifted on a breeze several miles to snuggle into a nice cool alfalfa field. We paid some stiff charges.

If there are susceptible crops in the area, consider using an invert emulsion spraying system. This consists of two tanks on the plane, one carrying chemical and invert, and the second tank has the carrier. The two pipelines meet at the orifices of the spray plane. The invert emulsion emerges from the orifices looking like foamy shaving cream. It breaks into droplets in the slipstream and falls heavily to the ground where it adheres to leaves and stems of plants. There is little or no chance of volatilization.

Beginning the Process

If using diesel oil, take a tank of it to the field, or if using stationary storage tanks, have the local bulk supplier driver bring a load. Tell the supplier about when another load will be needed. If a storm is forecast, order diesel at once so it will be on hand when the weather clears and before roads are dry enough for the truck to arrive.

After arriving at the strip, calibrate the planes to be sure they will apply the proper amount of spray mix. To do this, scatter twenty to thirty white cards (12"-square) over a course about 200-ft. wide and several hundred yards long. Typewriter paper is too light and blows around from the slipstream of the plane. Specially treated cards are available that change color when a droplet hits, making it easy to see. Lacking these cards, use cardboard (white poster type). Place the cards on the ground in between and under the brush. Identify the cards by row and numbers within rows. Put a flagperson at each end of the course, load up a plane and have the pilot spray down the course. He will turn and spray a second swath on the way back. No pilot will land a loaded plane, so expect him to load just a few gallons; he won't drop a whole load in such a short course.

As soon as the plane has landed, retrieve the cards. Examine them as they are picked-up to determine the spray pattern. The central cards should be covered with droplets; almost spray sized and from 1/32ed to 1/16th inches apart. The outside cards will have progressively less spray. Determine from the outside cards how wide a swath the plane can effectively spray, then tell the flagperson how far to move on each pass. Show the cards to the pilots and they can make any adjustments necessary to the spraying mechanism to increase or decrease the amount of spray.

Other methods to correct this are to change the speed of the plane, by mixing more or less carrier with the chemical, by changing orifices (the nozzles from which the spray emerges) or sometimes by changing the pulley sizes on the spray pump. It is up to the pilots to figure out how to do it. When each plane is calibrated, spraying may start.

Normally, do not spray if wind speeds exceed 5-mph. Carry a small wind gauge and check it often, record the time and wind speed in a logbook. If there is too much wind, the spray pattern drifts and there is not proper coverage.

Inversion layers are a real bugaboo for spraying. Sometimes on a clear calm morning the pilots load up and take off, they spray out a load and come back in with goggles up and cleaning their windshields. Shut them down. There is an inversion layer and the spray just hangs in the air and won't drop to the ground (called 'go in'). This occurs with either carrier. The goop can drift long distances before dropping. The flagpersons can use radio to advise if the spray mix won't go in.

One person should designated as official record keeper who floats around the area, sometimes near the landing strip, generally out where the spray is being dropped where he oversees operations. He checks the wind velocities, and puts out cards to check spray patterns, etc. He keeps a written log of what is going on and is in communication with the airfield. He will also take the flaggers out to the line and bring them back.

Flagpersons

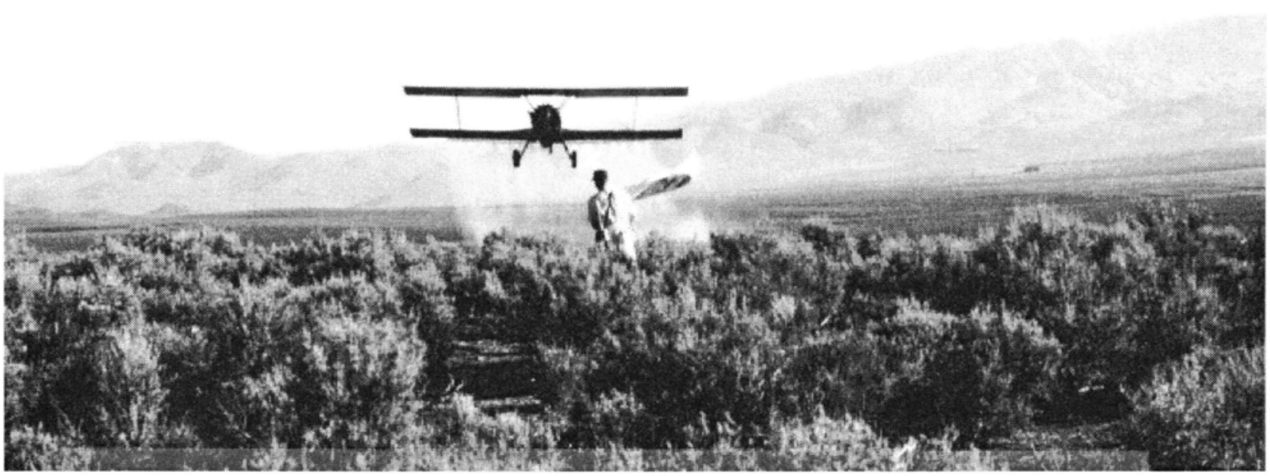
The flagpersons are important people on the team. Place a trusted person at each end of the line and be sure their radios are working. A flagger will notify the airfield when they are on line and ready. It is normal to spend one to two hours driving cross-country to put the flagpersons on line. Insist on furnishing the flaggers, choose responsible people.

If the contractor picks up flagmen along the local skid-row, try not to have them move over ten paces between passes, most of them actually can't count except on their fingers. When work is through for a time, be sure the flaggers leave their flags at their last stations so they will be able to locate that spot when they return.

The flagperson faces the plane and waves a flag, which is a bamboo pole about ten-feet long with a three-foot square white flag. The flagger continues to wave slowly until the plane homes in. When the plane is a hundred or so yards away, the flag is lowered and the flagger runs toward the next station. The flagger runs to get out of the heavy spray and to escape being struck by the plane, which is flying 80 to 100 mph, and the wheels are dragging in the taller sagebrush plants.

Impress on the flaggers to get out of the way fast. After 5 or 6 running steps, the flagger can walk the rest of the way to the new station where the flagger again faces the direction the plane will come from and gently wave the flag so the pilot can line up on both the close and far flag for the next run.

The flagpersons should wear white coveralls for visibility and to keep the spray off their clothes. They should have been inoculated for Rocky Mountain spotted fever if spraying occurs in spring in sagebrush. If the spray run is over a mile, or has ridges and hollows, a flagperson may be needed on the ridge near the center of the run. Usually pilots prefer to fly parallel to the ridges, so two flagpersons are enough.



The Airfield

Working the airfield involves supervising the mixing of the chemical and carrier, recording each load of goop that goes into the plane and the gallons per load from the meter, and generally watching, helping, and recording all that transpires to the minute. Round trip time is important to record.

The goop is mixed, generally in a collapsible rubber vat. A measured amount of chemical goes in first. Then the proper amount of carrier is pumped into the vat through a meter. The goop is mixed by putting both intake and exhaust hoses of the pump into the vat. The goop should be well mixed to begin with and remixed about every hour while flying.

The plane taxis up to the loading spot and the pump moves the goop through the meter into the plane's tank. The pilot decides how much he will carry; depending upon temperature (lift), how well the plane is running, etc.

The pilots can see from the air before workers can see clearly from the ground at first light in the morning. When the pilots are ready, let them go.

The flagpersons give the first indication of increasing wind velocities that will stop the spraying. Rarely are conditions favorable to spray all day long, usually always by 9 a.m., the wind velocity requires a halt.

It is not wise to spray all day even if weather permits, people get tired and make mistakes that may be fatal. Be content with spraying 3 to 4 hours in the morning and then again in the evening.

Many days the winds will drop just before sunset and it is calm until dusk. Every hour counts so never miss an opportunity. In one case we finished in mid-afternoon and by daylight the next day there was 6-inches of snow on the bushes.

Helicopter Spraying

The big advantage of the helicopter is that the mix tanks can be placed within the spray areas so the ferry time to the job is minimal. Helicopters do not carry heavy loads of goop so if there are long runs, put mixing tanks at each end. Helicopters cost about ten times as much per hour as a fixed wing plane so don't waste even a minute.

The helicopter (called a chopper) makes a strong downdraft, which helps get good coverage on the top, bottom, and sides of the plants. The downdraft hits the ground, bounces, rolls and settles. The drift can be severe in a 3 to 5-mph wind.

The chopper booms generally deliver 2 to 3 gallons per acre, much less than the normal 5-gallons per acre delivered by a fixed-wing plane, and this means more acres per load. Calibrate chopper spray booms exactly as for fixed-wing planes.

If there are susceptible crops within several miles, use an invert emulsion system to reduce the chances of spray. (This was discussed earlier under fixed-wing spraying).

All the other do's and don'ts that apply to fixed-wing operations also apply to helicopter operations.

Ground Rig Spraying

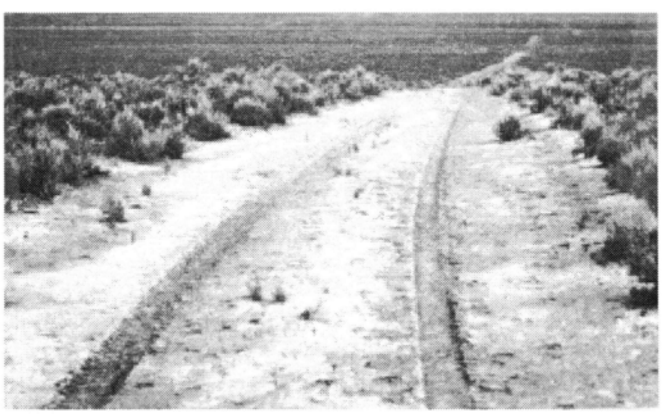
If spraying small areas on fairly flat ground, it is easier to use a pickup mounted spray rig than any other method. Needed are a 4-wheel-drive pickup, a tank to hold a reasonable supply of spray, and booms with orifices set to deliver the required amount of goop per acre (usually 5-gallons). A pump moves the goop from the tank to the booms. Mixing is done in the tank on the pickup or in a separate tank. Since ground speed is not constant, there should be a shut-off valve that can be operated from the pickup cab. Fairly short booms will be used since long ones will bounce wildly and eventually break.

Boom Sprayer Calibration

Nozzle Spacing inches)	Length of Calibration Course (feet)
12	340
15	272
18	227
19	214
20	204
21	194
22	186
24	170

Using nozzle spacing of your booms as a guide, measure off the desired distance and stake each end. Drive the course just as you would when spraying. Record time in seconds., then drive back also recording and average the two times. Leave the tractor running at same rpms, turn on pump and catch water from one nozzle for same number of seconds it took to drive the course. The number of ounces caught equals the number of gallons per acre applied. Check each nozzle and replace any that vary over 10% of the normal.

Most ranchers own a livestock sprayer (a tank and motorized pump mounted on a trailer) and this can be adapted with spray booms to apply goop to low vegetation. If spraying taller vegetation such as mesquite, the boom is not used, but the spray is adjusted on the livestock sprayer hose orifice to mist the plant.



Rangeland before spraying with 2,4,5-T.
Note absence of grasses

Same area following application of herbicide
to reduce sagebrush competition.

Mechanical Control of Woody Plants

Plows

Reduce the competition from low brush, such sagebrush, with disc plows. Moldboard plows are not used because of the narrow swath it makes.

The two types of disc plows in general use are: (a) Killifer-type and (b) one-way. A different type (c) is the root plow.

Plow the area twice over with disc plows to get enough competition reduction to insure success of the subsequent seeding. The second plowing is usually at right angles to the direction of the first plowing, but rarely may be in the opposite direction of the first plowing. Never plow twice in the same direction. The second plowing should remove additional brush plants. 100% removal is unachievable, but 90% is satisfactory and 80% is minimum. Check the percentage of removal by walking across the plowed area and pulling at the plant closest to the right toe (each step) for 100-paces. If the plant is not completely free of the ground, it is not 'removed', and will grow again.

The poorest control by plowing occurs when it rains between plowings. The soil should be completely dry before plowing begins. Should it rain while plowing, shut down the operation until the soil is dry again. The contractor will not be pleased, but brush reduction will be so poor if plowing wet ground that it is best to save the money for a later date or another year. Be sure the contract mentions this item.

Killifer-type Plows

Killifer-type plows are disc plows with two sets of discs enclosed in a heavy box frame. The front set (or row) of discs is set to cut in one direction, the rear set cuts in the other direction. This minimizes side-draft, the tendency of the plow to move sideways from the pressure of the soil against the disc while it is plowing. Killifer plows, being very heavy, require a large tractor if they are hooked in tandem. Generally two plows (twenty-foot swath) is the maximum that will be pulled. Plow twice over with this type of plow to achieve sufficient brush control. The first time over removes very little brush.

The USFS Equipment Center has developed the Brushland-Plow, which is a Killifer plow that can be used in rocky ground, areas with tree-stumps, and other rough areas. Plowing such areas is a slow and expensive process and these plows are not available except to government agencies. If they are available, use them on tough areas that cannot be plowed with conventional equipment, *AND* where it is essential that the area be plowed.

When plowing slopes, more brush is removed by plowing up-and-downhill than on contour. This leaves a dead furrow, which becomes a ditch if it rains hard. If required to plow up-and-downhill, always drill seed on the contour to help counteract the dead furrows.

One-Way Plows

One-way plows have only one set of discs and no frames around them. They can be set at a very wide angle to the direction of travel and this can remove up to 80% of the brush in one pass. There is lots of side-draft on a one-way plow so the contractor will try to compensate with a series of different hitches. He must have a welding outfit in the field to make repairs. Plows are set at the proper angle in the field to suit local conditions of soil and brush. A series of plows can cut a 50-foot swath when teamed with proper hitches and a large tractor.

The photo at right, shows a large rubber-tired tractor with one-way plows.

Tractors

Plowing may be done with a 2-horse-power (hp) tractor and a small disc plow, or with a 45-hp tractor with a large disc plow or with a track-type tractor pulling several plows, or with a huge rubber-tired tractor and gangs of plows. The huge wheeled tractors do a fine job. Track-type tractors are somewhat slower and the tracks invariably need repair on a large plowing job. Parts for minor repairs should be available in the field.

Root Plows

This type of plow is a blade the width of a track-type tractor, attached to the rear of the tractor, operated for depth hydraulically. The blade is set at an angle to pull itself into the ground and the depth is controlled. The blade cuts the taproots of plants while 'kicker bars' (vertical bars welded to the blade at 2 to 3-foot intervals) push the plant out of the ground and cut any lateral roots. Kicker bars are essential.

The root-plow was developed for plowing mesquite trees, so it will plow 24 to 36-inches deep. It can be set at lesser depths, of course. The root plow can be mounted on a small track-type tractor (Caterpillar™ D-6, but is usually found on the larger sizes (D-8 or D-9 or equivalent). The power needed makes the plow an expensive machine to operate. It is not used in an 8-inch rainfall belt; it is used in a 30 to 40-inch rainfall belt where the tonnage of grass grown could pay for the plowing operation in 2 to 5 years.

The root-plow cannot be used on rocky areas; use a sharpshooter shovel and be sure soil depths are proper for the plow.

A bulldozer blade is mounted on a root-plow-equipped tractor to push over larger bushes and trees to protect the equipment. A cage protects the operator from trees and tall brush as they fall.

It is usual to rake the dead trees and brush from the plowed area to permit drilling seed and access by livestock into the area. This can double the cost of the operation. There are both dozer-mounted rakes and towed rakes available.

Where the brush is fairly small and can be left on the ground, seed can be broadcast from a seed box mounted on top of the root plow. Wires dangling from the seed spouts will wiggle as the tractor moves and permits the seed to flow from the spouts without bridging or clogging. A bull-wheel driven agitator cannot be used here.

Chaining and Cabling

In pre-planning, certain goals have been set forth and these help determine how to go about competition reduction. If only watershed improvement is needed or if only wildlife habitat improvement is desired in an area with few seedling trees, you may choose to use chain or cable, one pass, on contour. This will lay the trees over but not kill them. It will kill about 3/4ths of the roots, leaving space for the seeded plants. Trees laid down on contour will break the flow of water and for a limited time (20-years) will achieve considerable watershed protection, reducing sediments and water overland flows.

Any chain or cable will tend to bend over the trees the first time through, leaving the trees rooted on one side. The second time over the area, usually in the opposite direction to the first pass, will remove the trees from the ground.

The smaller trees and saplings will not be removed by chaining or cabling and will grow rapidly once released from the competition of the older trees. Examine the area before chaining to see how many small trees exist, add 10% for the seedlings that will appear and make a determination as to whether chaining will be just trading an old stand for a new one. For any chaining, budget time and money to hand-cut the young trees beginning the year after chaining.

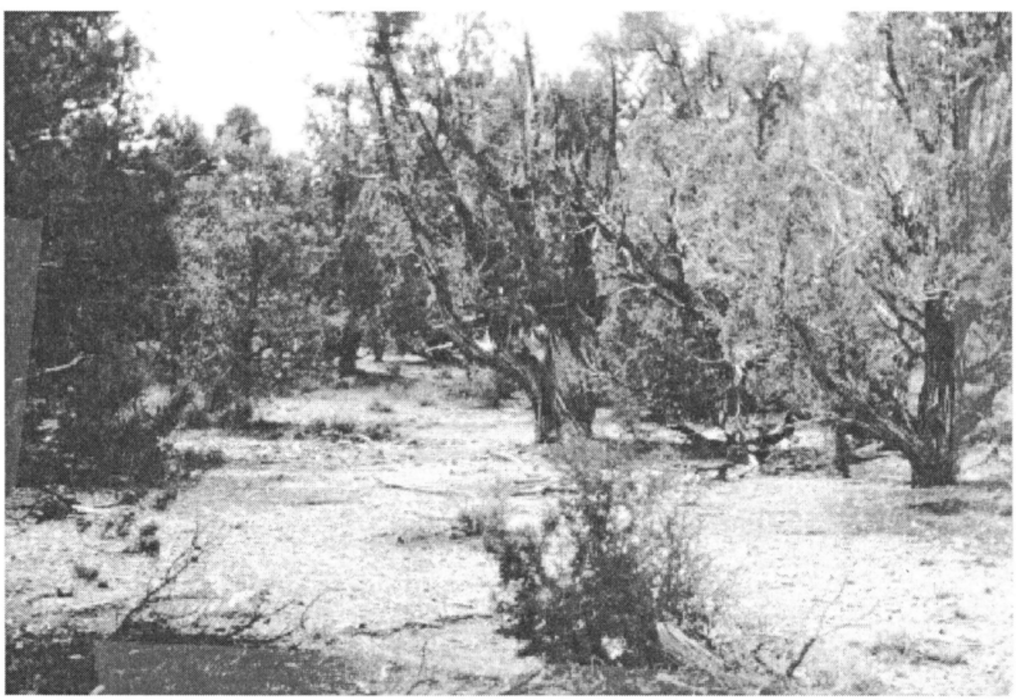
Where planning reveals opportunities for a multipurpose operation to benefit wildlife, watershed, livestock, etc., chain twice over, pile the trees (and burn them if aesthetics demand), and seed a mixture of grasses, forbs, and browse species. The seed may be applied by plane in between the two chainings. If the trees are just laid over, there is so much tree trash on the ground that passage by wildlife is difficult and travel by horseback is impossible.

The removal of the trash will permit drilling in the seed and insures a much heavier growth of grasses and other plants to protect the soil. Expect benefits to continue for at least 50-years with complete removal of trees and occasional maintenance to remove seedling trees. One reason for removal of the trees was to eliminate crown intercept of precipitation, usually estimated at about 25%. A pinyon-juniper stand may be in a 12-inch ppt. Zone, but only 8-inches ever gets to the ground.

Working the Chain or Cable

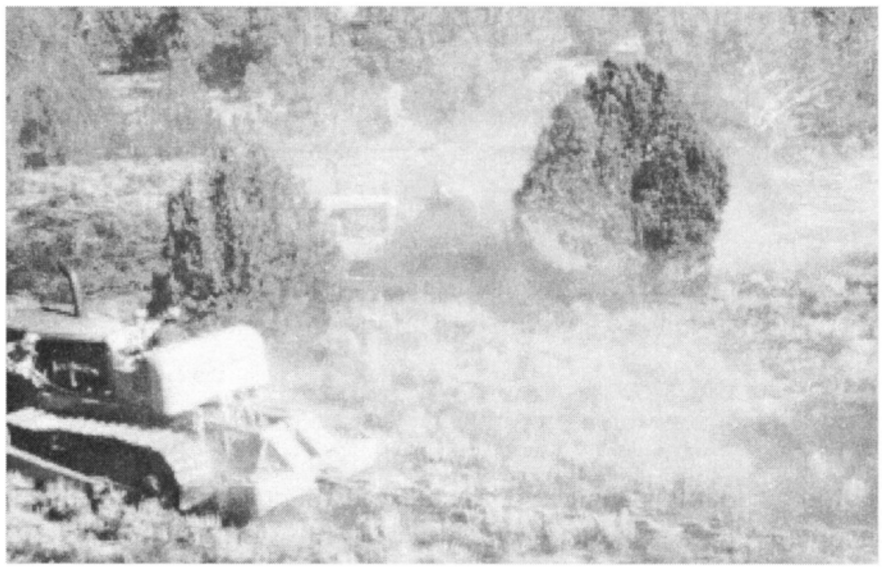
The chain or cable is strung between two large tractors, which work in tandem. Heavy steel cable is minimally effective on brush and only slightly more effective on trees. Some cables have plow discs threaded onto the cable to make it more efficient.

The photo at right shows rangeland area invaded by pinyon-juniper. Note the bare ground and dying brush plants.



A chain is a ship's anchor chain and is very heavy. A very effective chain is the Ely-chain, developed by the technicians of the BLM Ely District, Nevada. This is a 90-lb. per link chain, with short pieces of 60-lb. railroad rail welded across each link. These rails are about 6-inches longer than the chain link is wide (on each end), and must be hard-faced with a welding outfit else they quickly wear out. The end links are welded to short pieces of lighter chain so the operator can pick it up to hook into the tractor drawbar. In each length of the smaller chain is a swivel so the chain can roll. The $1,500 patented swivels wore out in a few hundred acres, but swivels made from a D-8 track roller lasted for several thousand acres.

When working sagebrush or other low brush, set one tractor well ahead of the other so the chain forms a 'J'. The long slant of the chain does very well on low brush. When working in trees, place the tractors about even, so the chain forms a 'U'. The bars on the chain scarify the soil giving a good seedbed for broadcast seeding (by airplane). The Ely-chain tends to pile the brush and trees so most of the area is cleared during the chaining operation. When the loop of the chain gets full of trees, one tractor goes around the pile to clear the chain and they begin again.



The photo at right shows two D-9 Caterpillar™ tractors pulling the Ely-chain. The tractors should be pulling a 'J' in this sagebrush area, not the 'U' as shown.

This photo at right shows a close-up of the Ely-chain showing cross bars and swivel attached to a D-8 Caterpillar™.

The chain is a 90 lb./link anchor chain with 60 lb./yard railroad rail.

Other Brush Removal Tools

Stinger

The Stinger is a small (1-ft. wide) cutting blade attached to a tractor's front-end loader, and is usually found on a small rubber tired farm tractor. Some persons replace the bucket with the blade. In operation the blade is lowered to the ground as the tractor approaches a single tree or bush; the tractor is driven forward, forcing the down-angled blade into the ground under the plant. The blade is then raised hydraulically, removing the plant. Such a tool is very useful to remove scattered mesquite, juniper, or other noxious brush. It is more economical to remove invading plants while there are yet a few small plants per acre. Rubber-tired tractors are used almost exclusively because they move faster and do not dig up the grass on a turn.

Tree Crusher

This is a monster drum with cutting bars welded spirally on the drum. As the drum rolls, it mashes down small trees (up to about 8-inch diameter) and cuts them up into 18-inch lengths. It is filled with water for extra weight and is pulled behind a large track-type tractor.

Hammermill

This device has a cutter bar that cuts brush and small trees, which are fed into a hammermill that spews out wood chips. It also requires a large tractor for power.

Brush Beaters

These are rotary cutters, like a rotary lawn mower. They have blades or chain flails to cut non-sprouting types of brush. The presence of many brush seedlings will indicate an area unsuitable for treatment with a brush-beater; these seedlings are released when the older plants are cut.

Fire

This ancient tool can, under proper conditions, be used to control brush and trees. There must be sufficient understory to carry fire from one woody plant to the next; not all areas can be burned. Ideal burning conditions include dormant target plants, dry soil, low humidity, moderate winds, and warm temperatures. These conditions are also near fire-storm conditions. Under fire-storm conditions, a fire once started is impossible to stop until it rains or the fire runs out of fuel.

It is difficult to start Wildland fires without most of these conditions; a tree or a few acres of brush can be burned, but the fire will not carry nor spread. Stringers of big sagebrush, in draws adjoining rocky sparsely vegetated slopes, are successfully burned before the snow is entirely gone. Flame-throwers or butane-fired weed burners may kill individual cholla cactus plants.

If fire is to be used as a tool to remove brush, build fire lines prior to beginning the burn and have pumper trucks standing by to prevent escape of the fire. Seed the area immediately after the fire is out to be sure the dormant brush seed in the soil does not repopulate the area before good grasses and forbs can be established. Fire creates a hydrophobic effect on many soils, therefore drill in the seed, and do not broadcast.

Water

Irrigating the plants over a period of time can eliminate big sagebrush and rubber rabbitbrush.by in effect, creating near-swamp conditions to drown the plant, by excluding oxygen from the roots. This method of brush control may be used under some conditions, such as meadow development for sagegrouse habitat or clearing land for irrigation.

Chapter 21

Wildlife Guzzlers

Some game birds, notably quail, doves, and chukar, inhabit ranges within a few miles of water. To increase the habitat for these birds, guzzlers are constructed to provide additional water. Guzzlers are used in areas where there is no possibility of drilling a well or running a pipeline. A guzzler is a baby catchment. Chapter 16, Catchments will enlarge on the theory and practice.

The catchment for a guzzler is made of wood, metal or plastic, any impervious material that will shed water into a holding basin. Some are inverted cones, like a funnel, where water runs to the center and down under to a basin. Some are roofs with gutters and downspouts to the basin. They are not large, usually about 10 to 12 ft. in diameter.

It is important to secure the guzzler against high winds and to restrict entrance to small birds. The guzzlers are low structures, seldom over a foot above the ground with a few openings giving access to the central pool of water. Openings should be offset so wind cannot course through.

Begin construction by clearing brush and rocks from the area of the guzzler, and then excavate a sloping hole in the center This hole is lined with concrete or plastic. It may be more than a foot deep and side slopes are gentle. Then the supports for the roof are installed; usually steel pipes set in concrete. And last, the roof is placed on the supports. Walls are built under the roof to deny access to coyotes and foxes. The entries should be pipes that the quail or chukar can enter but the coyotes cannot dig out. Once inside, the birds can walk down a ramp to the water where they will drink about one tablespoon per bird per day.

To determine how large the pool should be for a 10-ft. guzzler roof, multiply Pi x r-squared, x average annual rainfall. In a 6-inch precipitation zone, this will harvest nearly 40-cu.ft. of water or a little under 300 gallons. Since not all the year's rain will fall at once, estimate the amount for any one storm and end up with about a 20-gallon storage. The water is protected from evaporation and wind.

If a drought occurs, water can be hauled to fill the guzzler pool. Wildlife clubs usually volunteer to do this work.

Guzzlers are usually well hidden and the location is known to only a few. These preserve a population that is not hunted and can fill in losses from predation to other coveys.

In favorable situations, larger guzzlers may be constructed for big game animals such as bighorn sheep, or elk. One requirement is that the animals will remain in the area for only a portion of the year.

The guzzler is really a catchment, albeit a smaller one than normal. A strong high fence must protect the catchment apron from which water is piped to a storage tank and then to a trough with a float-valve. Chapter 15, Troughs, Wildlife Waters, contains additional information., as does Chapter 16, Catchments.

Chapter 22

Roads and Water Bars

Someone in Washington DC, once wrote a memo that stated that there are only three problems with road maintenance; they are water, water, and water. This is true. Roads should be engineered with water in the back of the mind at every step. Road building is one job that only engineers should do. They can design proper cuts and fills and culverts of correct size.

Roads are hard, fairly flat and smooth so they allow water to run rapidly along or across them. The coefficient of friction is very low, compared to adjacent areas. On flat country I have seen water move on contour to the road because of the pull of the water moving more rapidly down the road.

Any area above the road is a watershed for that part of the road; every draw is a potential torrent. Culverts are used to pass water safely under a road. They must be a proper size to carry a normal storm from the watershed. Disposing of the water safely from the outlet of the culvert is always a concern. In some places it may be piped down a slope to flat land before being released.

Culverts are made of corrugated steel instead of flat plate to slow the speed of the water. Maintenance to keep the culvert clear of clogging trash is important. It may be necessary to clear the culverts during a heavy rainstorm. Culverts should always be checked and cleaned after a storm.

Dirt or graveled roads should be built with a crown in the center to help drain water from the surface, but they seldom are in the Wildlands. A ditch is usually cut on the uphill side of the road to prevent the water from running over the road and to lead the water to a culvert.

Many persons concerned about erosion of the road surface build water bars (called 'thank you, ma'ms') across the road to interrupt the flow of water down the road. These resemble speed bumps in a paved private road. If bars are necessary, they should be built from above, that is up-slope from the bar. If dirt is scooped from below the bar, it will become a pool when it rains. They should be about 10-feet from toe to toe and about 8-inches high. There should be a smooth approach and exit that can be driven at 30-mph. Importing dirt for a water bar is proper to avoid cutting into the road for dirt to construct the bar.

Another solution is a water crossing across the road. Here, dirt is scooped out so the water will enter it and be diverted from the road into a small ditch to lead the water away. Built on a gradual smooth grade and if paved with concrete this offers an excellent safe crossing.

Frequently, a ditch is made from the road edge to divert water from the road. If the water is released onto a flat area, these work well to relieve the road of flowing water.

Maintenance rules are: To throw out (cut) on clay soils and to pull in (fill) on sandy soils. Most operators do the opposite so the sandy roads are eventually several feet below ground surface and the road becomes a canal.

Chapter 23

Water Spreading

In many areas of the Wildlands, water may be spread to help revegetate rangeland or to grow crops. It is a basic form of irrigation and can be a useful rangeland tool.

Water tends to channelize and this water-spreading combats this. Where water begins to congregate, usually before it is in a defined waterway, water can be conveyed and spread on reasonably flat areas. The Wildlands are subject to intense slashing summer thundershowers where a great deal of water is deposited suddenly. This water can be spread to benefit the land.

Dirt Spreaders

Dirt dams and dikes are often used to move water from one area to a series of water spreaders. A problem with dirt is that no water goes through the dikes so the land below gets no water and is 'bled' (No water, no production). The spreaders can be built to avoid bleeding much land. These are low barriers, with about 2-foot settled height.

One type is a broad 'U', square bottomed, level from side to side and built from below so a ditch is along the bottom or outer side. The sides will have a .5-foot fall, so the 'U' may measure 200-feet on the sides in nearly level ground. Water overflowing from the 'U' will run down along the ditches to the base of the 'U' and then overflow the ditch to water land below the spreader. The water will be picked up again by lower spreaders, slowed and again spread.

Another type is a wide 'V', again with .5-foot fall from top to bottom of the 'V'. Once filled, the water will spill from the 'V' on the top wings, run down the ditches along the sides (this is built from below, too) and spread out over the land. Other staggered 'Vs' will pick up the water and slow it, and re-spread it.

Wire Spreaders

These were invented at Marfa, TX, by an observant range technician who watched water run off a slope, strike a net wire fence and travel along the fence as if it were a real barrier. Which it can be, due to Manning's 'n'. There is slightly more friction going through the fence that traveling along it.

A major benefit of the wire spreader is that if installed properly, it will let some water through the fence and not bleed any area. A second benefit is that it can be removed at any time without damage to the land.

A wire spreader is constructed using 24 inch net wire, doubled so it is 12 inches tall. It is attached to white topped (for visibility) steel posts that have been carefully surveyed into place.

If taking water from a watercourse, place a few large rocks into the streambed to raise the level of the water up to ground level. This takes the water away from the stream fairly rapidly (½-foot per 100-ft.) to where it is to be spread and then slack off the grade of the fence to about 1/10th to 2/10ths of a foot fall per 100-ft. If carrying the water several hundred yards take it at 1-foot per 100-foot, this much fall will take all the water and spill none through the fence. This would be an erosive grade except that the vegetation will protect against erosion.

Do not try to turn a spreader against itself. If topography changes, stop the spreader, then go below it 10-feet, and start another leg. My longest spreader was a series totaling 1,400-feet. and it watered about 640-acres.

Spreaders can also be very short, like 20 to 50-feet, and used to slow the energy of water making a head cut. Let enough water through so the grass is watered, but not enough to keep the head cut active. The head cut will heal itself, once the head of water is reduced.

In time, the wire spreader will silt up, making it inoperable as designed. Then pull the posts, roll up the wire and use it someplace else. After a week, no one can tell there was ever a spreader there, except for the thick grass. This is a major benefit of using a wire spreader, instead of a dirt spreader, is that no bare dirt is ever turned up and no vegetation is destroyed in construction.

When looking for an area to spread water, take a dumpy level along and a survey rod. To find an area, use your hat brim. Stand tall, pull the hat brim down so you can see only about ten feet. Turn slowly not moving head or hat, only your feet, and see if you can now see farther. If you can, it is downhill that away and you maybe able to spread water there. This combats the problem of determining downhill from uphill.

In some areas, you decide by eye it is one foot lower at that bush. A level will tell you it is 2 feet higher. So double your estimate in the opposite direction and you'll be right on.

A short wire water spreader leading water from a small earth berm in a draw to a formerly bare area. White-top posts are used to warn livestock and riders of the presence of the hazard.

Figure 23 - 1

Chapter 24

Cadastral Survey

Early in the nation's history, the Congress established a method of land identification, the Cadastral Survey System. All of the mid-west and western states were surveyed according to this system (except Texas, which has its own similar system). It provides an exact legal method of describing a parcel of land.

Any work in the Wildlands will be recorded with its position referenced to the Cadastral Survey. Its recording establishes the ownership of the improvement and is an implied easement. About half of the field time will be spent locating the work on the Cadastral Survey grid.

The cadastral Survey is a system of squares laid out on the earth's surface. The Coast and Geodetic Survey (super-accurate surveyors) first establish base points. From a base point, the Bureau of Land Management (BLM) cadastral surveyors run a base line east and west and a meridian line north and south. Then townships are established, which are 6 miles square, measured along the Base line and the Meridian line. This continues east or west and north or south (sometimes both) from the base point.

There are numerous base points, base lines and meridians in the U.S. Some apparently end at a state line, while others were established because of a physical feature like the Grand Canyon, which could not be surveyed across.

Because the earth is a ball, the north-south lines would eventually converge, so these lines (now called Range lines) are corrected every 24 miles on Standard Parallels (parallel to the base line and now called township lines). A legal description of the land always includes the numbers of the Township and range, the name of the Base and Meridian, and the name of the state.

A township is a square block of land, 6 miles on a side. It was considered to be the amount of land needed to support a town and a couple of schools. It contains 23,040 acres. The township is subdivided into one-mile square parcels called sections. There are 36 sections in a township and each is numbered, starting at the northeast corner. Figure 24-1 shows how sections are laid out and numbered. A section contains 640 acres.

The surveyors mark the four corners of each section on the ground. These are called section corners. Midway between section corners, along section boundaries, markers are placed called quarter-corners, to mark quarter sections, once the size of homesteads. See Figure 24-2. The center of the section is not marked. A section can be divided into smaller parts. When Congress talks about 'the smallest legal subdivision' they mean a 40-acre parcel. But smaller portions, even less than one acre, can be described legally, too. Figure 24-2 shows a section divided into quarter sections and re-divided into 16ths or 40 acre parcels. In describing the shaded parcel in Figure 24-2, we call it the Northwest quarter of the Southwest quarter of section 3 and write it "NW1/4 SW1/4, Sec.3." Do not put a coma in between: a coma means "and the"; no coma means "of the". Had you written NW1/4,SW1/4, you would have described the Northwest quarter *and the* Southwest quarter, or the west half of the section, compassing 320 acres, not the forty acre tract you intended to describe. The west string of 40's of a section is called the W ½ W ½. The east ½ of the section (320 Acres) is called the E½, Sec.3. No other fractions may be used.

Remember to read backwards through a description. Start with the last item, the section number, then the last subdivision. Divide the section into as many squares as is necessary to plot the subdivision. Draw a section and plot the SE1/4SE1/4 NE1/4SW1/4 NW1/4. This is a 1¼ acres plot. Before looking at Figure 24-3, remember the implied "of the" between each description.

Where the square survey doesn't quite fit, as when lines of convergence begin to be noticeably closer, the cadastral surveyor places 'lots'. A lot is any parcel not exactly 40.00 acres in size. Lots are commonly placed on the north and/or west side of a township. Figure 24-4 shows typical lots on a fragment of a township plat. The sheet of paper is called a plat and there is one township per plat.

On attaining statehood, all of the unclaimed land in the new state was quitclaimed to the federal government. Only a few of the land disposal acts allowed title to pass before the land was cadastral surveyed. The state, in addition to the acreages for prisons, hospitals, etc, also received from 2 to 4 sections in each township for the support of schools. Title passed when the township was surveyed. Only Nevada relinquished this right to school sections in exchange for other lands. A township is not officially surveyed until the fieldwork is done and the plat of survey is approved and signed by the Secretary of the Department of the Interior. Incidentally, the federal government does not give deeds to land; it gives patents, which are in the nature of a quitclaim deed.

Prior to 1912 the General Land Office contracted all cadastral surveys to private surveyors. Beginning in 1912 the GLO hired its own surveyors, a practice that continues today. In 1946 the Hoover Commission Report was approved by Congress to combine the Grazing Service with the General Land Office into the BLM.

Pre-1912 Surveys

The private surveyors marked the section corners and quarter corners with marked or chipped rock or with scribed wooden posts. Some contracts with private surveyors under contract were carried over so some surveys approved and dated 1912 or 1913 with the General Land Office are wood or stone.

For the most part, the contractors were excellent surveyors. A few did their work on a pool table and turned in pure fiction for survey notes. This created problems that we still live with today. The southeast corner of each township is described by longitude and latitude. Using star or sun-shots, the surveyor located this corner and began his survey there. The Cadastral Survey Manual, which hasn't changed much over the years, requires that the surveyor run north from the Southeast corner to establish the range line, setting section corners and quarter corners. He kept notes of the topography along the route and described the corner set. The private contractor stated whether the corner was wood or rock, and if rock, the approximate size and colors of the rock. When the surveyor got to the top of the township, 6 miles, he was supposed to deadhead back to the southeast corner of the township, run west one mile and then run north. On this trip, he was to tie back to the corners he had set on the range line and set a quarter corner as he returned to his north-south line. Each interior line was to be surveyed starting from the south township line.

Very few surveys were done this way. When the surveyor got to the top of the township, he ran west one mile and then ran south on the first interior line. He stubbed out the quarter corners either going up or coming back down, whichever was easier. The notes, of course, are written as if he had performed the survey according to the manual. So parts of the notes are true and parts are fiction. To find a corner you must determine which is which.

The stone corners were to be marked as shown in Figure 24-5. The ones on the township and range lines are marked on two opposite faces. Township corners were marked on 4 faces or 4 corners. The stones for the interior sections were marked on the south and east sides. Figures 24-8, 9 and 11.

A scribed post corner is rare these days, the elements having taken their toll. The ones I have seen were about 2 in. square and 5 ft. long and were scribed in Roman numerals. Figure 24-10.

If there were trees near the corner, these were blazed and scribed in the blaze with the corner information, township and range, generally using Roman numerals. These are "witness trees" and are sancrosant. Do not try to cut the bark to read the markings; the marking are usually visible only on the bark which dries up and blows away, so this record is lost. Only cadastral surveyors who are re-surveying a township and who will mark the corner with a brass-cap are authorized to cut into a blaze.

If the surveyor goofed and set the corner in the wrong place, can you correct this? **No**, you may not. No one can. Where the corner was set is the legal corner of the section, even if it is N13E and .4 miles from the last corner when it was supposed to be N at .5 miles. This is true for both section corners and quarter corners. Quarter corners were marked with '1/4' or rarely with an 'X' or a cross. Some artistic license here?

If working in a township that was surveyed before 1913 (and there are many of these), first get a copy of the original notes written many years ago. The BLM state office has these and will sell copies. It is helpful to have a reduced-size copy of the township plat to give a better idea of the topography.

Post-1912 Surveys

Most cadastral surveys dated 1912 or later were done by government surveyors. Another important change at that date was the introduction of brass medallions, called brass-caps, to mark corner locations. The size of the brass-caps has changed over the years, becoming larger, but the information on the face is substantially the same. The brass cap is set on a steel post or pipe, except in salty areas where concrete posts are used. On top of the brass-cap is marked in Arabic numbers, the section number, Township and Range and Base and Meridian. See Figure 24-7.

The Coast and Geodetic Survey uses similar markers in their work and BLM uses aluminum markers to identify projects. Look at the marker to determine which kind you've found.

The brass-cap surveys were accurately done and you may be *almost* sure that the corner was placed where the plat shows it was placed. If a corner would fall in an inaccessible place (cliff face) or where it would be destroyed (in a big draw), on line and in a safe place a 'witness corner' (marked WC) is set. Another common marking is CC for closing corner or SC for section closing corner. Usually a section corner is common to four sections, but especially along standard parallels, where adjustment for convergence is made; you'll find CC.

Finding Section Corners

Certain aids are needed to help find section corners.

(1) The reduced size plat of survey of the township, from the BLM State Office.

(2) A copy of the original surveyors' notes.

(3) A field map of the area, preferably a United States Geological Survey topographic map. This map will show any section corners found while the USGS was surveying that area.

(4) Your personalized pickup, with calibrated odometer or survey odometer.

(5) A staff-compass and jake-staff.

From previous planning work, the section corners needed to be found can be determined. If a point object, such as a spring is concerned, only one corner will need to be found. If a 20-mile long fence, many corners must be found and the fence will be built right on the section line if at all possible.

Section corners are seldom sitting beside a road. Studying a map may determine where a section line crosses the road. Check carefully to be sure the road is the one shown on the map and that someone has not moved it. Correlating map detail with ground detail, drive to a point where the section line crosses the road. Along a fenced highway, where land ownership changes, there may be an offset in the width of the highway right-of-way. You should be no more than ¼ mile from corner in a cardinal (N, S, E, W) direction. Set up the compass and point it in the appropriate cardinal direction. Take a foresight on the most distant object seen, preferably a mountain across the valley. Memorize the point; look away, then back to find the point again. Recheck with the compass sight that you are on the proper point. Then secure the compass needle and pick up your equipment. Pace exactly on line.

Determine from the map about how far you should go to the section corner. The cadastral plat gives distance in chains, 66 ft. per chain. (Chains times chains divided by 10 equals acres). Links are subdivisions of chains, 6.6 in. each, but usually distance is given in chains and tenths of chains. The distance can be measured with a tape or chain, if there are two people, or with stadia. If alone, pacing is the fastest and easiest method and is sufficiently accurate for this work. To learn to pace, lay a hundred-foot tape out on the ground and walk alongside of it, counting paces. One pace is the distance covered by two steps, count each time the right foot hits the ground. Walk naturally, dodging rocks and bushes, but walk in as straight a line as possible. After three or more trips up and down the tape, determine how many paces are used to cover 100 feet. Beginners should use a tally-whacker to keep the numbers straight.

If permissible and possible, drive the pickup on line, measuring the distance with the odometer. To assist in driving a straight line, stick a 3 to 4 foot long strip of masking tape on the hood to extend the line straight forward from the steering wheel. While driving, keep the tape pointed at the foresight.

When the correct distance has been covered, drop a flag on a bush and walk circles around it looking for the corner. There may be surveyor's lath still standing if it was a recent survey. They use yellow strips on line lath, red for a corner. But they may have had to correct so the corner may not be right near the red flag. There may be truck tracks to help find the line and the corner. Tracks may be very faint, but look for them. Lots of brass-caps are under bushes; apparently digging a hole to place the corner makes a suitable site for sagebrush seedlings.

If the corner can't be found, study the township plat and the notes to see what topography is noted nearby. A draw, a ridge-top, or an old road may give you a distance from the corner. Then parallel the draw (or ridge or road) at the proper distance to find the corner. Trees along the line will have been cut down or limbed so the transitman can see. Witness trees will have been blazed and scribed. Look for these signs. Once the corner is found, successive corners can be located on to the corner needed to tie the project. Drive a steel post on a found corner, take a picture of the corner and surrounding area, then fill out a BLM Corner Location form. It takes from 30 minutes to several days to find a corner; if it is marked with a steel post it can be relocated in minutes. Use a half of a steel post if near a road to avoid theft.

If Global Positioning System is in use in the agency, this may be a handy aid, if the software on Cadastral Survey is available.

Never assume that, since it is a brass-cap survey, that directions will be cardinal and distances exactly ½ mile. Many old rock surveys have been re-surveyed and the brass-caps were placed beside the original corners. Study a township plat to determine distances and directions.

Finding wood or rock corners is infinitely more difficult than finding brass-caps because time has eroded or covered up some corners, and there is always the problem of initial mendacity. Assume that the corners are there until proven differently. Ability to read the marking on the corner when found is essential to being sure it is a corner and that it is the right corner. See Figures 24-8, 9, & 11.

Always carry copies of the field notes when searching for wood or rock corners. Read these notes to see what kind of a marker was set, its size, and (sometimes) color. Check the USGS map; found corners will be marked with a red cross. Since USGS does not search for every corner, not all of them will have been found.

When all else fails, and if there are aerial photos of the area, locate features on the photos that are described in the field notes. If the notes say it is 28 chains between draws on a certain section line, find the draws on the photo and the proper distance and thus establish line. If able to pinpoint 4 or 5 corners on an aerial photo, then a trip to the field to find them is in order. Determine which lines the surveyor actually ran and which he didn't. The notes compared to the photos will help determine this.

When a rock corner is found, it will still be legible, if you know how to read it. Turn the rock to the light to properly see the chips. It will be a smallish rock that could be carried in a wagon and was marked with a steel chisel while sitting around the campfire at night. Most surveyors tied a rag on a wagon spoke and got distance by counting the revolutions of the wheel. If you can't drive the line, they didn't either, so be forewarned.

Errors were made, a common one being picking up or dropping ten chains in a half-mile. Sometimes a strong magnetic pull from an ore body will cause the compass to point awry.

In some cases, the exterior lines of a township were run by one surveyor-contractor and a few years later the interior lines were contracted to another surveyor. Sometimes the second surveyor couldn't find the original corners and set his own, so there may be two sets of corners on a township exterior.

Protractions

Because there are hundreds of unsurveyed townships in the West and people wanted oil and gas leases on this unsurveyed country, BLM has computed where section lines would be and how many acres there would be in each section. There are no corners set in a protracted township; this is purely a pencil exercise in the office.

These plats are in a separate book.

The cadastral surveyors estimate that they will complete their backlog of survey about the year 2060, so the protractions will be with us for awhile.

↑
N

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

A Standard Township

Figure 24 - 1

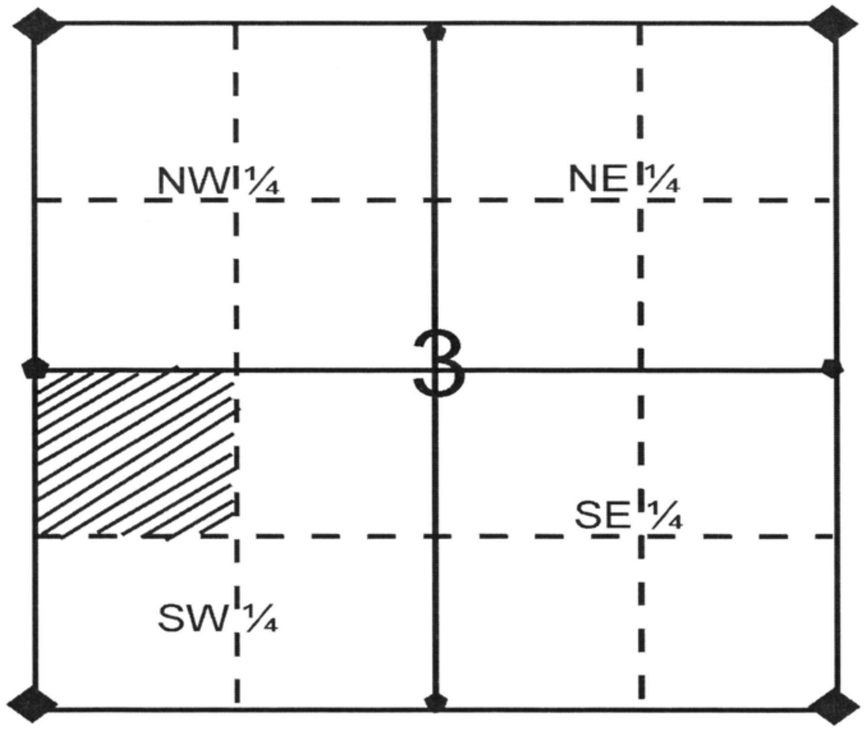


FIGURE 24 - 2

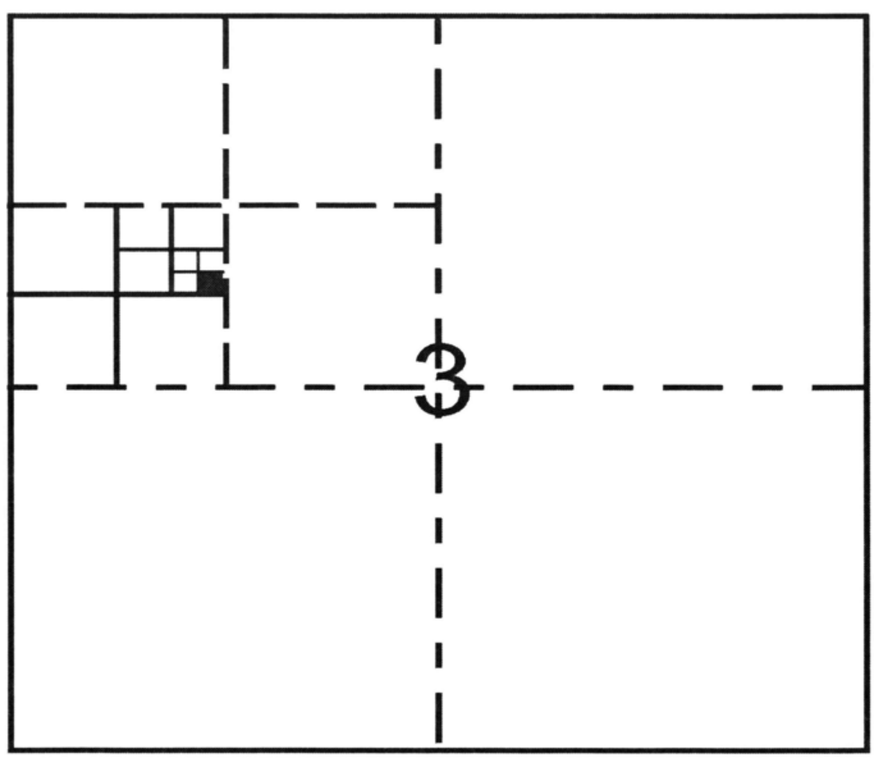
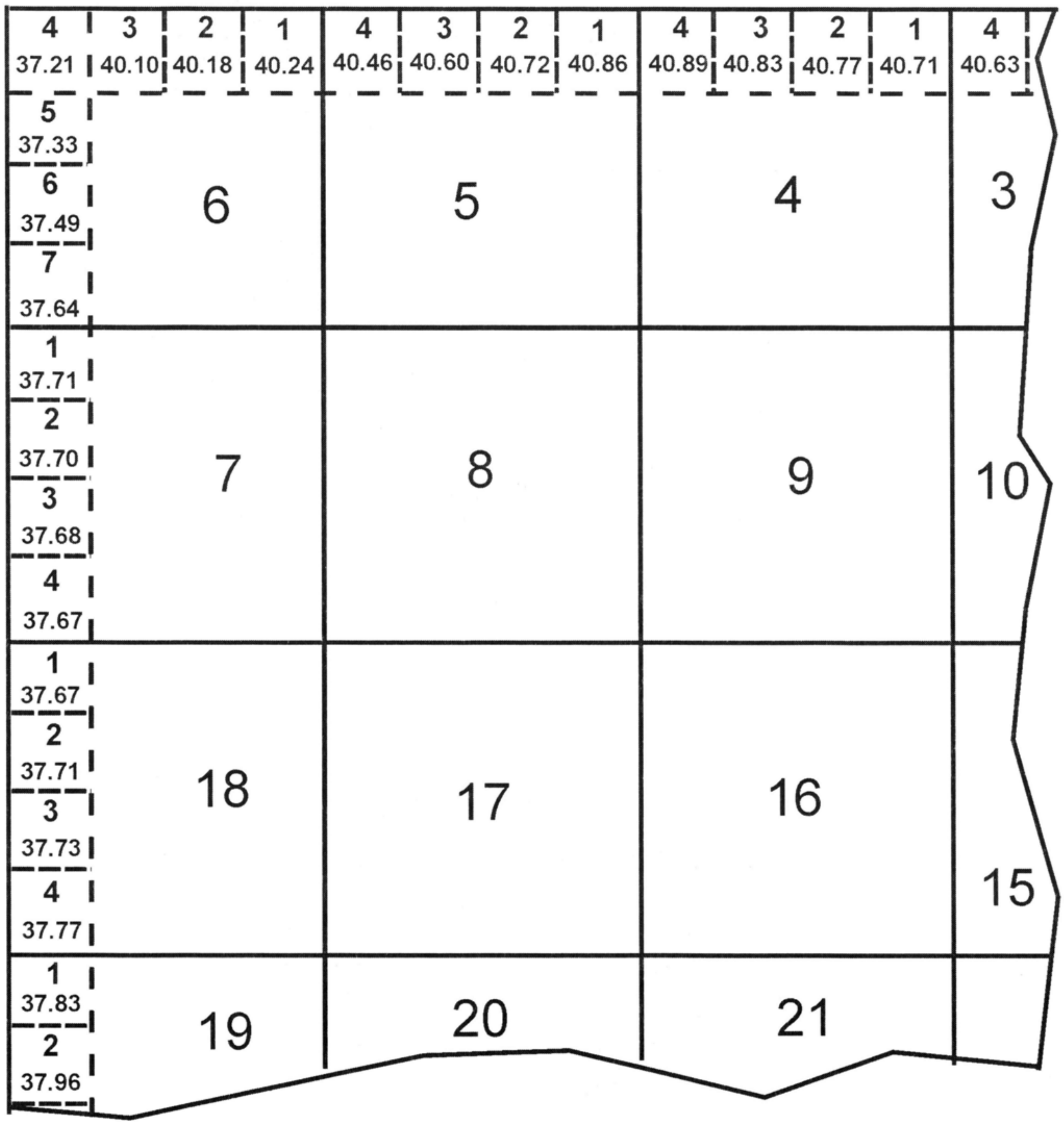
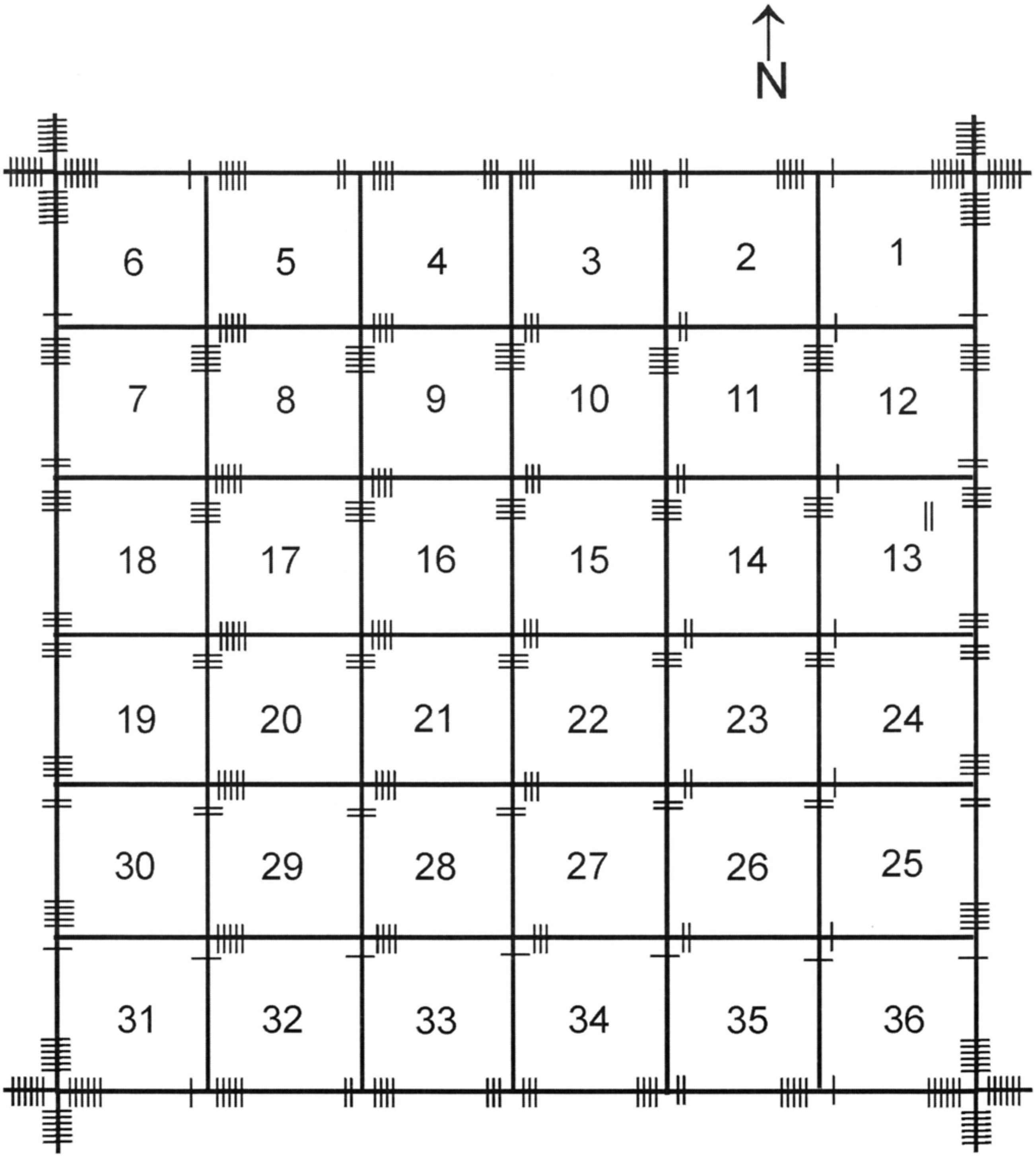


FIGURE 24 - 3



Township 15 North, Range 9 West, GSRM

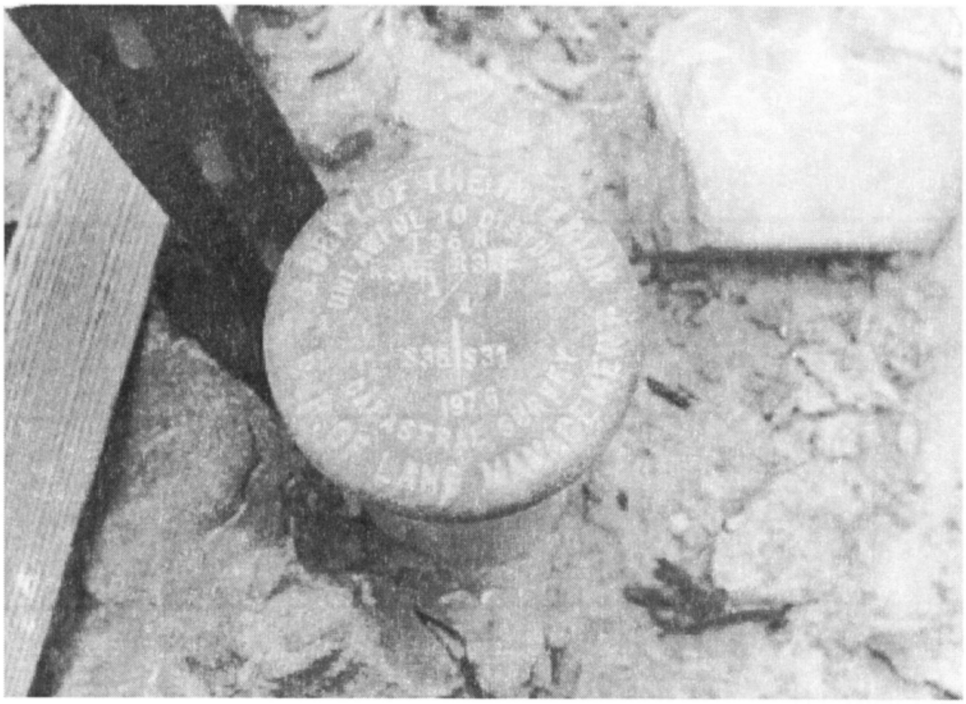
Figure 24 - 4



Rock Section Corner Markings

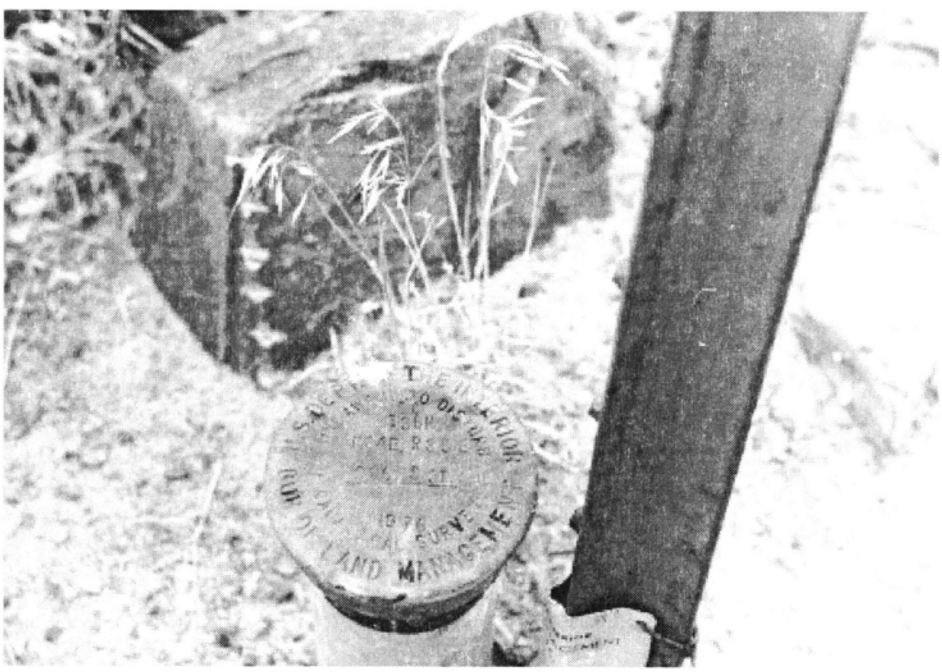
Lines indicate number of scribed marks on Twp, Range and Section Corners Rocks marked to indicate distance from SE corner of township. Exterior lines marked on opposite faces, interior corners marked on S & E faces.

Figure 24 - 5



A ¼ section corner.

Figure 24 - 6

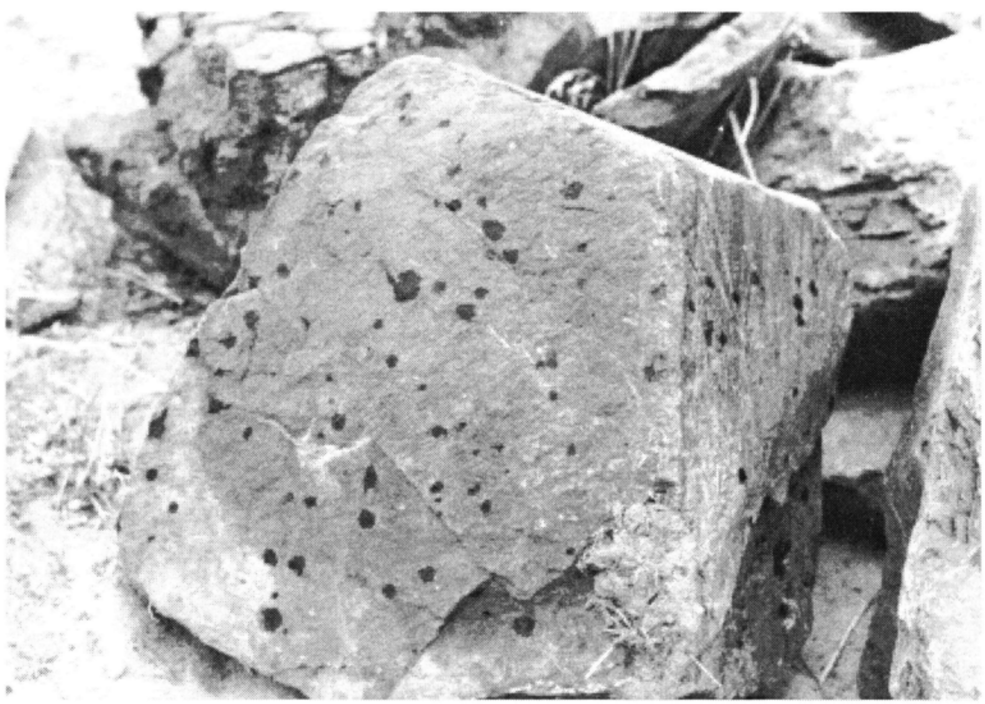


A closing corner on a township line.

Figure 24- 7

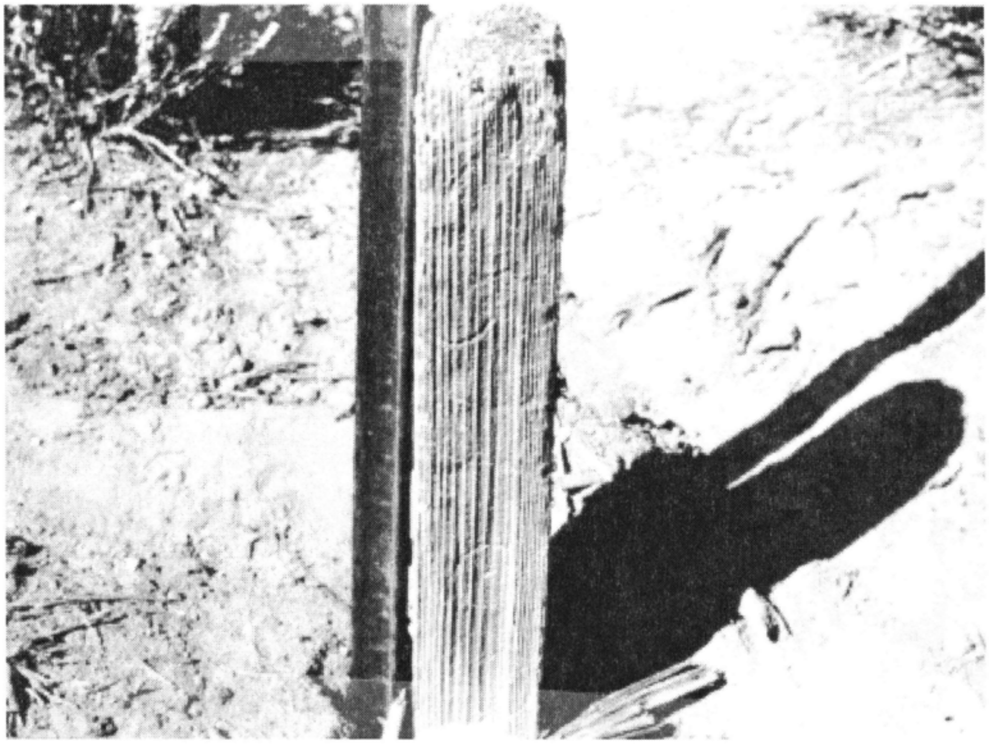
A well-marked township rock corner.

Figure 24 - 8



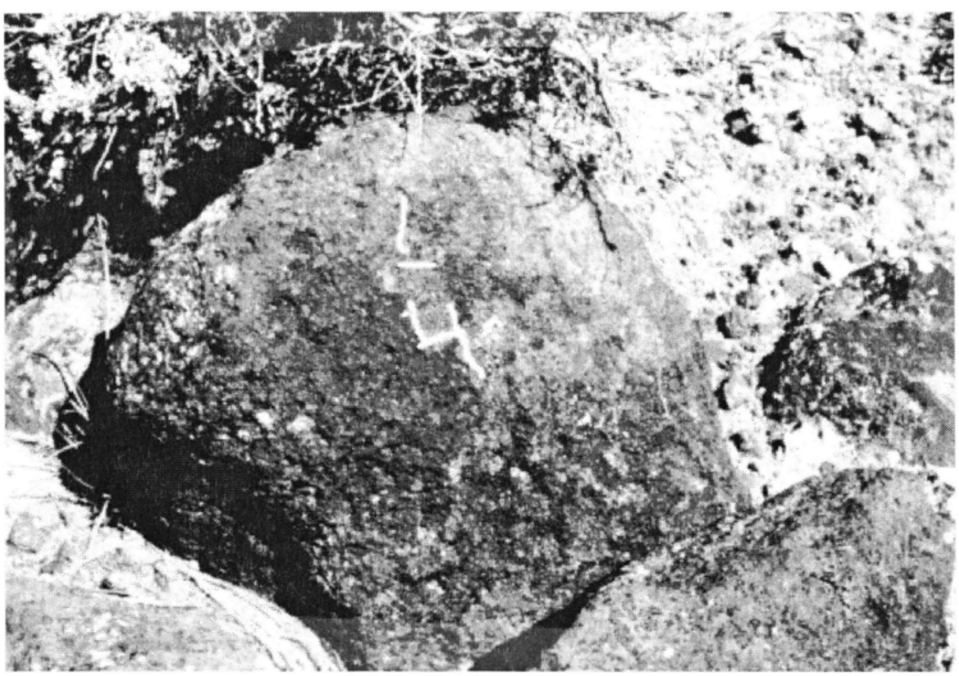
A poorly marked township rock corner. Marked lower left side.

Figure 24 - 9



A wooden section corner. Scribing is faint and barely legible. Any found corner should be marked with a steel post to aid others to find it quickly.

Figure 24 - 10



A well-marked ¼ corner.

Figure 24 - 11

Chapter 25

Range Evaluation

Develop a perception of the state of health of the soil-vegetation complex, sometimes called Range Condition. Background studies will include Soils, Geomorphology, Ecology and Plant Identification.

If moving to a new area, locate soils maps of the area. Failing this, get a geology map and ask a local geologist to interpret the rock-to-soil process. Soils near a mountain will have derived from parent rock of the mountain. Thus pre-Cambrian granite will be expected to produce almost sterile soil; Jurassic sandstone will produce deep sandy soils, etc.

Determine the conditions prevailing in recent and earlier geologic periods. For instance, Lakes Lahontan (Nevada) and Bonneville (Utah) dried up a mere 10,000 years ago and since annual precipitation in the area is low (5 to 7-inches), there may not have been time to ameliorate the salty lake bottoms into productive soils. Only above 7,000-feet elevation in Nevada is found black rich soil, lending credence to Lovejoy's Theory of the Miocene-Pliocene lakes. Understanding how the soil was developed is essential to understanding the ecology of the plants.

Soils

There is comparatively less activity and creatures above ground as compared to below ground. Below ground is teeming with millions of bacteria, virus, protozoa and even nematodes. Bacteria and viruses divide to form new organisms, and at a rate of some 300 generations per day. Protozoa reproduce sexually so are much slower. Nematodes feed on dead plant roots and may starve if the plant dies. And bacteria seem to feed on others who feed on decomposed plant litter. All are essential for healthy soils (Wilson Quarterly. Pg. 50).

Nematodes are a primary producers. Numbers vary from 250,000 to 112 million per square meter of soil. There are different species of nematodes on different vegetative sites. Nematodes do not need water, as do bacteria and fungi. Plants can lose 60% of their root systems to drought; 90% of a plant's biomass is below ground. Most nematodes are herbivorous, they poke stylus into other cells and suck the innards out. If nematodes are killed by catastrophic forest fires (for instance), there may be an increase in root and top biomass of grasses. Heavy clipping increases nematodes. If high levels of nematodes, some 12 million square meter of soil, they eat 75 grams of roots per growing season. Recent trials with varieties of wheat show some are resistant to nematodes. Perhaps someone will do a trial with crested wheatgrass and see if the same is true with this grass. Early grazing increases soil flora which die and become nutrients for grass (Casper meeting notes).

Try to determine what climax vegetation is expected under local soil and climatic conditions, and then determine how much of a disclimax is present and why. Determine the probable mix of plants in climax vegetation by hunting relict or natural areas. Cover the entire area where similar vegetation grows. Look for the best mixture of taller grasses that can be found on the same soil type and aspect as the problem land. There may be only a few acres, or it might be an entire ranch. Once it is found, photograph it, write up the vegetation complex, and study the past uses of the relict area. This is a comparison area that can be seen, tasted, felt, smelled; no longer is it an idea of what once was, it is fact. Hint: The NRCS had done this in many areas of the West. The vegetation near Pecos, Texas, bears no resemblance to the climax vegetation found on Diablo Plateau east of El Paso, yet it should be the same.

Do not fall into the trap 'all Nature is sublime and only man is vile'. Many vegetation changes and erosion scars are caused by nature; be sure of the cause before assigning blame. Erosion is a natural process, caused by gravity. A mountain is, geologically speaking, perched sediments waiting to be moved to an ocean. Man can slow erosion of fertile soils by manipulating plants and animals and this is a worthy goal.

Two sure signs of improving health of the rangeland are young (yearling) diverse climax plants and the presence of litter. Seedling plants mean only that favorable climatic conditions happened this season; most of the baby plants will die of drought before the next growing season. In the hot desert, the sun will oxidize any fine litter; dead plant roots enrich desert soils.

Extend the investigation by digging holes to see what the soil horizons can tell. See Chapter 19, Revegetation, for details.

Adopt a proven method of determining range condition, such as an agency method and use it to improve your understanding. You'll improve or shortcut the method as experience grows. A drawback is that most agency methods change with each agency change in Washington DC. It is suggested that the old Soil Conservation Service range site and condition class methods will provide a good base.

Range Condition

Range condition is generally defined as the present plant composition as compared to the plant composition in a pristine state (before the advent of domestic livestock). There is also an inference of productivity of the species. For various political reasons, other definitions are rampant. A range cannot be returned to pre-Colombian condition, because no one knows what was there then. Besides, that was before the Little Ice Age during which climatic conditions changed vegetation drastically. I suggest that range condition be defined as what plant composition we have today as compared with what the land needs to be protected from excessive erosion and to fulfill the uses of the land. This requires determining what are the highest and best uses for that particular piece of geography. Nonuse does not qualify as an option; it is a treatment, a temporary treatment. If livestock are removed, the value of the forage for grasshoppers, rabbits, and wildlife will decrease. And in many cases, perennial grasses disappear to be replaced by annual plants and brush, in the continued absence of grazing.

Man's cities, factories, highways, farming and grazing have drastically altered much of the western U.S.A., major factor was man's control of fire. The Great Plains vegetation developed under the pressure of enormous herds of buffalo, deer, elk, and antelope, so the pre-Colombian vegetation on the high prairie may be similar to present day vegetation complexes. There are areas, however, where a tall grass prairie was changed to a short grass prairie. Read the record of the Abilene Grass Experiment Station in the late 1800's (printed about 1905). This change may have been natural as the Little Ice Age ended in 1850, accelerated by livestock use. Intermountain Basin vegetation supposedly developed without heavy wildlife grazing; however, recent studies indicate that mastodon, etc., heavily grazed the area some 5 to 10,000 years ago and Bison thrived during the Little Ice Age (1400 to 1850) in eastern Nevada.

Be aware of an outline for sustainable rangelands exists at: *htttp://sustainableranglands.cnr.colostate.edu.*

Do not confuse the United Nation's definition of sustainability with the real world one. The UN would do away with private property rights and have state governance of all natural resources. The UN meeting at Rio de Janero laid out the plans for the 21st century in Agenda 21. Which is. *REQUIRED READING* for all Wildands workers. You find it on the UN web site.

After discovering the probable mix of plants in climax conditions and comparing that with present day plant composition, decide how far it is practical and economical to move (manage) toward climax.. Why try? Because the most nutritious plants should be dominants in the climax plant community. These plants result in livestock gains of about 3 pounds per head per day. Since these plants are preferred by all herbivores, they are the first to be grazed out in the absence of management to be replaced by plants with lower palatability which are less nutritious and produce lower (or negligible) weight gains. The climax plants are also excellent soil protection for watershed purposes and to feed wildlife.

It is virtually impossible to eliminate all the climax plants from a range area, so some system of discontinuous grazing will help the remaining plants to recover, make seed, and reproduce. A healthy climax plant can out-compete most invading plants. The recovery of a range can be a distressingly slow process with progress measured in decades; hence, the demand for plowing, spraying, and seeding.

Today is the day of the grazing system salesman, with various persons making their pitches for range improvement, (without reducing livestock numbers) in a few short years using *THEIR* system. Each system has merit, none is a cure-all. Study the systems, find the good points and flaws in each as they relate to a particular range area.

Proper Use of Rangelands

Proper use has been defined and redefined. To most government agencies it means to graze no more than 50% of the current year's growth of the most palatable plants. To most ranchers it means grazing as much as possible of all the plants without weakening them.

One item over which there is little dispute is that a plant will die if defoliated excessively over a period of years. A great deal of recent research deals with the phenology (seasonal development of plants) and the effect of clipping at various growth stages. Learn all the books and instructors have to say about plant physiology. Then spend a few days watching tame livestock graze a pasture. Livestock graze from the side of a plant, one bite per plant. Horses bite, cows tear the vegetation (and so may uproot young shallow-rooted plants) using tongue against teeth since they have no teeth above. Sheep and goats also tear.

There is no resemblance to livestock grazing in the researcher's shears. Only on the fourth or fifth trip over a pasture will the plant top be grazed flat by livestock, and this approaches overuse. Phenological studies show that most grasses contain half their weight of the new growth in the top 2/3rds of the plant. Black grama must be grazed to 80% of its height to achieve removal of 50% of its weight.

Watching the animals graze, note how selectively they graze, even on a monoculture (pure stand). On subsequent trips through a pasture, note how livestock prefer regrowth of a previously grazed plant.

When distance from water and topography are introduced as factors, you decide that if there is one animal in a pasture some plants will be overused. Correct. The animal can be a jackrabbit. So two management plans are presented: (1) Recognize that some overuse will occur in valley bottoms and near water and 'X' percent of overuse is acceptable so use can be made of the outlying areas.

Or (2), go by the book and remove the livestock as soon as one palatable plant next to water is grazed down. The rancher cannot live with the second option; he can't pay his taxes because too much forage is left untouched, so he goes broke. This second option is used only on public lands.

Some experts, notably August Hormay, ignore proper use entirely and depend upon periodic rest to restore plant heath and vigor. This premise is effective, if the grazing period never extends through an entire growing season, because of the habit of livestock to re-graze regrowth.

Adopt a sound method for determining proper use. The Wildlands worker must examine and record the health of vast areas of land each day spent in the field. The method must be a rapid extensive method.

Learn Schmutz' Step-toe-and-Photograph method, the philosophy is excellent for Western ranges where rainfall is erratic.

"Take some and leave some" is a popular mantra. Dead vegetation left on the ground after frost is not wasted. There is a rule called Manning's (n), which deals with the coefficient of friction of running water. The dead vegetation slows the flow of water across the land and gives it time to sink into the ground, helps filter out the silt. Recent work in New Mexico by Holechek, indicates one should graze one-third of the current years' growth to have some for next year when it may not rain at all in the Sonora or Chihuahuan deserts.

Range Plants

The ecology and physiology of range plants have long been studied. Sort from this mass of material the information needed. Plant identification comes first. Carry a small pocket notebook in which to mount the plants found, with identification as soon as possible. Keying the plants is tedious, unless there is a specialized key of the area (e.g. Coulter's 1898 Botany of West Texas, for the Trans-Pecos area). Most herbarium keepers are reluctant to permit search of their files. Reliance on verbal identification is shaky, particularly with desert plants, which may bloom only once in 20 years. Use the plant keys for the ordinary plants and try of find a plant identification specialist for the plants that defy keying.

The phenology of the plants must be known to properly manage them. The Journal of Range Management indices and the newer Journal of Range Ecology and Management are good source of information. Also check Ecology and Ecological Monographs.

Foreign literature with suitable translations is difficult to find although many U.S. researchers publish in these magazines. Certain Masters and Doctoral theses will have valuable information, but finding this information presupposes that you are aware of the work. We Must Network!

The phenology of plants is the seasonal stages of development. Usually these begin with Green-up, then on to Seed Stalk Emergence, then Flowering, Seed Ripe, Seed Shatter, and Dormancy. The physiology of a plant runs something like this. Most cold desert plants begin growth at snowmelt time, using water in the soil. Hot desert plants begin growing when the rains fall. The new green growth is fueled by food stored in the root the previous growing season. When sunlight falls upon the green leaf, a truly marvelous process is initiated, the upshot being the formation of simple sugar. Sugar is soluble and can be moved around in the plant as needed for food. The food is used to promote growth of both tops and roots. At a particular time, based on length of day, or on the availability of food, or sometimes on temperature, the plant begins to make seed. First comes the seed stalk, then the florets form and it flowers and casts its pollen. If grazing interrupts the seed making process here, the plant may try again to make seed. If the process is interrupted at flowering time by drought, it will not try to make additional seed stalks and the plant will go dormant.

Once the seeds begin to form in the seed heads, the process is irreversible. The plant will use every last bit of food from anywhere in the plant, including that stored in the roots, in an attempt to make viable seed. It is during this time that the plant is most vulnerable to grazing. After the seeds are mature, then the food made in the plant leaves will go to storage to initiate the next year's growth.

Examine the plants of the area to determine the dates for the various stages of the plant's growth. Record this data in ink. After several years, an approximate date can be determined for plant green-up, when it will be in flower, and when seed will be ripe. This information can then give some stability to dates to turn in the livestock, dates to move from a pasture to allow seed to develop and set, and dates that the plant will be dormant. Although dormant, the plant is still alive and respiring, using food stored during the growing season after seed has ripened.

The most important point is that food is made in the green leaves. No leaves, no food is made, the plant dies. If seeds are broadcast on well-prepared farmland, planting rates are from 40 to 100 pounds of clean viable seed per acre. On the Wildlands, no one can guess how many thousand of seeds must be spread by the wind before one seed falls into a nook where it can germinate and grow into a plant.

Most of the moisture in the top 6 inches of the soil is lost to evaporation, so the plant must make deep roots if it is to survive the annual drought. It needs food to make roots. The plant needs to rest only periodically to store food for regrowth and to make seed. It can be grazed during the time it would be setting and maturing seed without severe damage if it is allowed to grow the next year, and if it rains.

The ecology (the study of an organism in relation to its environment) of the range will require study and effort. Livestock are not the only herbivores, at times rabbits multiply to eat all the grasses and forbs, at times grasshoppers can denude an area, on some years tiny thrips and other bugs eat masses of vegetation. Deer and elk will eat the last leaf of a grass without showing signs of regret.

Most range plants in the hot and cold deserts have the ability to live for years with only a few short leaves emerging on spring green-up. This is apparently a device to escape death by overgrazing by rabbits or grasshoppers. Death occurs when the reserves of food in the roots are completely exhausted. Once grazing pressure is reduced or eliminated, grasses will appear where none was apparent before, coming from under the sand and from old plant crowns. For this reason, rest a pasture for a year before planning some more drastic and expensive method such as plowing and seeding. Nature has enormous recuperative powers.

Precipitation Patterns

Understand the precipitation patterns in the area. During the summers in most of the Western U.S. the precipitation comes from thunderstorms. Since the daytime temperatures reach 90 to 100 degrees, the thunderheads must be very tall. Rain cannot begin to fall until the cloud temperature is well below freezing, so the clouds are usually at an elevation of about 30,000-feet. The ice formed in the cloud begins to fall. If it is just a small droplet, it will evaporate (called 'virga') as it falls through six miles of dry atmosphere.

The turbulence in the thunderhead recirculates the ice droplets until they are good-sized hail and heavy enough to fall from the updrafts. The hail melts on its way to the ground and strikes the soil as a large drop. It is large enough and hits hard enough to make a small crater in bare soil. The raindrop picks up silt particles from the crater. Water sinks into the soil mostly by gravity coupled with "hydrostatic head" which is the depth of water needed to weigh enough to be able to enter that particular soil type. If the water is full of silt, the silt is filtered out at the soil surface and infiltration all but stops, so there is lots of runoff of muddy water. Where raindrops fall on vegetation or litter, the raindrops are broken up and fall a spray that soaks into the soil very readily. Dig some holes next time it rains and see for yourself.

Conifers, and junipers in particular, have been found to intercept the first ¼ inch of precipitation from a storm and hold it up to be evaporated. By checking local rainfall records, determine how many precipitation events are less than ½ inch and subtract this from the annual total. Usually it figures out to be about 25%. Thus, when a good cover of juniper invades a range site, it changes the precipitation available from 12 to 8 inches, moving the site from semidesert to true desert.

Weather

Learn how to calculate 'degree days' to be able to predict proper turnout time for livestock grazing (*Click on www.ipm.ucdavis.edu/WEATHER/ddconcepts.html*).

Basically, read the high and low temperatures for yesterday, add them together, divide by 2. Subtract 50 from the remainder. The result is the degree days for yesterday. If a negative, there are no degree days. Every plant and animal and insect needs a certain number of degree days to break dormancy, to hatch an egg, etc. So you can keep up with when the grass will be ready to graze, when the grasshoppers will hatch, etc. (Capital Press, Nov. 23 ,2007).

Leafy spurge can be controlled by cattle/sheep. Use cattle early since the spurge contains 18% protein early, too hot for sheep. If must use sheep, inoculate with Clostridium pferingens Type D. Later in the year protein drops to safe levels for sheep.

Yellow star thistle- germination 100% from ray flower seed, Disc flower seeds also geminate well, but at specified temperatures, generally about 20-degrees C (70 degrees F.).

Stream Temperatures

If air temperatures didn't rise 8 or more degrees between 5a.m. and 9a.m., there will be no change in Burnt River's temperatures that day: Flow is 105-cfs (cubic feet per second). This is a stream large enough that water temperatures are not affected by streamside vegetation. Only streams of less than 1-cfs (about 500-gallons per minute) are affected by streamside vegetation, both in a rain forest and in a clear cut. Ambient air temperatures control water temperatures in streams of over 1-cfs.

Buffer strips are useful in eliminating sediment deposits into stream. Thirty feet is a proper width; wider strips have no more effect. Sedges are a superior buffer zone vegetation because of deep roots and rhizomes. Stubble height is less important than stem numbers.

Mountains flush bacteria in four years, foothills in ten. Intermittent streams should have vegetation in the bottoms (Notes from Casper Meeting-50th).

A spring snow storm can be unexpectedly heavy.

Chapter 26

Grazing Management

A grazing system is a method of managing grazing herbivores so they don't eat themselves out of house and home. Animals never discipline themselves in their eating habits, show no remorse when they fang off the last blade of grass.

The rancher's problem with acceptance of a grazing system is, I suggest, genetic. Man has been a meat hunter for millions of years and seems to be genetically programmed to watch for movement. It takes years of training to divert his attention to the vegetation. The rancher is in the forage growing business. It is difficult for the old-time ranchers to recognize this; he thinks of himself as a livestock grower. Actually he is both, but traditionally his attention has been focused on the livestock.

Those who graze livestock, in the final analysis, are using livestock to harvest vegetation. Under intensive methods of growing vegetation (farming), machines are used to harvest because they are more efficient in getting maximum yields stored. The use of animals to harvest alfalfa, for instance, is seldom economical because vegetation loss is high due to trampling and defecation, plus bloat danger to livestock.

On the Wildlands, vegetation is harvested with animals because the vegetation is sparse, grows in mixtures of edible and inedible plants, and too many mower blades are broken on the rocks and trees.

The type of animals used to harvest Wildlands vegetation is tailored to the feed available. The cow, having multiple stomachs, is more efficient and can digest and extract more energy from coarser forage than can horses (who have a simple stomach). Sheep and goats have multiple stomachs but prefer finer forage. Goats will browse on woody plants; thus some areas furnish more energy for goats than for other classes of livestock. Deer, elk, and buffalo (plus some exotic animals) are favorite animals to propagate on Wildlands areas, and some ranches have sold the livestock and exist on hunting fees or hunting leases from urban hunters.

The function of the herbivore is to harvest the vegetation, extract the sun's energy from the forage and utilize this energy to produce meat and fiber. Whatever kind of beast that does this best on a particular piece of geography is the kind that should be used.

One of the jobs of the Wildlands worker will be to gently point out to the rancher that the vegetation will not stand continuous livestock use and flourish as of old. This is because of 'spot grazing'. Livestock have a definite preference for certain plants under certain conditions. Wildlands grows mixtures of plants, generally from 20 species to over a 100 species within an area. The animal picks and chooses which plants it will eat and which it will not eat first, and which plants it wouldn't touch with a 10-ft. pole. The nutritional difference between ice-cream plants and meat-and-potatoes, simmers down to about 2-pounds more gain per day by the animals according to early researchers in West Texas, comparing animals on side-oats grama to those on tobosa grass.

This preference may extend to an area. Cattle heavily grazed a 40-acre parcel in Wyoming. Not a bite was taken off half of the pasture; all the use was made on the 20-acres on the south side. Perhaps the grazed area had been in alfalfa, was richer, grew better tasting grasses? This area grazing will be found on almost any ranch; cattle will trail through a nice tall patch of grass to another area where they will graze. Different areas will become popular throughout the year.

To the livestock grower, rains mean grass, and no rain means no grass. True. No matter how clever a grazing system is concocted, it will fail on a drought year. Plan for the next year.

The U.S. was settled from east to west, the settlers were used to wetter climate. They stocked at a rate of 1 to 3-acres per cow in Kentucky and Illinois, so those were the beginning stocking rates when they came west. The settler arrived during a period when the native population had been almost wiped out by diseases imported by Europeans. Prior to this time, the natives had kept game numbers in check (If it's brown, it's down.). Before the game animals could rebound, the settlers arrived to find abundant forage. In many cases they encountered 'virgin' stands of grass; it took several years for the livestock to change the vegetative composition. When the Great Drought of the 1930's hit, some of the tall grasses vanished.

Mourning over lost vegetation complexes is the height of futility, since no one knows what mixture of plants occurred back then. Nor will nonuse bring the vegetation back. Most of the really sad areas have been fully occupied by woody species such as mesquite, juniper, or sagebrush. A fire-storm someday will eliminate the woody plants and then the herbaceous species may have a chance to establish. Where sage-brush as been burned, too often it is replaced by rabbit brush, an inedible shrub.

Distinguish between hopeful areas and hopeless areas. In 1912 an eminent scientist determined that lands in Arizona that lay below 2,500-foot elevation were not suitable for livestock grazing because the perennial grasses grow only some years. The first year the author lived in Las Vegas, NV, it rained a total of 1.11 inches. Any attempt at rest rotation grazing systems here are doomed to fail. In the hot desert, it seems best to ignore the scant perennial grazing and base grazing on the annual or ephemeral vegetation, which may not appear some years.

Areas proper for improvement through grazing are limited to those above the hot desert and excluding areas clogged by weedy woody species. Check the soil before trying improvements to be sure the soil is sufficiently deep and fertile for the planned improvement.

Planning the Grazing System

The first step is a vegetative inventory. Some plants are edible only to a certain class of livestock. Some plants are required by wildlife and some are ignored. Some plants are used by all herbivores. How can you find this information? Find some old palatability tables that were used with range surveys and use this information as basic. Refine the data with the local Wildlife people and stockmen.

List the plants needed by birds and bees as well as by the deer and antelope. Some seemingly worth-less plants are valuable for a certain use, such as the cholla cactus in Altar Valley in Arizona; here 80% of the bird nests are built in cholla cactus. Local Fish and Game people can help estimate wildlife numbers.

Included are the numbers of livestock and wildlife the ranch or allotment should support and which specific plant species will support the animals. This list will take some thinking, reading, and observing to complete.

Recognize that on drought years, cattle are required to 'condition' the grasses for elk and antelope. Whenever cattle have been removed from antelope ranges, the numbers of antelope have plummeted. In the days of the buffalo, the numbers of antelope almost equaled the buffalo and they grazed together, the antelope grazing the short nutritious regrowth of the grasses 'conditioned' by buffalo. Cattle serve a similar duty today. Elk herds grazing on ranches with rest-rotation systems have greatly increased numbers of healthy elk. Sage-grouse also follow cattle as they are moved to new area under a rotation system. The young Sage-grouse require bugs and cattle manure attracts bugs.

Extend the columns of the plant list for growth data. When does each plant species usually green-up, when does it set seed and when does it go dormant? Mesquite green-up and leaf-fall occur on length of day, as do many plants. In hot desert areas, the plants green up when it rains and dry up when the moisture is gone. So this average date of green-up is rather nebulous and the need arises to examine the State Probability Charts of Precipitation and also the temperature records for first and last frost. A professor at a University will be in charge of these data, it is no longer a federal function.

From the phenology chart, select the important species, the ones to increase for a reason discovered in Objectives. These will be called 'key' species. Pick the earliest green-up date for the group of key species or if there is only one species, then that date. Pick the latest seed-ripe date. These are the dates for excluding animals from a pasture to totally rest the vegetation. Can the rancher afford *NOT* to graze for this period of time? The livestock are not to starve, nor is the wildlife. Will fences help? Or water development?

Goals or Objectives

Goals should be tentative until planning is advanced. A goal simply may not be achievable. For example, the allotment may now be running 500-head and the tentative goal is to maintain this number. Leave the exact numbers until it is determined how much forage is needed for other uses, and then see how much forage is left for livestock. If too much forage is dedicated to other uses, reduce these uses to increase livestock numbers to be sure of an economic unit. This may require additional hunts to reduce surplus wildlife, so close coordination with State officials is a necessity.

Figure how much of each of the existing species are required to meet the goals. If there is an 80% sagebrush cover and 20% is needed for Sage-grouse, that's one item. If there are 20% edible grasses and a goal is to feed 'X' head of cattle and 'Y' elk, that is another item. This is figuring Objectives. What should be changed and by how much?

Decide which plants should be increased and how to do it. Will the range user be asked to haul water to an outlying area so it can be grazed? If this happens, what areas will be rested and what improvement is expected? Will a goal be to let the plants make seed? If so, will be livestock be moved back into the pasture at seed ripe time to shatter the seed and to make footprints for the seed to fall into so it will sprout in the spring? And, following this thinking, should the plan defer grazing on the pasture while the seedlings are small; provided it rains enough for them to sprout? Extend the pattern through several years to insure goals will be reached.

Resting the Range

The only essential goal is to rest the range periodically. Tailor the periods of rest to fit the situation, don't always insist on the optimum. If it is unhandy to rest a full growing season, the vegetation will gain some vigor if the animals are turned in at green-up, then moved to another pasture at flowering. The rancher will want the least disruption possible; gathering the cattle and moving them to a new pasture may knock as much as 30 days gain from the animals.

Dates set for livestock movements should be tentative and will be confirmed in the field each season as the phenological phenomena occurs.

Livestock Stocking Rates

Determining proper livestock numbers to run is always difficult and too often, people err on the side of no reductions when beginning a grazing system. Stock at a rate to remove about one-third to one-half of the current year's forage production by weight on the pastures that are grazed. Determine this by clipping a few plants, extend the visual area to the allotment and add in a few palatability factors. The figure will be a guess, but it will be an educated guess. The reason for stocking at a fraction of production is that if it doesn't rain next year, there is a cushion to fall back on and the rancher has time to dispose of some livestock to help balance forage and hungry mouths. Some ranchers carry over yearlings and if it rains, they graze out the animals. If it doesn't, they take the yearlings to town. Flexibility is essential, daily, weekly, and monthly. Precipitation on Wildlands seldom if ever is Average. Grazing strategies should change as often as needed.

If it appears that a reduction in numbers is needed on a ranch, run these figures by the rancher as an exercise:

There is a ranch which will run, conservatively stocked, 500 head of cows. If stocked with 1,000 head, this is what will happen:

Cows - 1,000	Cows - 500
Calf crop - 50%	Calf crop - 80%
Calf weight - 300 lbs	Calf weight - 400 lbs.
Price per cwt - $80	Price per cwt - $90
Cash income - $120,000	Cash income - $144,000

The 1,000 cow spread will expect a higher death rate, increased labor costs, increased feed costs, etc., which will make the disparity even larger in favor smaller herd.

Considerations

The rancher may have spent a lifetime breeding a herd of cows exactly suited to his eye and the ranch. They are his pride and joy. If the range is cross-fenced, this will fence some of the cows off the nook where they have lived all their lives. These cows will walk the fence line, trying to get back home. The calf may die. These cows will have to go to town (be sold), and replaced with more amenable animals. The rancher must know of this possibility before he signs approval of the grazing management plan.

When planning interior fences, consider fencing on vegetative type lines. Inspect the soils to determine if a vegetative type, such as sagebrush, extends through several soil types. On a valley site with heavy soils, the key species may be Basin wild rye. On the adjacent upland, the favored grass species may be galleta. The two species have different phenological dates and will be easier to manage if the soil type is uniform within a pasture. If fencing federal lands, it may be best to fence on section lines because the land is always subject to sale or trade.

Chapter 27

Some Suggestions on Running a Field Trip

by

John Buckhouse, Extension Range Specialist

How many times have you bounced along in a school bus, for miles over dusty roads, only to be off-loaded at a site where everyone wandered around, talking in small groups, ignoring the speaker, and were then loaded up again for the next site more miles away? Grim, eh? Moreover, it is all too common.

After leading field trips over many years, I found several things that work for me. Some of them may work for you too. Consider this:

1. Reduce the number of stops. I think three or four are probably plenty in the course of an all-day trip. I want them to be educational not just an exercise in variety.
2. Choose each site carefully. I like knolls where everyone can sit in a circle and everyone can see a variety of things that the leader can point out.
3. Encourage discussion. However, do it in the context of education and group participation. If you get everyone in a circle and ask for points of view and/or explanations of what they are observing, it will work well; otherwise, you get small groups drifting away and distracting the focus.
4. Search and regroup. Sometimes, after a few minutes in the group, I'll give everyone a task, set a time limit and ask them to walk around, looking for some specific things, then regroup for discussion.
5. Encourage each person to make new acquaintances. The best way I have found to do this is to make a rule "that no one can sit in the same seat, next to the same person, more than once". On field trips using vans or cars, I tell everyone to ride in a different vehicle after each stop. People tend to be remarkably territorial. If you leave them alone, they will always go back to their original places. However, with encouragement, they will sit elsewhere and learn a terrific amount from each other.
6. Have a wrap-up where everyone speaks. Obviously, this gets tougher if you have groups in excess of thirty people. However, I have found that you can have a wrap-up where each person speaks to a question such as "how did this day alter my thinking and how will it impact me on the job back home?" You will get very thought-filled replies. More than that, you will insure that there is some sort of closure at the end of the day. If, on the other hand, you let them slip away without coming to some sort of a conclusion, they may never reach a conclusion. Once back at home, there are just too many other pressures to expect someone to spend time analyzing the field exercise…and it can too easily become an opportunity lost.
7. Be sure you know why they are there. I have shifted my thinking from leading 'tours' to leading 'short courses'. I no longer believe it is enough to simply visit a host of sites. I want the day to be a learning experience, a chance to gain from each other's experiences, and an opportunity to come to some conclusions. Thus, a day in the field with me as the leader, is a lot different than it would have been a few years ago. Consider trying it. I will bet you find your field trip time is much more valuable…and much more fun!

Chapter 28

Farming or Ranching Wildlife

In some cases harvesting wildlife may be the major income generating activity. In most cases it is a subsidiary but important income generating activity.

Farm Ponds

If there is or can be a farm pond, it may be a source of pleasure and even income, if it is large enough for fish. Coupled with a meal or a bed-and-breakfast, a small pond would be safe for small children and yet give a day of recreation for a family on vacation.

An old weed-choked pond can be rejuvenated by:

1) Killing the weeds with chemicals or by draining.

2) Drain the pond to get rid of undesirable numbers or ratios of fish.

3) Work the banks to provide a shallow area, then deeper water, which will discourage weeds in deep water. How deep? Depends on the climate. Ideally the pond should be deep enough that it will not freeze to the bottom. If this is a problem see number 6) below.

4) Fish grow best in water that is slightly alkaline. Adjust this as necessary.

5) Pond structures. You will have removed the junk heap while working the pond's slope, now go back and place shelter for fingerlings and minnows to hide, such as brushy tree branches in a bucket of concrete. You will work with local conservationists to improve the bed of the pond before re filling the pond and determining which species of fish to plant and in what ratios. (Progressive Farmer-April-May, 2005)

6) A common problem is winter fish-kill when ponds freeze over. This prevents additional oxygen entering the water by normal wave action. Thus, the decomposition of organic matter continues, utilizing oxygen, but the fish eventually die from lack of oxygen.

To prevent this fish-kill, and to improve water quality, it is possible to aerate the pond using a windmill with a special cylinder to pump air into the deepest part of the pond or ponds.

The continuing flow of air agitates the water and prevents freezing over in a pool some six to ten feet in diameter, usually until temperatures reach minus 20 to 25 degrees below frost (15 degrees F). Using such an aerator permits natural decomposition to occur all winter so the pond is pretty clear of debris come spring. It also supplies enough oxygen to permit fish to survive. Freeze control features the use of RV anti-freeze, which is biodegradable and will not harm the fish.

During summers, aeration reduces stratification of water by temperature. It also reduces algae growth and possibly important, it reduces mosquito larvae, which may carry West Nile disease.

Check with a local supplier for this equipment. One model also has a split cylinder and can pump water with one side and air with the other. Thus, one can water livestock at a nearby trough and still keep the pond aerated. (Source: California Grange News)

Big Game

Raising deer and other animals to be hunted on private land or nearby leased land is a multi-billion dollar business though out the United States.

Most ranches are enclosed with tall fence to prohibit your animals from leaving or scrub bucks entering to contaminate the offspring. Ranchers try to have a least one buck that produces offspring with heavy antlers at about three years of age. His offspring are sought after by city hunters who are willing to pay upward of a thousand dollars for a few days hunt and the chance of dropping a trophy buck.

Some ranches specialize in exotic animals such as Barbary sheep. Many grow bobwhite quail or chukar. The Dakotas and Nebraska are famous for pheasant hunting.

All of these activities help bring in income in a very iffy business; that of cattle or sheep raising. So it behooves the rancher to seek all other sources of income, and wildlife may well be a lucrative sideline or even a main effort.

A 2002 survey by the U.S. Fish and Wildlife Service found that 13 million hunters averaged 17.5 days in the field and that 34 million anglers averaged 16 days. Hunters spent $1,585 apiece and anglers $1046 each. Total spending in 2001 was $55 Billion. (Outdoor Life, September, 2002)

Chapter 29

Other Grazers

Dung Beetles

There are many species of these and some may fit your climate and ranch. Basically, they gather and bury manure. Benefits are many, including removal of dung which may contain worms and cysts of disease.

Ants and Termites

Ants are ever present. Some harvest seed and store it deep in the ground, causing a significant loss. Some harvest dead insects. The ants die and furnish NPK for plants. There are mound builders, carpenter, and harvester ants; hundred of species of each. Density of vegetation has no effect on ant numbers or species. Ant tunneling improves water channels in the soil.

Termites eat dead vegetation, recycling the nutrients. In most places, termites eat 46 to 100-pounds of vegetation per acre per year. In some West Texas areas, termites coat plants with mud to kill them and then eat hundreds of pounds of forage per acre. Real pests.

Grasshoppers

There are over 400 species of grasshoppers, but only 8 to 12 are damaging. They have 5 instars between egg and adult. Climate and daily weather affect numbers. Climate has 30 to 35% of total effects.

The size of a grasshopper's mouth determines what it can eat, but most eat grasses and forbs. Hoppers eat about as much as a cattle or bison herd. Heavy infestations consume over 1 aum/acre, If have 25-plus hoppers per square meter, they will eat 450kg/ha (383 kg = 1 aum).

Body temperatures of hoppers is 35 to 38 degrees C (Hot). If it is sunny, hoppers can control body temperatures to prevent overheating. If cloudy, they have no defense and this slows development.

Birds and spiders have a huge affect on hopper populations by feeding on the 3 to 5th instars. After a hopper is adult it has few predators (Indians and sea gulls?). Hoppers lay eggs all year long but only July and August broods live to hatch. In Arizona, there are more hoppers on grazed pastures, in Nebraska, the opposite is true.

Traditional season-long grazing has three times as many hoppers than twice over rotation-systems (Casper meeting notes).

Pocket Gophers

The gophers' extensive underground tunnels and their heavy grazing can change a site from grass to bare ground and weeds.

Small Mammals on Southwest Rangelands

Cattle can eventually change an ecosystem, but small mammals can do it rapidly. The rodents represent important ecosystem, stabilizing and sustaining agents. On a short grass prairie, prairie-dogs eat all the vegetation if densities are 20/ha.(10/acre).

Where densities are lighter, bison spend most of their grazing time in prairie dog towns because of the regrowth and the many forbs. 25 dogs equals 1 cow.

Rabbits

Rabbits directly compete with cattle, sheep, antelope, and elk.

We have black-tailed jackrabbits, white-tailed jackrabbits (Arizona and New Mexico), cottontail and pygmy rabbits.

Blacktails are born with eyes open and fully furred, ready to run. Whitetails are born blind and naked.

The pygmy rabbit is a sagebrush obligate, and has a winter diet of 99% sagebrush, lives in tunnels in the soil.

Cottontails need heavy cover, Such as big sagebrush thickets, brush piles or old rat nests and prefer to live on the edges of alfalfa fields.

1 sheep equals 15 jackrabbits.

1 cow equals 62 jackrabbits.

Often find 460 jackrabbits per square kilometer (320-acres) around seedings. Normal population is 50 per 320 acres. May find 600 jackrabbits around alfalfa.

Populations peak every 10 to 15 years, No one knows why.

Coyote populations are controlled by rabbit numbers as are hawk populations (Notes from Casper meeting).

Chapter 30

Noxious Weeds and Livestock

All plants contain nutrition and toxins. The toxins do not automatically mean toxic. Even thistles, spurges and knapweed can be very nutritious, but the toxins reduce the palatability.

Be aware that livestock can be trained to eat certain noxious plants along with other vegetation. Start with a half dozen young cattle or sheep, pen them and bring in noxious plants and alfalfa. Be sure the noxious weeds are at least as nutritious as alfalfa; spotted knapweed, leafy spurge, Canadian, Distaff and Italian thistle are.

Do not try to starve the animal into eating the weeds, put all feed in a tub. Start with offering the weeds morning and night. Add molasses to induce them to try the new food. It takes five hours over a 7-day period to train an animal to eat a new food. Lots of nutrients are needed to process the toxins, so feed well.

The few young trained animals will soon teach the others in the herd to eat the weeds along with grass (Source: Pat McCoy at: *pmcoy@capitalpress.com*).

Many ranges have unpalatable food such as common sagebrush, or oak; that cattle and sheep will eat only if fed high protein supplements. These unpalatable plants may contain toxins such as terpenes, menthol, lithium chloride, or tannins. The animals will thrive if the correct mixture of high-energy supplements are fed, then given free choice to eat the unpalatable plant. They can detoxify the forage if they have the supplement.

In Utah, it was learned that feeding a supplement of 50% beet pulp, 30% corn, 5% soybean meal and 15% alfalfa, in winter when sagebrush leaves have the least terpenes, can effectively control size and form of sagebrush where it is becoming too thick. Grasses and forbs are then dormant and able to withstand the high densities of livestock needed. The result of the experiment was better populations of sage grouse and antelope (USDA Utah Experiment Stations - *www.behave.net*).

At one time some 48,000 cattle grazed the coastal watersheds in northern California. These were sent packing by Super Greens, who object to anything not 'natural' on the land. Then, after a nearly 20-year hiatus, cattle were reintroduced because the lack of forbs seemed to threaten the bay checker-spot butterfly. Too much grass. And exotic grasses were getting the upper hand over native grasses without cattle grazing.

Now, in Alameda, Contra Costa, San Mateo, and Santa Clara Counties, cattle are back to suppress exotic grasses, reduce fire danger, maintain a healthier environment, and prevent encroachment of forests.

Animals benefiting from the cattle use include toads, salamanders, ground squirrels, bobcats, coyotes, hawks; plus listed species such as the red legged frog, San Francisco garter snake, and the San Mateo wooly sunflower (Capitol Press - 12/28/06, Don Curlee).

Stone Lakes National Wildlife Refuge outlawed cattle about 1989, but brought them back in 1999 to graze the grass and to suppress weeds so wildlife have their required food.

Also, to reduce grass height so Canada geese can graze on the nutritious short grass left by cattle. Before, the grass was so thick and tall they couldn't even land. The refuge is using sheep on Jepson Prairie Preserve in Solano County, California to control rip-gut brome and medusa head.

With star thistle, don't graze early as it reduces competition so star thistle can grow better as a flat rosette. Graze in early summer when neighboring plants have dried and star thistle is growing rapidly but has not yet set spines. Yellow star thistle has 100% germination from ray flower seed.

Disc flower seeds also geminate well, but at specified temperatures, generally about 20 degrees C (70 degrees F) (Range Magazine, Summer 1999, Scripps-Howard News Service).

Leafy spurge can be controlled by cattle and sheep. Use cattle early since the spurge contains 18% protein early, too hot for sheep. If must use sheep, inoculate with Clostridium pferingens Type D. Later in the year protein drops to safe levels for sheep.

Chapter 31

Publicity

Press Releases and Press Kits, Two Essentials for Wildlands Workers

You should issue a press release for each notable accomplishment. Like a spring development that also serves wildlife; a new fence that will control cattle but permit easy passage of wildlife, etc. Spin the benefits to the land.

Writing: 'The Press Release'

Most experts agree that the words, "FOR IMMEDIATE RELEASE" should lead, followed by who to contact for more information. Name and phone number is minimum; most will include mailing address, email address, phone number and web site.

Use New Courier or Ariel, 12-point font. Bold only on Headlines, and sub head. Or Verdana font is best, if you have it.

The Headline is all capitals, tells what and where at minimum, plus when if possible. There are six parts to a Press Release, Begin writing about 1/3rd of the page from the top.

1) FOR IMMEDIATE RELEASE and who to contact. Name, street address, phone number, e-mail address and web site address.
2) Headlines and sub heads. This should include where, when and what.
3) Date and city of release.
4) Lead paragraph. Here you develop who, what, when, where, why. Be upbeat and enthusiastic but no adjectives. This is not an advertisement.
5) Body of the release, with other information needed to sell the idea. Include a call to action. Or invite readers to visit your web site and your landing page, which gives full information on ordering additional information on your product, etc.
6) Boilerplate. Name of ranch or organization. Repeat how to contact you. Prices, if any; how to order your product, and any special offers or gifts, etc.

If you have more than one page, place 'more' at the bottom of sheet one. The top of next page repeats your headline from the first page and is labeled with the page number.

If sending to print media only, follow these rules: One page if possible, double space, friendly, upbeat, and about 500 words maximum.

However, that is your minor, smallest opening. Your big opening is on the web and here you need not try to keep the release to one or two pages, nor will you double-space it. You are writing to a different audience and market. You are writing to your interested audience, not just customers.

For more information please go to: *www.PublicityHound.com*, aka Joan Stewart, whose freebies will astound, inform and please you. Get her 89 tips for publicity.

Press Kits

Use when releasing a new book or when news headlines call attention to a subject of your press release. Remember they are designed to make a journalist's job easier. If you've done a book realize they no longer have time to read your book, so *DON'T* send a copy (saves you bundles).

A Press Kit contains 8 parts:

1) Press Release. Tie to some current event. Like a new fence to complete your rest-rotation system.
2) Write a Mock book report on the subject. Do a 3rd person, dispassionately but truthfully. Not an AD, no adjectives. Hard for most people to write. Think in sound-byte chunks.
3) Write an article on your book, or on a topic in the book. Works best if nonfiction, but can include research you do for fiction. These are used mostly by magazines as interesting fillers. They are free, but get you publicity. Again, tie to your event. Highlight things your activity or book can contribute to help readers add value to their lives. Ask for a 50-word bio-box if use of article is free.
4) Write topic segments. These are what topics you could you do on a radio or TV show. Or subjects you could write an article on. Think newsworthy. What is your area of expertise? Can you be a source of expert opinion? Title should be like an article title. Two to four sentences indicating applicability to the audience and a hint of what you can contribute to a show. No more than four sentences.
5) Interview Questions. Loved by radio and TV, not too popular with print media, but these give an idea of your expertise so include in all press kits. Start with a biography question, then on to subject and findings or high points of the book. Admittedly easier with nonfiction, but side topics are also interesting.
6) Biography. High points of your life. Write in 3rd person.
7) Sell Sheet, or Landing Page. Prominent!! Tells what the fence is about. If a book what it is about, price, where to buy, etc. Who you are as author, credentials (NOTE: A Catalogue Sheet is different, it is for pitching to a distribution houses and contains different technical information.).
8) Freebies. A cover of your book, a bookmark, once were match books, now postcards. The postcards and bookmarks are printed with information on you and your book. Free information on your web site. Some goodie that will make you memorable.

Place all this info in a manila file cover, inscribe to taste, use color to taste. Mail it to a real person, by name. Always include a cover letter, telling why you are sending this to them; because it fills a need of their particular audience. "Been to your website and think this subject perfect for you."

Do not shotgun. Research to find a particular market.

Again, get on the web to: *publicityhound.com*, and other sources to learn more about how to do all this.

PLEASE NOTE: I would appreciate your comments, corrections or questions about this Revised Wildlands Workers' Handbook.

You can e-mail me at: jimbrunner1@hotmail.com
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I will discuss this book with your Natural Resources class at no charge if the class is using the book.

I extend my thanks to Ewald Stollger Jr., whose help and skill in transferring photos and text using his computer skills have make this handbook possible.

WILDLANDS WORKERS' HANDBOOK - REVISED THIRD EDITION
By
James R. Brunner

This how-to manual gives details on the information the field worker needs to successfully accomplish a task, be it fencing, cattle guards, corrals, water development and most Wildlands jobs. It informs how to develop water from wells, springs or reservoirs and how to pipe the water to further human, wildlife or livestock needs. The recent fires on the sagebrush biome point the need for revegetation, which is covered in 3 chapters; one on Planning, one on Competition Control and one on Seeding. Other chapters deal with water spreading and cadastral survey, that most important of all subjects for landowner and land manager.

Included are chapters on livestock, western slang, driving and camping, horses, map reading, range evaluation and grazing management.

In short, it includes just about everything one needs to know to work or play on the Wildlands.

Here's what others have to say about the *Revised Wildlands Worker's Handbook:*

Dr. Clint Wasser, professor emeritus of Colorado State University, former Dean of Range Management Dept., past president of Society for Range Management, and numerous other honors.

"I read the chapters pertinent to me. You have a brief condensed style of writing which appeals to the practitioner, especially of the field worker variety.

Your book should be welcomed by all neophyte and city bred field workers in natural resources. You perform an essential service to the profession by writing and illustrating practical knowledge the field personnel usually only acquire near the end of their career after they have had a variety of different assignments over a period of years."

Dr. William C. Krueger, Head, Department of Range Resources of Oregon State University says, "I read chapter 27. It is very useful and well written. I enjoyed reading it."

Thomas J. Allen, retired BLM State Director of Alaska, long term Wildland Worker says, "Based on my own experience over the years as a natural resources manager and recent experience doing ranch work, the advice, direction, and 'how-to' explanations are on the money. It would be extremely valuable to persons…and makes it easy for specialists and managers to efficiently look at project options and determine their feasibility.

…every land manger should have the *Revised Wildlands Worker's Handbook* near their desk. More importantly, every person who works in the field should have a copy… it will give them a tool to make needed resource management improvements."

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