Section 8

Water supply and fencing options

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Watering Options for Grazing Systems

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One of the challenges of designing a grazing system is providing an abundant supply of clean drinking water to cattle that are located in multiple areas (paddocks or pastures.) The use of surface water (creeks) has multiple drawbacks. Fencing across a creek is always a challenge because of storm flows damaging the fence, and the fence preventing debris from flowing down the creek. Also, cattle tend to degrade the banks of the creek increasing sediment loading and decreasing water quality.

Mechanical watering systems have many advantages, but also present some challenges of their own. 1. They cost money to install and operate. 2. Many times, there is no electricity available for pumping at remote locations. 3. Multiple pastures or paddocks mean multiple waterers that are not fully utilized when the cows are in a different paddock. 4. Cows tend to congregate around waterers, the waterers tend often leak, and cows spill water, all of which leads to a muddy area around many waterers. Some of these challenges can be addressed and costs minimized by proper planning. This document will describe some of the strategies that have been used to overcome these potential obstacles.

Reducing the number of waterers required

Placing a waterer through a fence enables one waterer to be used from two paddocks. (See Figure 1.)

Figure 1: Waterer between two paddocks.

Care must be exercised to provide enough watering space for cows from each side of the fence, however. For waterers where only one cow can drink at a time, it is recommended to have at least **one cup or bowl for each 15 cows**. (Beef Housing and Equipment Handbook) For a drinking tank, it is recommended to provide **one foot** of accessible tank perimeter **per 10 cows**. That means one ft/10 head on each side of the fence for a split installation. Cows tend to drink as a group, so adequate access to the waterers is important.

Another option for reducing the number of waterers required is to place a waterer in a lane or a common area that can be shared by a number of paddocks. A waterer can also be placed in a working pen that can be accessed from a number of paddocks. This not only provides a common watering site, but accustoms the cows to going into the working pen. Care must be exercised to not allow the working pens to become too muddy however.

Availability of Power

If electricity is unavailable at a remote site, water can be pumped by solar power or a ram pump. (For more information on ram pumps, see http://www.caes.uga.edu/departments/bae/extension/pubs/documents/rampump3.pdf
and
http://www.caes.uga.edu/departments/bae/extension/pubs/documents/homeram.pdf
Solar energy can be used to pump water, and in some cases, may be the most economical choice.

In general, solar pumps are most efficient when pumping from surface water or shallow ground water (less than 50 ft deep.) Pumping from deep ground water requires more energy and considerably more investment in solar panels. Due to the intermittent availability of solar power (nights and cloudy days) a solar powered watering system requires considerable reserve storage, either in the waterer itself or in a tank that feeds the waterers. Another alternative is to have backup batteries that store solar power for use during those times when solar is not available. The batteries and required sensing and switching mechanism for this system are usually more expensive than providing extra water storage. I would recommend 2 to 3 days of storage capacity. A typical 1,000 lb cow would drink up to 18 gallons of water per day in hot weather, but on rainy or cloudy days, would drink considerably less, so I would use a figure of 12 gallons/head/day. This

reserve storage could be in the drinkers, the tank, or a combination of the two.

Stream crossings are still an option for livestock watering, although they have the drawbacks mentioned above, and precautions should be used.

Mud around waterers

"Heavy Use Areas" can be installed around waterers to minimize mud problems. An excellent publication on these surfaces is available from the University of Kentucky at: (http://www.ca.uky.edu/agc/pubs/aen/aen79/aen79.pdf) The idea originated in the road construction industry for stabilizing dirt roads. The principle of heavy use area construction is to stabilize the soil underneath the top layer so that it does not move, settle, and form mud holes.

Figure 2: Prefabricated Concrete Watering Tank on Heavy Use Area

Basically by putting down a layer of geotech fabric, the rock placed on top of the fabric cannot move from side to side, and thus depressions are prevented from forming. Typically this type of construction costs about ½ that of a concrete pad. When choosing the site for waterers, it is wise to choose a site that is high and well drained. In addition, regular checking and maintenance of valves and pipes is important in preventing excess mud as well as wasted water.

Choice of Drinker Type

Individual drinkers like the one shown in Figure 1 have the advantage that they help keep the water cooler and cleaner in hot weather and that they are virtually freeze proof in cold weather. Tank waterers (Figure 2) which can be made of galvanized steel, plastic, or concrete; have the advantage of greater accessibility to a number of animals and more water storage in the waterer itself. Individual waterers must have water provided to them at all times because the water would be quickly depleted if the supply were cut off. That is especially a consideration when solar pumps are used to supply the waterers.

Note that the concrete waterer in Figure 2 has the control valve mounted in the bottom middle of the tank. That protects it from both mechanical damage (cows rubbing against it or running into it) and freezing and eliminates many of the maintenance problems associated with top mounted valves.

Sizing the Supply System

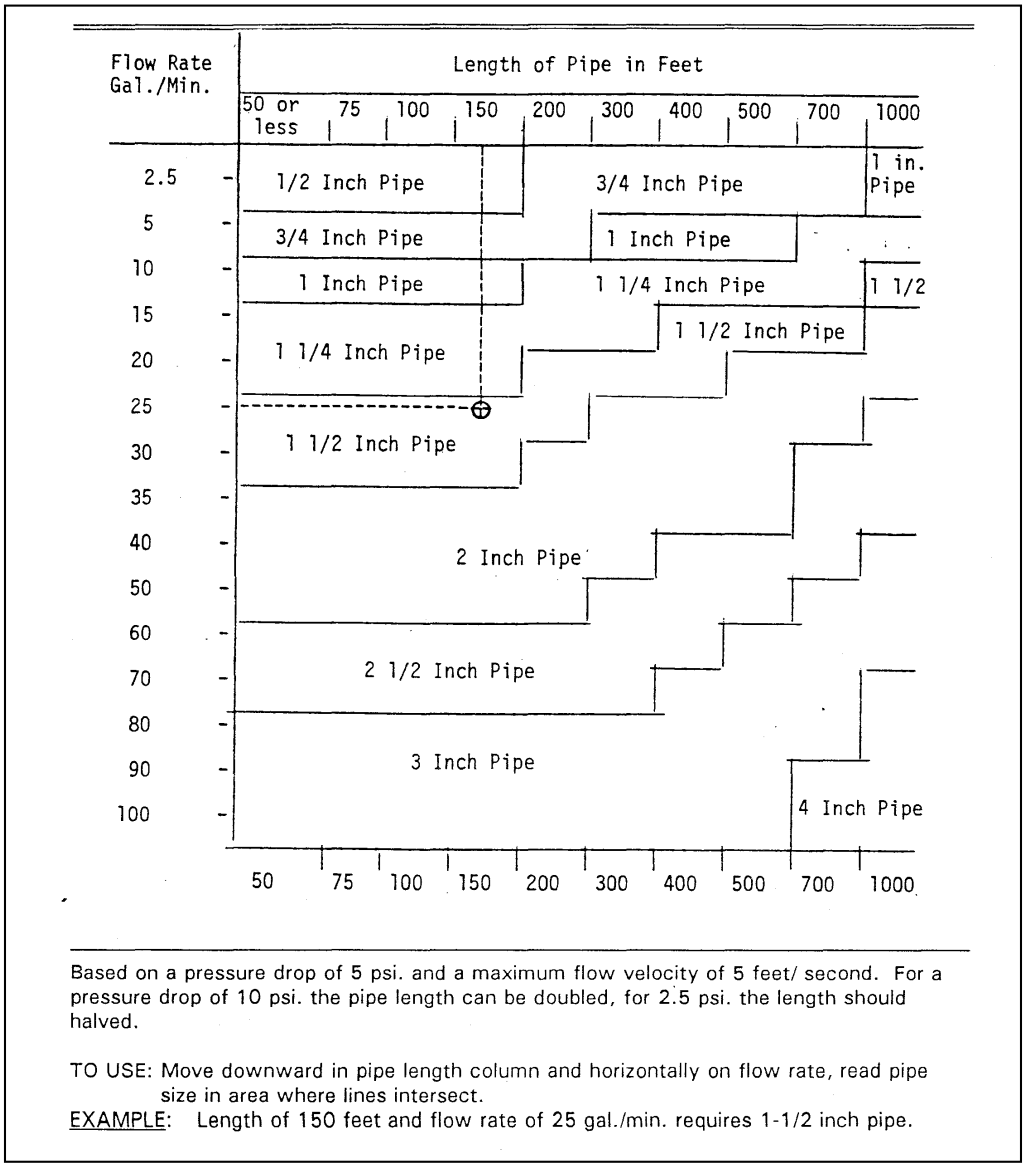
Whether using solar or conventional electric power to pump water, it is important to size the pump and pipe to deliver the maximum needed flow of water without excessive friction loss in the pipe. Three things potentially contribute to pressure drop in water pipes, the length of the pipe, the flow rate of water, and the elevation change from one end to the other. If we try to force too much water through a small pipe, friction loss will reduce the pressure at the waterer reducing the flow rate and sometimes causing the valve not to operate properly. The supply system should be able to pump water for a day in about 4 hours since cows tend to drink as a herd. With a maximum rate of 18 gal/day, 100 cows would need 1800 gallons of water. To pump that in 4 hours, the flow rate would be 7.5 gal/min.

Figure 3 may be helpful in sizing the pipe needed to supply the waterer(s). In the above example, if the flow rate is 10 gal/min, and the watering site is 300 ft from the pump, a 1 ¼ inch pvc pipe would be needed to limit the pressure drop to 5 psi. If sufficient pressure exists to allow 10 psi pressure drop, a 1 inch pipe would suffice. Generally, most home water systems operate around 40 psi, and the drinker valve should have at least 10 psi of pressure at all times. Also, remember that if you are pumping up hill, you will lose pressure as well. For every 10 ft of elevation, the pressure drops (or increases if going down hill) by approximately 4.3 psi. The pump needs to be sized to deliver the needed flow rate at the total pressure it will be working against, including elevation from the water level (bottom of the

well or surface of a pond), friction loss in the pipe, and the operating pressure in the system.

Sanitation

Waterer control valves should always be fitted with anti-siphoning devices. This prevents contaminated water from being sucked from the trough down into the well or water source when the pump shuts off.



Based on a pressure drop of 5 psi. and a maximum flow velocity of 5 feet/ second. For a pressure drop of 10 psi. the pipe length can be doubled, for 2.5 psi. the length should halved.

TO USE: Move downward in pipe length column and horizontally on flow rate, read pipe size in area where lines intersect.
EXAMPLE: Length of 150 feet and flow rate of 25 gal./min. requires 1-1/2 inch pipe.

Figure 3: Recommended Size for PVC or Plastic Pipe

References:

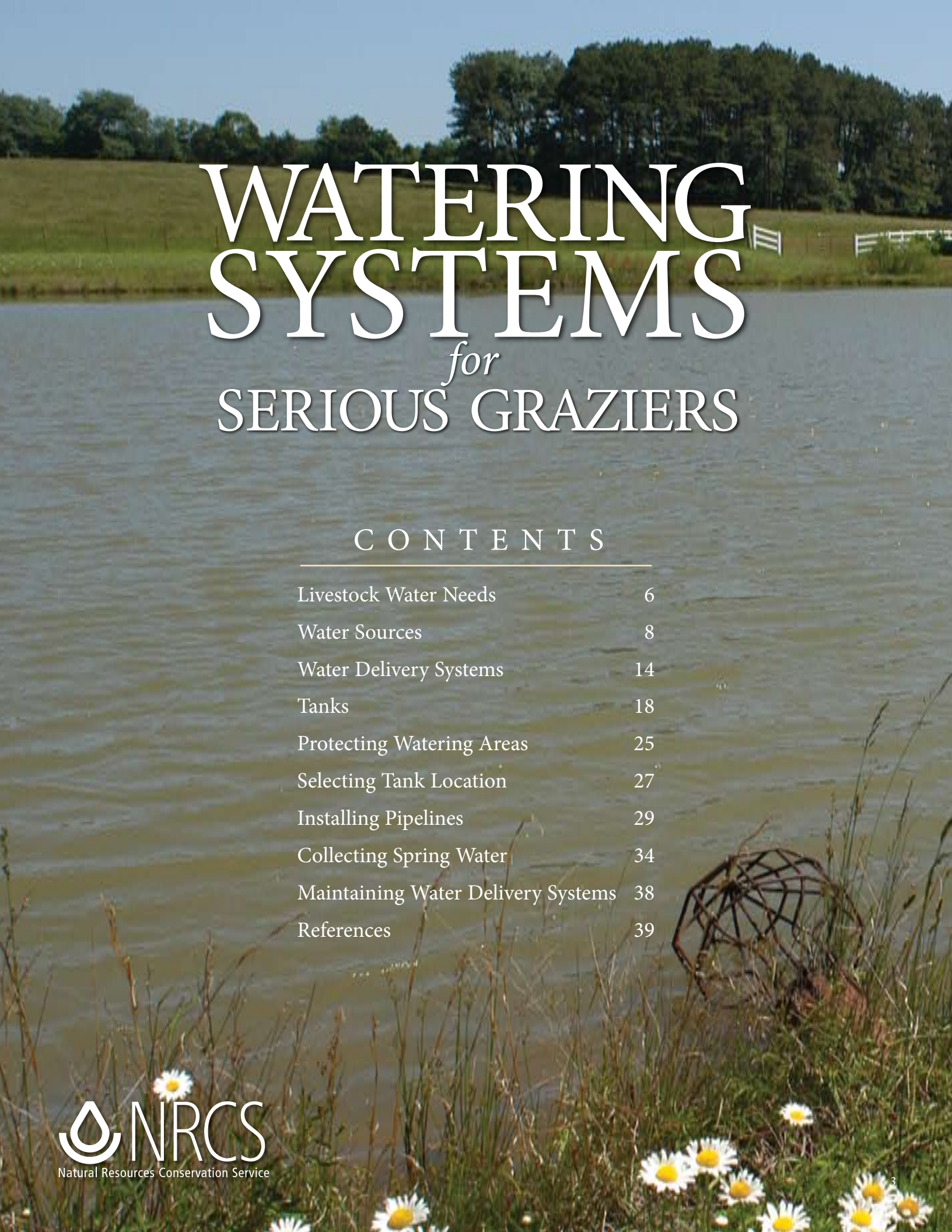
Beef Housing and Equipment Handbook, Fourth Edition. Publication MWPS-6, Midwest Plan Service, Ames, Iowa (www.mwps.org)

M I S S O U R I

WATERING SYSTEMS *for* SERIOUS GRAZIERS

UNITED STATES DEPARTMENT OF AGRICULTURE

NRCS Natural Resources Conservation Service



WATERING SYSTEMS *for* SERIOUS GRAZIERS

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NRCS
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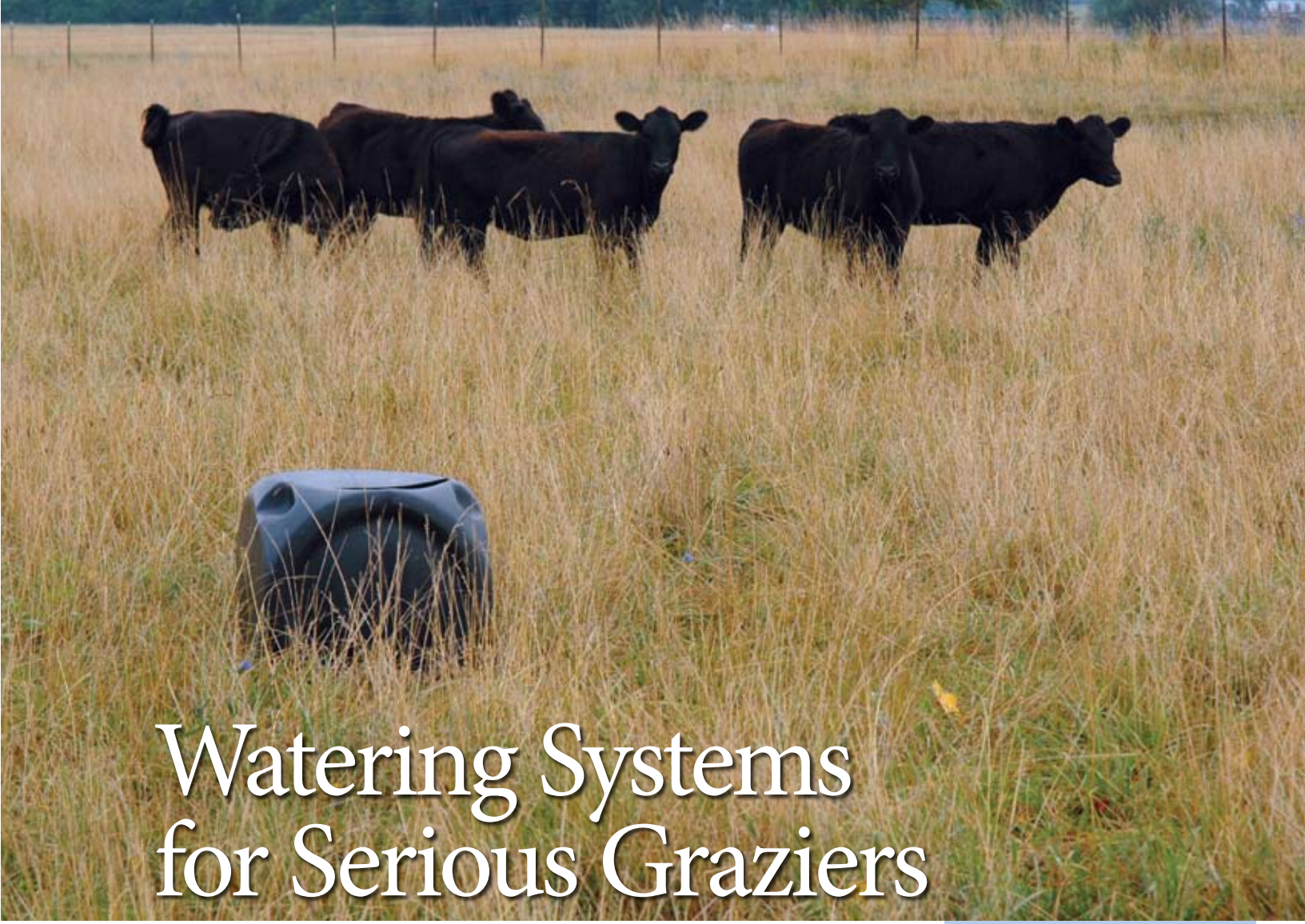

Watering Systems for Serious Graziers

Water is commonly the weakest link in grazing systems because it is the most overlooked and neglected nutrient on farms. Many people do good jobs ensuring that the pasture, hay and grain they feed to livestock is high quality and of sufficient quantity, but they ignore the quality and quantity of their herds' drinking water. The key to animal health, grazing distribution, and forage management is readily available, adequate supplies of quality water.

The cost of water systems is always a consideration, but cutting too many corners will reduce performance, flexibility, and user satisfaction. Well-designed systems constructed using quality components and good workmanship will provide many years of convenient, low-maintenance, profitable use.

The intent of this publication is to provide livestock producers with the basic information that they need to plan, design and install water systems that will maximize animal performance and minimize the labor necessary to care for their herds' water needs.

tip:

For more information about watering systems or how to improve your existing system, contact the NRCS office serving your county. Look in the telephone directory under "U.S. Government, Department of Agriculture," or access this website: ***http://offices.usda.gov.***

Livestock Water Needs

Failure to get enough water will reduce animal performance more quickly and more severely than any other nutrient deficiency. So producers should provide livestock with plenty of good, clean water to drink. A general rule for water consumption is that livestock need one gallon of water for each pound of dry matter consumed. Access to good, clean water increases the animals' intake of water, which increases their intake of dry matter. More dry matter consumption improves animal performance.

The first step in designing livestock-water systems is to determine the water needs or demand of the animals. Water requirements of grazing animals depends on several factors, including species, age of the animals, air temperature, moisture content of the feed, and the distance animals must travel to water. The chart below provides a general idea of how much water livestock require.

As the air temperature increases from 50 to 90 degrees Fahrenheit, livestock need more than twice as much water (see table).

Livestock	WATER NEEDED PER ANIMAL (50° DAY)	WATER NEEDED PER ANIMAL (90° DAY)
Dry beef cows	8 - 12 gallons	20 - 30 gallons
Lactating beef cows	12 - 20 gallons	25 - 35 gallons
Lactating dairy cows	20 - 30 gallons	30 - 40 gallons
600-pound weaned calves	6 - 9 gallons	10 - 15 gallons
Horses	8 - 12 gallons	20 - 25 gallons
Sheep and goats	2 - 3 gallons	3 - 4 gallons

Moisture in the forage or feed can greatly affect the water intake of livestock. Lush pasture growth in the spring can contain enough moisture to meet part of livestock's daily requirements. For example, if forage contains 80 percent moisture and a cow consumes 150 pounds in a day, she is consuming 30 pounds of dry matter and 120 pounds of water, or 15 gallons. Animals also consume precipitation or dew on forage. That greatly reduces the amount of water that livestock need to drink. On hot, dry days, forage moisture is lower, and animals need to drink more.

Here are some other things that producers should consider:

- Water consumption of Zebu (Bos indicus) breeds such as Brahma is generally lower than that of European (Bos taurus) breeds.
- Dairy breeds usually have a higher daily water need than beef breeds.
- Mature cows need 3 to 5 pounds of water per pound of dry matter intake.
- Calves need 5 to 7 pounds of water per pound of dry matter.
- Lactating females require more water than nonlactating (dry) females.
- Animals will drink more water if it is readily available. Research at the University of Missouri Forage Systems Research Center found that water consumption was 15 percent greater in "water-in-every-paddock" systems, compared to systems where livestock had to travel down lanes to get water.

Water Quality

The temperature of water is not critical. Cattle will readily drink water until its temperature exceeds 105 degrees Fahrenheit. Although cooler water has been shown to improve milk production in dairy cows, an adequate supply of clean water is most important.

It is not ideal for animals to have to drink directly from puddles, ponds, streams and other surface water. Bacteria and other pathogens can contaminate surface runoff, which also can be a source of parasite infestation. It is better for the

It is not ideal for animals to have to drink directly from puddles, ponds, streams and other surface water. Bacteria and other pathogens can contaminate surface runoff, which also can be a source of parasite infestation.

animals if each paddock has an appropriately placed water tank. These can be either permanent tanks or portable tanks.

Some research supports the idea that clean water has a positive effect on animal performance. Researchers in Alberta found that steers provided with fresh water gain 2.6 pounds per day, compared to 2.0 pounds per day when provided with pond water. Texas A&M University and University of Nebraska studies also indicate that water quality has an impact on animal performance.

Surface waters such as ponds and streams can serve as satisfactory sources, but only if the animals' access is limited. The Noble Foundation in Oklahoma found that uncontrolled access to ponds or streams leads to loitering and socializing at the waterhole. This contributes to the transfer of internal parasites. Even controlled-access facilities that are larger than necessary encourage animals to loaf. The result is erosion, water pollution and destruction of cover.

Here are some other things to consider:

- Water contaminated with manure may develop toxic, blue-green algae which can poison livestock and cause muscle tremors, liver damage and death.
- High nitrates interfere with the animal's ability to absorb oxygen.
- High salinity causes a form of dehydration.
- Bacteria cause diseases, such as leptospirosis and brucellosis.
- Sheep and goats tend to be more particular about water quality than cattle. Calves will also avoid fouled water to a greater degree than cows.
- Producer experience has shown significant increases in weaning weights and average daily gain for stockers when provided good, clean water.

Water Sources

The importance of good, reliable water sources to successful livestock operations cannot be overstated. And since sources of livestock water vary greatly in cost, quantity, and quality, they are major considerations for farmers and ranchers.

Wells, ponds, streams, rivers, springs, seeps, and public water systems are all options. The locations of operations, the lay of the land, and the types of soil on farms may limit the number of options.

It's desirable to have a couple of different sources of water for livestock. Drought, freezing weather, power outages, broken pipelines, and other events can render one source useless. Having backup water sources can avoid or reduce problems and expenses, such as moving animals or hauling water from off-site sources.

To be viable options, water sources must meet the needs, goals, and objectives of the operations. Water quantity and quality must be adequate, and the expense of developing the sources must be feasible.

To begin the process of selecting water sources:

- Make a list of available water sources;
- Decide if the quality of water from each source is acceptable;
- Estimate how much usable water each source can dependably supply. Remember to take seasonal fluctuations into account;
- Consider whether the source will be adequate for five-to-10 years.

Wells

Groundwater is high quality in many areas of Missouri, and many wells produce adequate rates of flow to serve livestock operations. For instance, most of southern Missouri has adequate groundwater quality and quantity, and wells should be strongly considered by southern Missouri producers as primary sources of livestock water.

Some parts of the state, however, have limited available groundwater. And a few areas have groundwater with high levels of salt, sulfur or iron that makes the water unsatisfactory. The map on the next page gives a general idea of the prospect for good wells in various parts of the state. The Missouri Department of Natural Resources' Division of Geology and Land Survey can provide valuable information.

Drilling wells can be expensive. Most companies charge for drilling by the foot. Reputable, experienced well drillers should know about how deep wells will need to be in their service areas to provide adequate water.

In addition to drilling costs, start-up costs can include expenses for casings, liners, pumps, pressure tanks, pump houses and electrical hookups. But in considering costs, keep in mind that operation and maintenance costs for good wells are quite low.

Producers should consider using existing wells, such as ones serving their homes, as potential sources of livestock water. They must be careful though, because wells drilled for home use may not be capable of serving both their homes and their livestock. If the yield of a well is not known, it should be tested. Pumps should also be evaluated because they may be incapable of servicing houses and livestock.

Wells that are not in use should be considered, too. They may serve the purpose well, but they need to be carefully evaluated before being counted on to provide water for livestock.

A big advantage of drilling new wells is that they can usually be located where they will best serve the operations. Providing electrical service to new wells may dictate location. Electric cooperatives install power lines to wells, but their costs to

MISSOURI GROUNDWATER

MISSOURI DEPARTMENT OF
NATURAL RESOURCES
GEOLOGICAL SURVEY AND
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P.O. Box 250, Rolla, MO 65402

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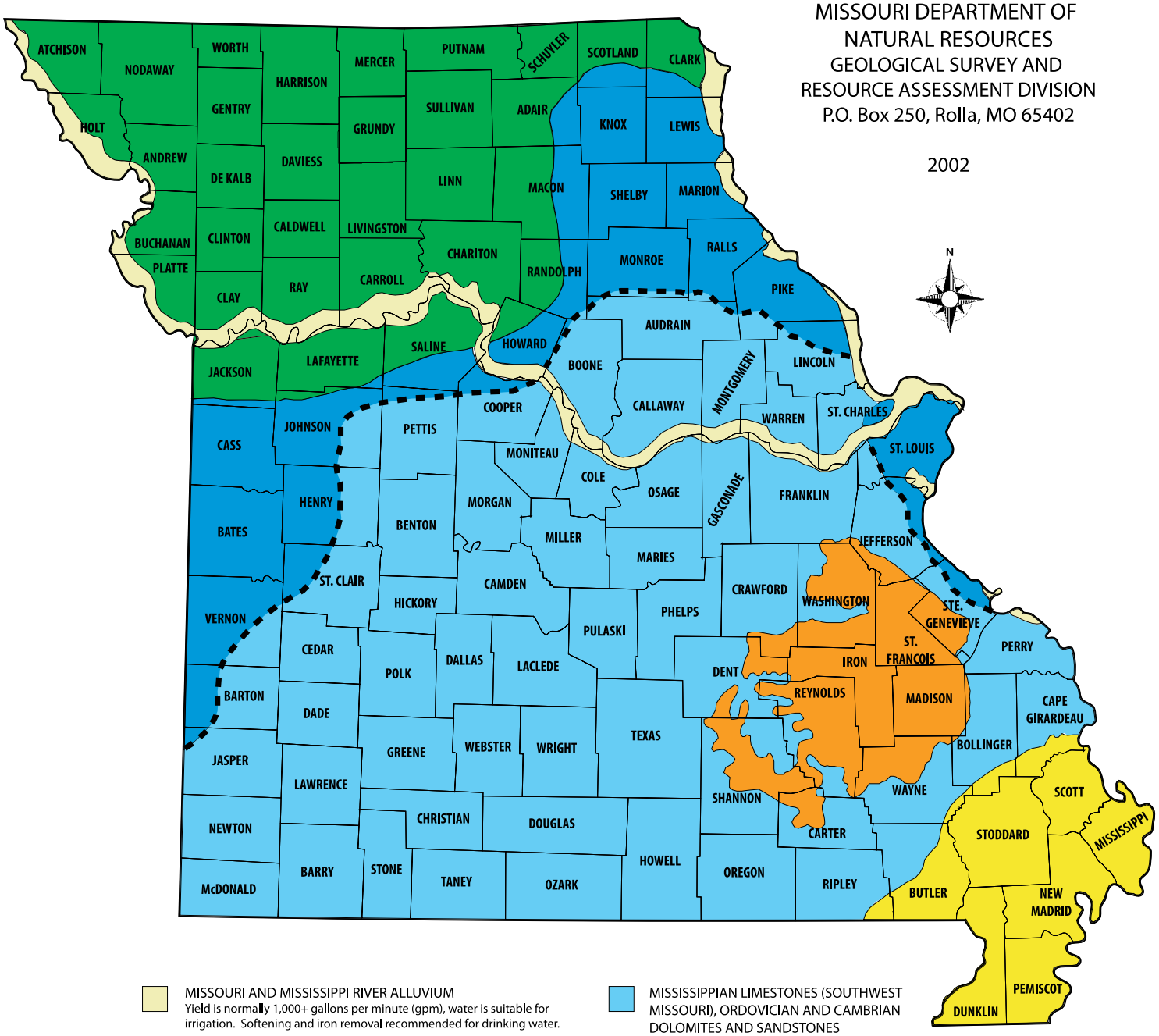

MISSOURI AND MISSISSIPPI RIVER ALLUVIUM
Yield is normally 1,000+ gallons per minute (gpm), water is suitable for irrigation. Softening and iron removal recommended for drinking water.

GLACIAL DRIFT AND ALLUVIUM
Yield is normally 1-15 gpm. Drift-filled preglacial channels locally yield 200 to 500 gpm. Alluvium in lower reaches of major rivers can locally yield 400+ gpm. Iron removal and disinfection is recommended. Bedrock aquifers generally yield mineralized water.

CRETACEOUS AND TERTIARY SANDS, AND ALLUVIUM
Alluvium typically yields 1,000+ gpm; Tertiary sands, 500 to 1,000 gpm. Both contain high iron. Wells in Cretaceous sands typically produce 150 to 1,000 gpm, have lower iron, are softer, have higher temperature waters, and may be artesian.

PENNSYLVANIAN AND MISSISSIPPIAN LIMESTONES AND SANDSTONES
Yield 1 to 15 gpm to depth of about 400 feet. Aquifers below 400 feet yield mineralized water. Wells in shallow Mississippian limestones yield 1 to10 gpm. Deeper high-yield aquifers yield mineralized water.

MISSISSIPPIAN LIMESTONES (SOUTHWEST MISSOURI), ORDOVICIAN AND CAMBRIAN DOLOMITES AND SANDSTONES
Yield 15-500 gpm, depending on depth and producing formations. Yields locally exceed 1,000 gpm in some areas including Springfield, Columbia and Rolla. Yields diminish substantially east of the St. Francois Mt. region. Highly-productive aquifers become mineralized north of freshwater-salinewater transition zone.

CAMBRIAN AND PRECAMBRIAN ROCKS
Dolomites typically yield 15 to 50 gpm. Lamotte Sandstone locally yields 300+ gpm. Precambrian igneous rocks normally yield 0 to 15 gpm.

FRESHWATER-SALINEWATER TRANSITION ZONE
North and west of this line, high-yielding aquifers contain water too mineralized to be used without extensive treatment.

SCALE
0 20 40 60 80 MILES
0 20 40 60 80 KILOMETERS

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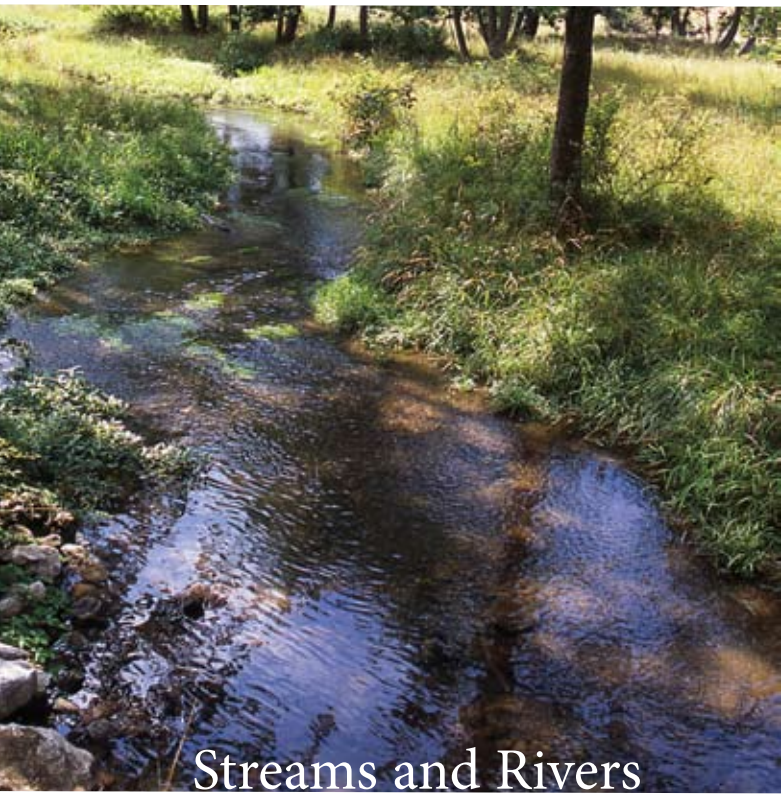
do so are related to how far they have to run the power lines. Policies and fees of electric cooperatives vary greatly, so operators should check with local cooperatives about anticipated expenses before making other commitments. It is often cheaper to bury pipelines than to install electric lines, so it could be cheaper to locate wells closer to electric sources and use more pipe to get the water to the supply tanks.



Streams and Rivers

Producers with streams or rivers on their property have probably used them as sources for livestock water. Stream flows vary a lot by season. Unless they are spring-fed, they may go dry at some time. Evaluate the dependability of a stream's flow, and have an emergency plan in mind for times when the stream fails.

The advantages of streams are that the water is free, and that trees bordering streams provide shade in the summer. But there are several disadvantages to using streams as water sources.

Spread of disease is a concern. Leptospirosis, mastitis, coccidiosis, and fusobacterium (foot-rot) is commonly spread from animal to animal through contact with infected mud and water. Livestock can also drown during floods.

Unlimited livestock access causes a great deal of damage to streams as well. Livestock urine and feces, and the animals' excessive trampling, can make water unfit for most aquatic life as well as making the water unfit for livestock to drink.

Traffic up and down streambanks denudes the banks of vegetation, resulting in erosion. Uncontrolled access also encourages livestock to loaf in the shade of the trees along streams. Time spent loafing is a hidden cost, because it uses time that animals should spend grazing. Their loafing also causes excessive grazing and browsing of understory plants, which results in bare ground that is subject to severe scour erosion during floods. Uncontrolled access also causes concentrated nutrients from animal waste deposits in and next to streams.

It is best to provide alternative sources of water so livestock are not forced to use streams. Tanks located away from streams give animals a choice of drinking locations. That could reduce their use of streams by more than half.

If it isn't feasible to provide alternative sources of water, fence livestock out of streams, and install limited-access ramps. Facilities that provide controlled access should limit the accessible water area to 15-20 feet square (225-400 square feet). An access ramp that is 20 feet wide should accommodate herds up to 150 head.

Use smooth wires for stream access fences because they do not collect as much debris as barbed-wire fences. Attach the wires solidly on one side with breakaways on the other. On some streams, depending on the size, electric water-gap fences will work (see drawing on Page 31).

If possible, exclude livestock from larger rivers and streams with very deep channels. Cattle and horses should be excluded from streams with very sandy or gravelly banks because of the damage that these heavy animals cause. Small ruminants (sheep and goats) do less damage to the banks in sandy and gravelly soils.

On smaller streams with channels less than 12-feet deep, manage the fenced areas as grazing paddocks so the forage produced can be utilized. Grazing impact should be carefully managed, however. Grazing periods should be brief, infrequent, and timed to provide a positive effect on the plants and streams.

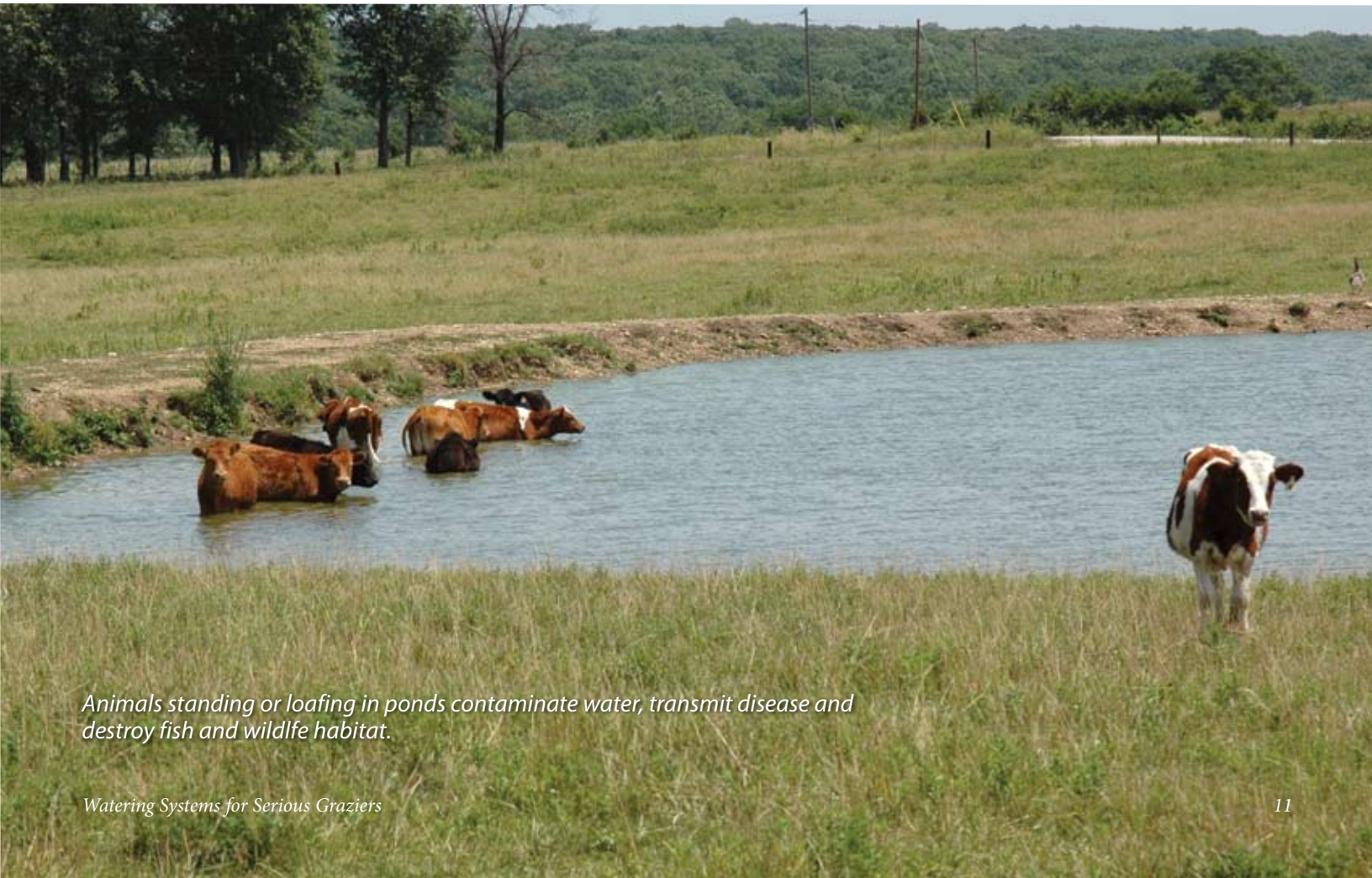
If expense, flooding, or personal preference makes fencing livestock out of streams impractical, then use controlled grazing systems that minimize damage to streams. Once again, it is better to provide alternative water sources so that livestock are not forced to drink from streams. When streams run through pastures, grazing systems should include at least eight paddocks. That will limit access to any segment of a stream to one-eighth of the time or less.

Streams can be good sources of water. But if creeks or rivers are used for livestock water, take measures to limit the damage that livestock cause.

Ponds

There are thousands of ponds throughout Missouri that are used for livestock water. Ponds can be excellent sources of water. But there are important reasons to keep livestock out of ponds:

- The animals can get stuck in the mud or fall through thin ice;
- Animals standing or loafing in water contaminate ponds, which causes and spreads diseases that are easily passed between animals through water and mud;
- When animals stand in ponds for extended periods, it causes their hooves to soften. The soft hooves can be cut and scraped easily, resulting in infections, foot rot and other foot problems.
- Unlimited livestock access ruins ponds, too. Animals trampling banks and lounging in the water erodes soil and pollutes water. The soil from the eroded banks also fills ponds, which reduces their storage capacity and useful life;



Animals standing or loafing in ponds contaminate water, transmit disease and destroy fish and wildlfe habitat.

- Fish habitat can be destroyed by continuous livestock presence in ponds.

Put fences around ponds to keep livestock from having free access. Water from fenced ponds can be made available to livestock by installing tanks below the ponds. Another option for making pond water available to livestock is installing limited-access ramps that allow the animals' to have access only to small, protected areas of ponds.

Producers may want to consider creating new ponds if additional water sources are needed. The larger the ponds, the more expensive they will be to build. Before building a pond, get technical assistance. Soil scientists and technicians can help determine the suitability of a site. Picking the right contractor is also important. Find one that is experienced in pond building in your area, and talk to several of the contractor's customers to see if they are satisfied with the contractor's work.

tip:

Before building a pond, get technical assistance. Soil scientists and technicians can help determine the suitability of a site.

In the Ozarks, building ponds can be very risky. High rock content, porous clay, and shallow soils are common. In parts of the Ozarks, ponds are more likely to hold water if they are built near the beginning of the drainage rather than lower in landscapes. These ponds are often small, but relatively small ponds that don't leak will provide water for a lot of livestock.

In other parts of the state, ponds can be built with only small chances that they will leak.

When new ponds are built, install freeze-proof water tanks downstream. If tanks don't fit in the plans, at least install pipes (1¼-inch or larger) under the dams so tanks can be added later. Supply pipes through dams also provide a means of lowering the water level in the ponds when necessary for maintenance or repair. Water supply pipes can be installed in existing ponds, but it is more difficult and expensive after the ponds are built than during initial construction.

Springs and Seeps

Springs or seeps occur where groundwater emerges naturally at the surface. Seeps may have small trickles of water that accumulates. They are usually identified as areas on hillsides or near the bottoms of slopes that are always wet. Plants growing there include those that thrive in wet places, such as willows, cattails and sedges.

It is usually easier to find the spot where springs emerge. Most springs and seeps yield high-quality water, but water yield and dependability varies greatly.

Water flow from springs can vary significantly by season as well as from year to year. Measure or estimate the flow during August or September in a dry year before considering a spring as a source of livestock water. For seeps, the extent of the area occupied by the water-loving plants gives some indication of yield and dependability.

With many springs, livestock can get to the water without development. As with streams and ponds, however, livestock traffic and loafing will make a mess in those areas. Because seeps are often just muddy areas, the damage to them is even worse. It is common for cattle to literally destroy springs and seeps by compacting the soil so tightly that flow is reduced or eliminated. Therefore, development to collect, pipe, and store the water is recommended. Livestock also should be fenced out of the collection areas of seeps and springs.

Springs are frequently located at lower elevations, close to the toes of hills or next to streams where it is difficult or impractical to develop them. Springs that are ideal for using as water sources have good flow year-round, are located higher in landscapes, and make it relatively easy to collect the water and pipe it to tanks at lower elevations.

Springs and seeps are relatively inexpensive to develop, require no energy to operate, and are usually freeze-proof. Producers with the good fortune of having springs or seeps on their property should consider using them as sources of water for their livestock.

Rural Water Supplies

Many areas of Missouri are served by rural water supply districts. Their pipelines are usually located along roads. Intended for human consumption, this source of water is very high quality, and usually chlorinated.

Using water from public supplies is attractive because it is convenient and requires no maintenance. But the expense may be a limiting factor. The costs of getting hooked to the systems can be high, but the bigger expense is buying the water. The cost of water from rural water supply districts varies tremendously from one utility to another. At use rates typical for livestock watering, the cost can vary from $2 to $12 per thousand gallons. Some communities also charge additional wastewater treatment fees.

Where public water is available closer to the $2 level, this is an attractive option, especially for smaller farms. There are many circumstances where using public water makes good sense, especially if it will be used as a temporary or infrequent source. Public water supplies also can be great back-up sources for those times when other sources fail.

If public water supplies are utilized for livestock, water customers are required to prevent backflow in order to protect public health.

Public water supplies can be good back-up sources for other watering systems but can be expensive

Water Delivery Systems

This section includes information about the four water-delivery options that might be useful to producers in deciding which systems are best for providing water to livestock. They are:

- it can be pumped to supply tanks;
- it can flow to tanks by gravity;
- animals can be allowed direct access to ponds and streams;
- producers can haul water to tanks.

Pumps

Many kinds of pumps are used in stock-water pipelines. Pumps move water by positive displacement (piston and diaphragm pumps) or with impellers (centrifugal and turbine pumps). The kind which will work best in a specific system depends on the availability of power, needed flow rate, pressure requirements, how high the water must be lifted, and the water source.

Frequently, the availability of electricity, or the cost to make it available, is a major factor in determining whether electric pumps can be used.

Jet pumps are usually centrifugal pumps with jet or ejector assemblies. A jet assembly constricts the flow of water in a pressure line and forces the water through a small passage. The tube narrows to increase flow velocity. Then the opening widens abruptly, creating a vacuum that draws water from the water source into the output line. Jet pumps have few moving parts, and both shallow-well and deep-well jet pumps can be located some distance from water sources. They provide high volume in installations where pressure and lift requirements are low.

Piston pumps are positive displacement pumps that use a piston and cylinder with valves. Double-action models move water with each stroke (both directions); single-action pumps move water with the up stroke and refill the cylinder with the down stroke. Conventional windmill pumps are piston pumps.

Submersible electric pumps are turbine pumps that operate below water level. They are often used in deep wells, and are typically more expensive than jet pumps.

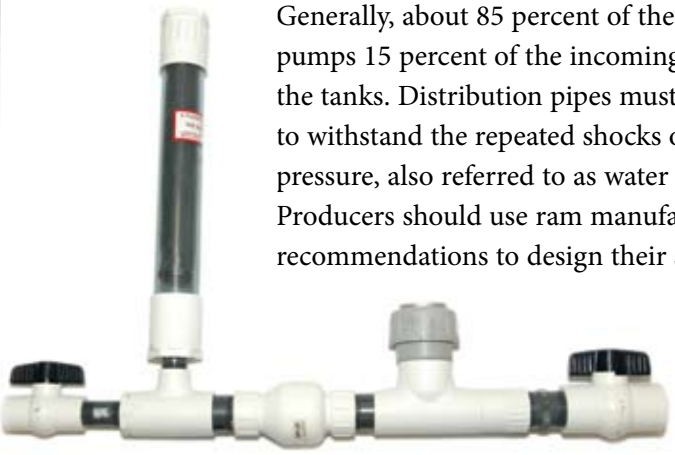
Turbine booster pumps are used to boost pressure from domestic water supplies and storage tanks.

Internal-combustion-engine-powered pumps: Internal combustion engines can be used to operate stockwater pumps. The engines may be started automatically using float-actuated starter and shutoff switches, or the pumps can be operated manually. The engines can be fueled by gasoline, diesel or propane. Engine-operated systems require frequent inspection, service and maintenance. If these engines are used, water systems

should include large water-storage tanks to ensure that there is adequate water for livestock if the systems fail.

Engine-driven systems can be set up in various ways, including: pumps driven directly by the engines; engine-powered pump jacks that drive piston pumps; or engine-powered generators for electric pumps. Engine-powered generators offer the flexibility to power any size pump, depending on the size of the generators.

Hydraulic ram pumps were invented in the late 1700s. They use the energy of falling water to pump a small percentage of that falling water to an elevation higher than the original. At least three feet of fall, and a flow rate of 1 – 3 gallons per minute, is required to drive the systems. Generally, about 85 percent of the flow pumps 15 percent of the incoming water to the tanks. Distribution pipes must be able to withstand the repeated shocks of surge pressure, also referred to as water hammer. Producers should use ram manufacturer recommendations to design their systems.



Windmills once dotted landscapes throughout the Midwest, but they rarely are used now. Windmills are expensive to install but cheap to operate. They can pump from surface water, shallow wells, or deep wells. Windmills are very convenient when electrical power is not available at a site. The most important consideration is providing adequate water storage to cover periods of little or no wind. Windmills also require regular inspection and maintenance.

Wind-powered generators can be used to power low-volume pumps. The generators require less service and maintenance than windmills because there are fewer mechanical parts. They should be more efficient than windmills, and they should be able to pump from greater depths. These systems are expensive, and they have the same disadvantage as windmills in that wind is needed to pump water. Storage tanks that can hold enough water for several days is essential to provide water during calm periods. The large tanks also allow the use of smaller, more economical generators and pumps. Unlike windmills, wind-powered generators can be located quite a distance from the pumps, such as high on hills, for better wind exposure. Wind-powered generators can be used to charge batteries that can be used to power electric-fence energizers and other devices in remote locations.

Solar-powered pumps operate as long as there is adequate sunlight, and many parts of Missouri have a high percentage of cloudless days. A principal disadvantage is that solar pumps are expensive. However, the cost of installing power lines at some sites makes solar power a competitive option. It is important to design the systems to meet water needs during cloudy periods. Producers can utilize batteries to store power or utilize water tanks that will store enough water for several days. Large storage tanks also allow the use of smaller, more economical pumps. Several types of pumps are available, each with particular advantages. Solar-powered systems must be tailored for specific pumps and solar panels, so close coordination with suppliers is essential. Elevating solar panels may reduce theft or vandalism of solar panels in areas where that is a concern. Solar panels can be located some distance from pumps to improve exposure to the sun. Tracking mechanisms that rotate the panels to face the sun also greatly improve efficiency in the summer, when water needs are the highest.

Sling pumps also are powered by moving water. They are open, plastic drums with coiled tubes inside of them. The drums, which float so that they are about halfway submerged, are tethered in flowing streams so that the water flows through them. Each drum has a propeller near the upstream end that rotates the drum, causing

water and air to be alternately taken into the coiled tube. The air pushes the water through pipes to stock tanks. The main drawback of sling pumps is that streams are usually at their lowest flows in mid summer, when the largest volume of water is needed.

Battery-powered pumps are typically 12-volt sump pumps. These pumps can move water a short distance into pastures from streams, ponds, springs, or shallow wells. Battery systems are portable, economical, use locally available parts, and can move a large volume of water quickly at low pumping height. Float switches at the tanks turn the pumps on and off. The disadvantage of battery-powered pumps is the need to frequently recharge batteries. Solar panels may be used to keep batteries charged.

Animal-powered pumps, often called nose pumps, are diaphragm pumps that operate when livestock push paddles out of the way to get to the water in small, sloped troughs. Each time animals raise their noses and release the paddles while getting drinks, about one pint of water is pumped in. Nose pumps are portable, simple, and ruggedly constructed. One nose pump can meet the needs of about 30 cow-calf pairs. Nose pumps can lift water a vertical distance of about 26 feet if they are located immediately adjacent to water sources. However, the amount of lift decreases when water has to travel farther. The paddles also are easier to push when lift and pipe length are shorter. Small calves, sheep, and goats may not be able to operate the pumps. Because water remains in the troughs, animal-powered pumps can't be used in freezing weather. Livestock may need a few days to learn to operate these systems, but most cattle learn to use the pumps rather quickly.

Gravity

When water sources (ponds, springs, or storage tanks) are at higher elevations than tanks, gravity will deliver water to tanks or troughs. Gravity is a free way to move water. It is also quite reliable. Gravity systems are usually low pressure. Therefore, larger pipes are needed to maintain adequate volume. However, low-pressure pipe is usually less expensive than high-pressure pipe. Extra care must be taken to ensure positive grade when installing gravity-flow pipelines because the water velocity is rarely high enough to purge air pockets from minor humps in lines. Those air pockets can reduce or stop water flow. Gravity flow can be used in combination with pumps to reduce the size and cost of the pumps. In this instance water is pumped from the source to reservoirs or tanks at higher elevations, from where it flows by gravity to supply tanks.

Direct Surface Access

Surface access can be simple and inexpensive, but it only provides water at one location, requires investment and maintenance, and provides greater opportunity for water contamination. Producers should include limited access points and ramps with direct-surface-access systems to prevent their livestock from loafing at the water sources, standing in the water, creating mud holes, damaging banks and increasing the transfer of disease.

Limited access points are simply planned locations where livestock can get to water in ponds and streams. Access is limited by some type of barrier, including floating electric fences, permanent electric fences, stock panels, boards or other materials. Access points must be wide enough to serve herds, but not wider than necessary. A rule of thumb is 10 feet wide, plus one foot per 10 head. For example, 100-head herds would require 20-foot-wide access points. Most limited access points need constructed access ramps.

Access ramps are walkways into the water with slopes of about 6:1. They are constructed of concrete or gravel that provides firm, non-slip surfaces. When livestock are given a choice between walking into water with a soft, mud base or a hard base, they will choose the hard base. Installing geotextile fabric under gravel ramps reduces main-

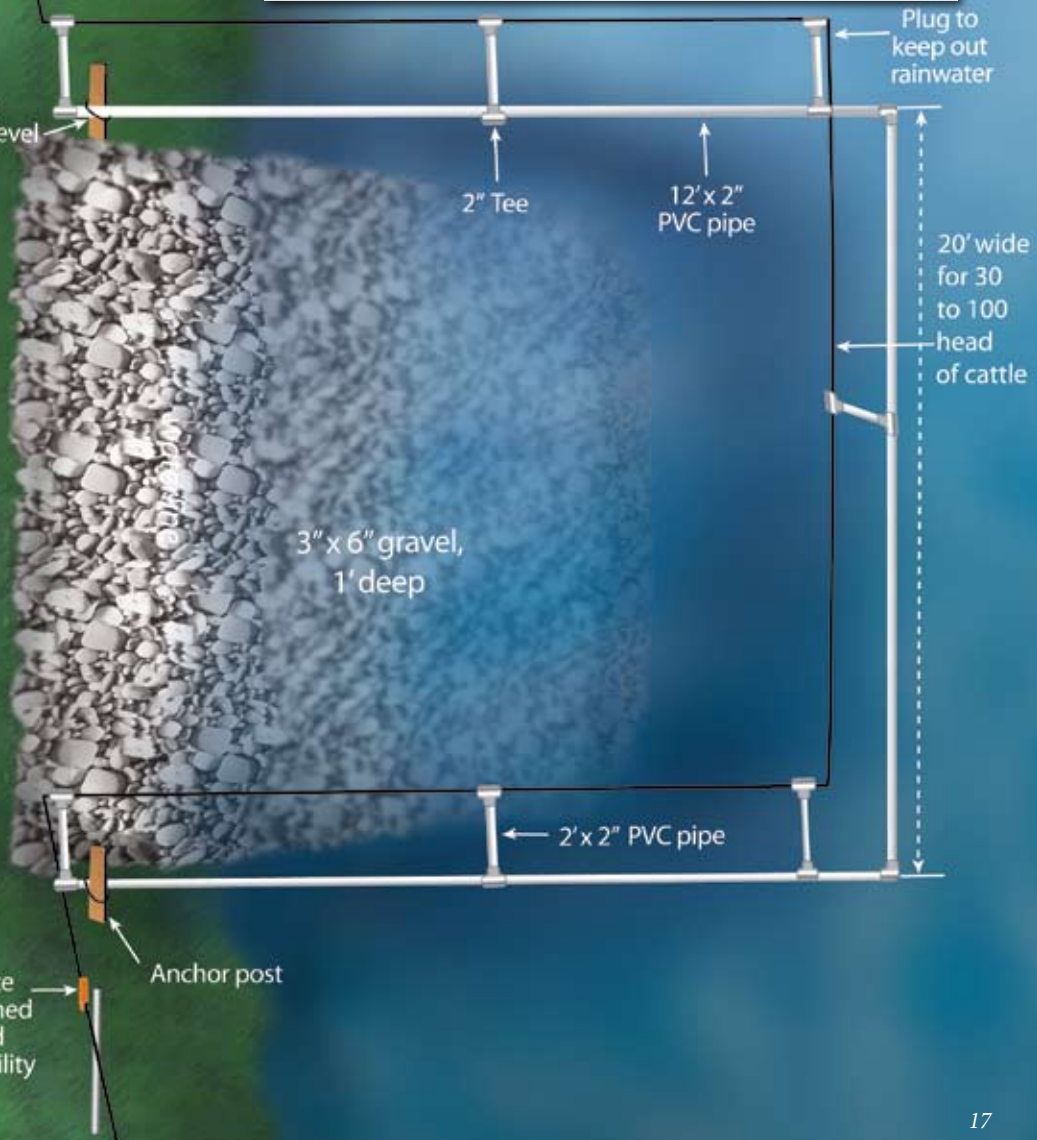
tenance and makes them last longer. Rough walking surfaces are important, especially during icy conditions. Also, ramps need to be rough enough to make them uncomfortable to livestock so the animals won't loaf in the watering points. Using large, coarse rock on the ramps is effective.

Hauling

Hauling water is expensive in the long run. However, there are unique situations where hauling might be the most practical method of delivering water. When it is difficult to pipe water to pastures or paddocks, when the number of animals served at a particular site is small, or when the length of time systems will be used is short, hauling should be considered.

A floating electric fence is a good way to limit livestock access to water in ponds and streams.

Floating Electric Fence



Materials:

- 56' - 2" schedule 40 PVC pipe
- 60' - 12.5 gauge high-tensile wire
- 12 - 2" schedule 40 PVC "T"s
- 2 - Steel "T" posts
- 3 cu. yards - 1" to 1 $^1/_2$" gravel
- 2 - 3' stakes to hold fence in place
- 2 - 2" 90 degree elbows
- 2" PVC caps
- 3"-6" gravel

Notes:

"T"s may be replaced with caps. Drill 3/16" holes below caps to run 12 $^1/_2$ gauge wire through for fence. This will keep water from entering pipe and eliminate the need to plug "T"s.

All connections need to be watertight.

Tanks

A variety of livestock water tanks are available to fit the watering needs and specific site characteristics of farms. The first step producers must take toward selecting tanks that are best for their livestock operations is to determine how large tanks need to be to serve their herds.

About 1.5 inches of trough space per animal in a herd is usually adequate. For example, three-foot diameter round tanks have circumferences of 113 inches. That's enough drinking space for 75 head. But tanks placed in fence lines cut the available drinking space in half, and will only adequately serve half as many animals. Different types of grazing systems also have an effect; less drinking space is required in controlled-grazing systems than in continuous grazing systems because of changes in animal behavior.

With the various types of livestock, herd sizes, water sources and tank locations, one type of tank will not fit all watering needs. Producers need to evaluate all of the sources in order to determine which types of tanks are best for them.

Concrete, Frost-Free Tanks

Concrete, frost-free, livestock water tanks are one way to provide winter water. They were developed to install below pond dams, but have also proven to be excellent alternatives with pressure systems.

Two things keep water in these tanks from freezing: The back halves of the tanks are covered with soil to provide insulation; and the tanks have valves that can be opened during severe cold weather to keep water circulating through the tanks.

Some advantages of concrete tanks include their durability; their ability to hold up to 250 gallons of water; large, open drinking areas which benefit livestock and wildlife; and their ability to provide open water during severe cold weather.

One disadvantage of these tanks is that they are not as easy to split with fences to provide water to two pastures. However, two-sided concrete tanks that are open on both ends and covered in the middle are available. These double-sided tanks can be placed in fence lines to water two areas at a time.

Some producers have found that they do not have to open the valves at all on tanks that are used frequently by livestock. But it might be necessary to run water when the weather is very cold during an extended period to keep the water in the tanks from freezing.

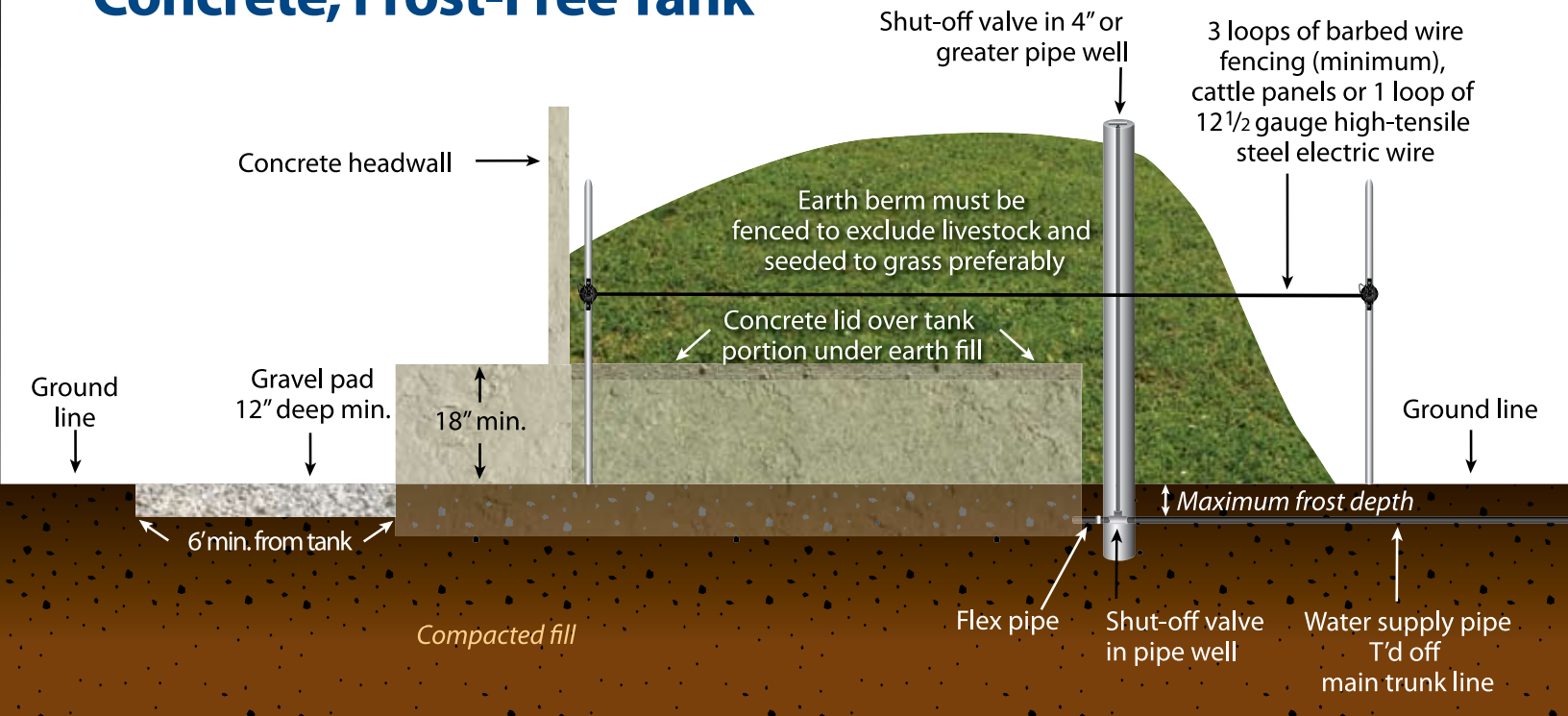
These tanks have a long history of dependable use in Missouri. If installed properly, they last many years.

Installation Tips

- Do not bury the drinking portions of tanks. This part of tanks should be at least 12 inches above ground for sheep and goats and 18 inches above ground for cattle and horses. That helps prevent drowning of animals that might otherwise fall or get pushed into the tanks. It also keeps dirt and debris out of the tanks.
- Provide additional insulation by placing one-inch-thick insulation board on the sides and tops of tanks before covering them with soil.
- Install overflow pipes that carry water to open outlets or to pits located 20-40 feet from the tanks. Dig the pits 4-6 feet deep, and place field rock or 2-3 inch gravel in the pits. These overflows prevent muddy areas from developing around tanks when water valves are opened during severely cold weather.
- Cover the backs of the tanks with at least two feet of soil. Backs of tanks must be fenced to keep livestock from removing the soil needed to insulate the tanks.
- Level the tanks before covering them with soil. Tanks that are not level may allow water to run over at corners and cause mud problems at the tanks.
- If possible, face the open ends of tanks to the south to protect them from northerly winter winds and to take advantage of warmer sunlight.
- Install gravel pads around drinking areas (see section about pads).
- Install shutoff valves in pipelines before hooking them to tanks. The valves allow water to be shut off when tank repairs are needed or when tanks need to be drained.

Some versions of concrete, frost-free tanks have easier access to the floats and valves in the backs of the tanks than others. Consider that when purchasing tanks because when tanks need repair, easy access is important.

Concrete, Frost-Free Tank



Lid and Ball Freeze-Proof Tanks

There are many different types and styles of plastic and metal freeze-proof water tanks. Some have lids or floating balls that cover the openings where livestock have access to water. Some models use electric heaters to keep the water from freezing; others have sensors and valve systems which circulate water when it reaches a preset temperature. Still others are energy free.

Many of these tanks keep water from freezing by incorporating heating elements or immersion heaters. Those tanks are usually located close to electricity.

Other tanks are energy-free. They limit exposure to the cold, have small water-storage areas with frequent replacement of fresh water, are heavily insulated, and are installed over earth tubes (geothermal heat wells) running three to four feet underground.

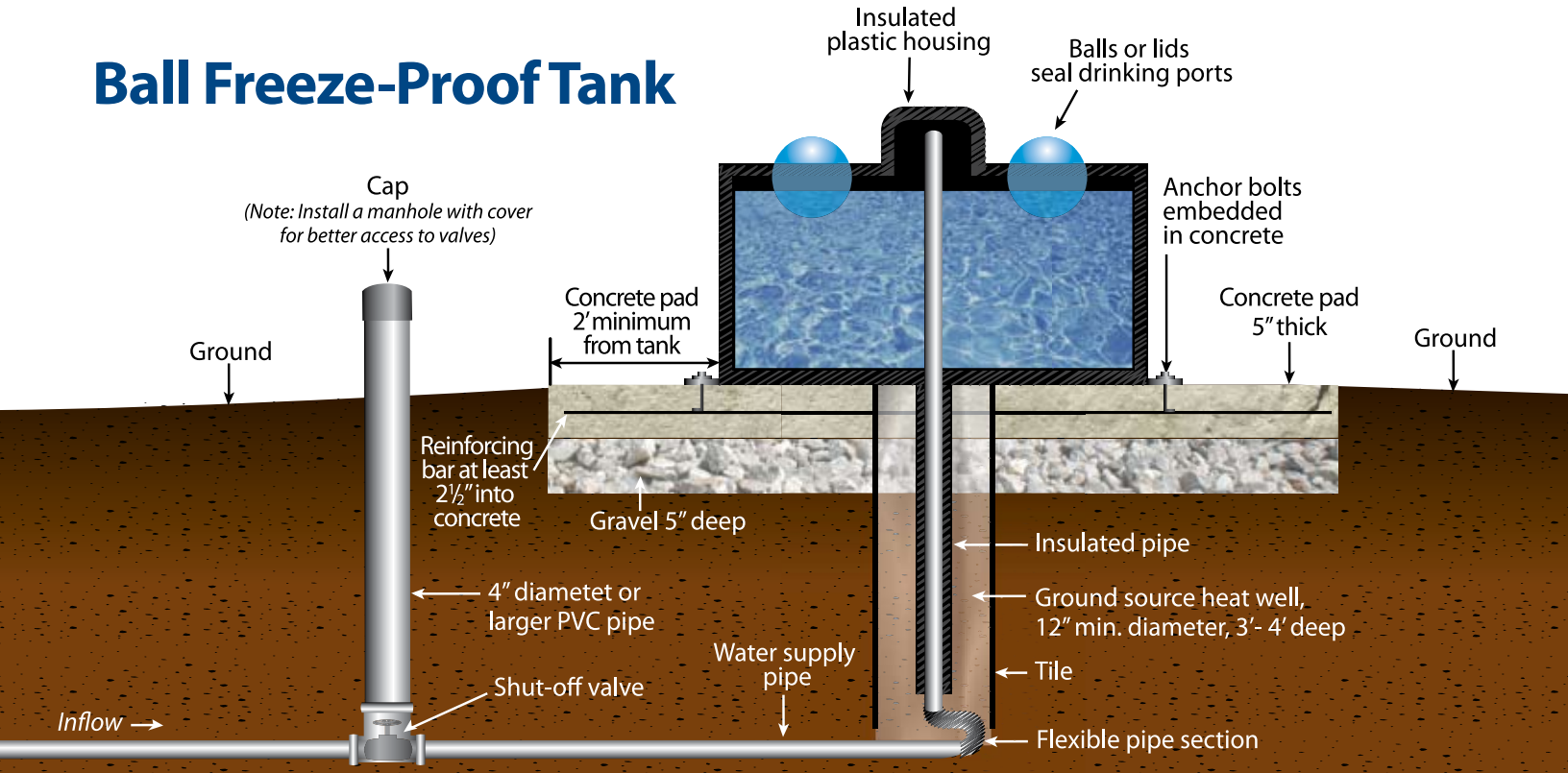
There are many shapes and sizes of tanks designed for various species of livestock. Tanks with lids require animals to lift flaps to gain access to water. Tanks with balls or floats require animals to lightly push the floats down to drink. Livestock need to be trained to drink out of these tanks. Flaps can be tied open or removed, and floats can be removed or adjusted so the balls are not in the water opening. Black balls or floats can get very hot in the summer, so moving them out of the way at those times makes sense.

These tanks come with one to six openings. Manufacturers' recommendations vary somewhat in the number of openings needed. For example, beef cattle recommendations are: one opening serves 25-30 head; two openings serve 75-100 head; four openings serve 200-250 head; and six openings serve 300-350 head.

Water storage in these models ranges from five gallons to 70 gallons. The smaller water storage causes more frequent movement of fresh water when animals drink. The water movement helps keep water from freezing in energy-free models. Many of these tanks come with valve options that can increase flow rates. They allow water to rapidly be replaced as the livestock drink.

Lid and ball freeze-proof tanks must be bolted to level concrete pads. Level pads ensure that the main tank floats can be adjusted properly and that

Ball Freeze-Proof Tank



Livestock learn to push balls and to lift flaps to gain access to water in these freeze-proof tanks.

there will be even water levels under each opening.

Be careful with ball tanks to not set the water levels too high. High water levels cause the floats to press tightly into the tank openings, increasing the pressure required for livestock to push them down and get drinks. It is also important to leave small gaps between balls and tank openings in the winter to prevent the balls from freezing to the cover housings. Install shut-off valves on all tanks, and make sure to protect the shut-off riser pipes from livestock.

The most critical components of energy-free, freeze-proof tanks are ground-source heat wells. A heat well is an open void under a tank that allows the earth's heat to rise through an opening in the concrete pad and warm the underneath side of the tank. The heat that rises from the ground helps keep water and valves from freezing. In southern Missouri, use heat wells that are about 12 inches in diameter and 3-4 feet deep. Larger, deeper wells are recommended for northern Missouri. Shallower or smaller heat wells will not keep tanks and valves from freezing.

Heat wells can be made from various materials. Corrugated plastic pipe is commonly used. Other options include large-diameter schedule 40 PVC pipe, chimney tiles, or even plastic buckets or barrels with the bottoms cut out and placed end-to-end.

Most tank manufacturers specify the types of heat wells to use with their models. Make sure to measure the bottoms of tanks before deciding what size heat wells to install. Heat well openings must be under the tanks, which are sealed to the concrete pads. Wrapping supply lines with insulation adds protection. But do not stuff the tops of heat wells with insulation because the insulation blocks the earth's heat from rising to the tanks.

Cut the side wall from the tires.

Install pipes in the ground before placing tires, leaving an extra length of inlet pipe that can be cut later to the desired height.

Fill the bottom center bead area of tires with concrete, and tamp it to seal tight around the edges.

Tire tanks can also have an entire bead cut out for more drinking area.

Tire Tanks

Livestock water tanks can be made from large machinery tires. Installing tire tanks as permanent water locations has several advantages. For instance, they are very durable and can be made freeze proof. They also put waste products to good use, and save producers the costs of purchasing tanks.

Tire tanks, like all livestock watering tanks, should be located on sites with solid ground, good drainage, and the ability to handle overflow. Large tire tanks are very heavy, so they should be located at sites accessible to heavy equipment.

The size of tires needed depends on the grazing systems and water flow. Large tires can collect enough water from very small spring flows to service many livestock. The top foot of an eight-foot scraper tire holds about 400 gallons of water – or enough to water an 80-head herd of cattle for a day. Tire tanks can also be hooked to pressure systems by installing good float valves on the inlet pipes.

Select solid tires with carcasses that are in good shape. Avoid steel belted tires because they have small cables in the side walls that make it difficult to cut out the sides of the tires. The cables can also injure livestock. Bias ply tires are best.

Outlet pipes should be the same size as inlet pipes, or larger. Four-inch outlet pipes installed with the bell ends flush with the concrete floors make cleaning easy because they allow mud, grass and leaves to pass.

With springs as water sources, tanks may be stair stepped down the pipeline with the outlet of one tank serving as the inlet to the next. When using pressure systems, all tanks need to be hooked to the supply lines and have their own shut-off floats.

One thing to consider with tire tanks is that some horses have been known to chew on the beads of the tires, which could cause health problems for the horses.

tip:

When using tire tanks, avoid steel belted tires. They have small cables in the side walls that are difficult to cut. The cables can also injure livestock.

Installing Tire Tanks

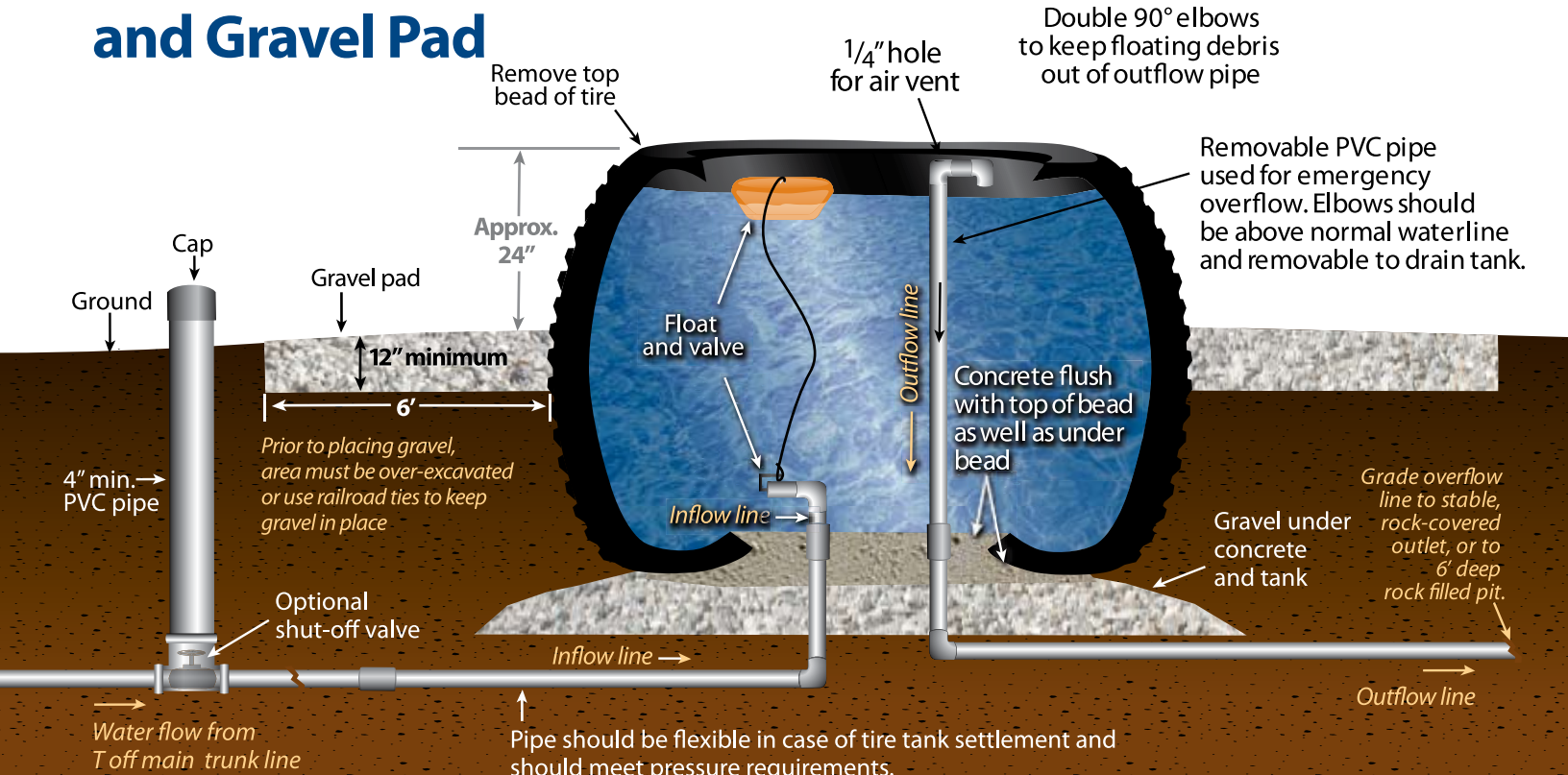
Properly installed tire tanks offer many years of low maintenance performance. Here are some things to consider:

- Tires are very heavy, with many over 1,000 pounds. So never get under tires being installed, and don't stand behind something that could be pushed into you by tires.
- Unless you have purchased pre-cut tires, lay them on their sides, and cut one bead from the tires to allow access to water from the sides. Some people find that removing sections of tire sides is easier than removing whole sidewalls. When cutting with reciprocating saws or chainsaws, angle the blades down and towards the outside of the tires.

The weight of the beads falling inside the tires prevents binding and overheating of saws. Wooden wedges can also open up the splits.

- Fine-toothed blades on reciprocating saws work better than coarse-toothed blades.
- If using chainsaws, grind off the chipper teeth between the cutter teeth of old chains.
- Keep a small, steady flow of water on the saw blades and on the areas being cut. This keeps the reciprocating saw blades cool and helps lubricate the rubber. Dish washing detergent works well in lieu of water. Be sure to keep all electrical cords out of water areas to avoid electrical shocks. Also be careful of the hot, flying, rubber bits.
- Clean tires thoroughly before using them as water tanks for livestock because they may have been filled with chemicals such as ethylene glycol or calcium chloride.
- Install pipes in the ground before placing tires, leaving an extra length of inlet pipe that can be cut later to the desired height. Carefully measure the bell-end of outlet pipes so they will be level with the concrete floors.
- Keep the top edge of tires 12-18 inches out of the ground to keep small livestock from falling in. If mature cows or horses are the only animals watering at the site, a 24-inch height is better.
- Fill the bottom center bead area of tires with concrete, and tamp it to seal tight around the edges. Be sure to get concrete under the bead located between the ground and the tire bead to ensure sealing. Filling the bottom sidewalls is optional; it requires much more concrete, but also makes tanks easier to clean.
- Placing extra ¾-inch pipes through the concrete with sweeps at the elbows allows insulated electric wires to be fed through to the center of the tanks. The insulated wires can feed hot wires across the tops of tanks to keep cattle from crawling into the tanks. Placing tanks in fence lines serves the same purpose.
- Homemade covers can be added to limit drinking areas. They keep cattle out of tanks; protect valves, floats and overflow pipes; insulate; and provide shade to reduce algae growth.

Tire Tank with Concrete Floor and Gravel Pad



Portable, Seasonal Tanks

Using portable watering tanks for seasonal grazing is an excellent way to improve the flexibility of grazing systems. Portable tanks also are an inexpensive way to get water to all of the paddocks during the growing season.

Portable tanks can be made at home from plastic barrels or purchased at local farm supply stores. Plastic and fiberglass tanks are reasonably priced, and come in a variety of sizes. Plastic and fiberglass tanks have several advantages over steel tanks; they last longer, they are less expensive, and they are easier to move around because they are lighter.

Size and quality should be the most important considerations in selecting portable tanks. Tank sizes vary from 55 to 1,000 gallons. However, smaller portable tanks are easier to move. And since portable tanks usually are placed in smaller paddocks where the entire herd won't be watering at the same time, large tanks usually are not necessary.

Portable tanks can greatly improve the flexibility of grazing systems. They can be placed under fences to supply two to four separate paddocks with water. Tanks also can be located close to areas being grazed to create shorter distances for livestock to travel to water.

Livestock quickly learn that the old herd mentality is not necessary with these tanks; one or two head at a time will go to water, making it possible for smaller tanks with full-flow water valves to remain nearly full at all times. Also, if smaller tanks are used, one tank can be moved easily to other paddocks. That reduces costs because one tank can supply water to several paddocks.

Water valves are available in a variety of sizes and with a variety of flow rates. The flow rates of valves needed with portable tanks will, in large part, depend upon tank sizes and herd numbers. Use "full flow" float valves with smaller, portable tanks to allow rapid refill of the tanks. Avoid the smaller float valves that clamp on the sides of tanks because they do not refill tanks rapidly enough, often resulting in livestock damaging empty tanks. Protect valves from cattle by placing the valves beneath fences.

Examples of full flow float valves

Portable, seasonal tanks can be hooked to plastic pipe rolled hundreds of feet above ground or hooked to hydrants with short feeder hoses. Having those watering points in all paddocks improves grazing efficiency in the systems.

Portable tanks can greatly improve the flexibility of grazing systems. Size and quality should be the most important considerations in selecting portable tanks.

Unprotected areas around water sources can be dangerous to livestock and detrimental to water quality.

Protecting Watering Areas

Areas around tanks, ponds and streams need to be protected by gravel or concrete pads. Areas that become muddy are dangerous to livestock, and erosion caused by animal traffic damages water quality. Pads provide firm footing for animals, and they reduce erosion around tanks. Tank type determines what kind of pads to use and where to locate them.

Concrete and Gravel Pads

Recommended pad size depends upon individual needs and preferences, animal size, and tank size. Some producers prefer that animals have all four of their feet on the pads while they drink. For cattle, that may require 20-foot-by-20-foot pads. Smaller livestock may only need pads that are 10 feet by 10 feet. Other producers prefer that their animals' have only their two front feet on the pads while drinking. For them, pads that extend about two feet from the tanks are adequate.

Pads that are large enough to allow animals to place all four feet on them can reduce erosion. However, the animals may get too comfortable, linger on the pads, and deposit manure in the tanks. Smaller pads encourage animals to drink and leave.

Plastic ball or flap tanks must be bolted to level, concrete pads. When forming pads, know where the shut-off valves in the supply lines will be placed. Shut-off valves must be protected from animal traffic and freezing. They can be placed close to tanks, but off the pads. Another option is to form access wells in pads, and locate the shut-off valves in the access wells. Access wells require heavy duty lids to support the weight of the animals.

Concrete pads should be at least five-inches thick, and the pads should extend at least two feet from tanks on all sides that provide access to the water. Add steel reinforcement to the concrete – either No. 4 steel rebar 18 inches apart; a single layer of six-inch-

Gravel pads should be at least 12" thick and extend at least six feet from all drinking areas of tanks.

by-six-inch, 6-gauge welded wire; or two layers of six-inch-by-six-inch, 10 gauge welded wire fabric. Concrete and gravel pads should be slightly above ground level. If pads are high above ground level, livestock will create holes as they step on and off the pads. Put five inches of gravel under concrete pads for drainage. Concrete surfaces should have rough textures to keep animals from slipping. When placing tanks in fence lines, add posts on both sides of the tanks before the concrete pads are poured. The posts can be metal, hedge or fiberglass.

Geoweb on top of geotextile reinforces gravel pads.

Freeze-proof concrete tanks, open-top concrete tanks and tire tanks are typically installed with gravel pads placed around them, but concrete pads can be used. Tank style determines the size and placement of pads. Freeze-proof tanks that have one side open for drinking are usually set on compacted soil, with gravel pads placed along the three sides of the tank's drinking area. The rest of the tank is covered with soil for insulation, and fenced from livestock.

Freeze-proof tanks with two open sides, concrete open-top tanks or tire tanks need pads on all sides of the tanks. Gravel pads should be at least 12-inches thick, and they should extend at least six feet from all drinking areas of the tanks.

Excavate 12 inches below ground level or use a curb made of railroad ties to help retain gravel around tanks. Installing geotextile fabric under gravel pads will keep the gravel from sinking into the soil.

Approach Ramps

Stabilize the banks at limited-access points at ponds and streams to prevent erosion. The approach ramps should be as wide as the access points and at least eight feet long and 12 inches thick. Ramps should extend into the water. Use two-inch to four-inch rock on these ramps. The rock should be small enough to allow the animals to walk on it without getting injured but large enough to make it uncomfortable for them to loaf in the watering areas. Geotextile fabric placed under the rock will help stabilize these areas. Less rock is needed and the areas require less maintenance when fabric is used.

Selecting Tank Location

Watering tank location is important to successful management of grazing systems. Consider whether the locations will be flexible enough to accommodate future changes. Also consider whether the locations will allow easy pasture subdivisions during peak growth seasons or for strip grazing of stockpiled forage during the winter.

Soils

Producers need to think about the soils where their tanks, or other watering points, will be located. If the soils are gravelly, wetness and mud probably will not be problems. If the soils are free of gravel, or moist, it may be necessary to install geotextile fabric to keep the gravel from being pushed down into the soil. If possible, place tanks on well-drained soils.

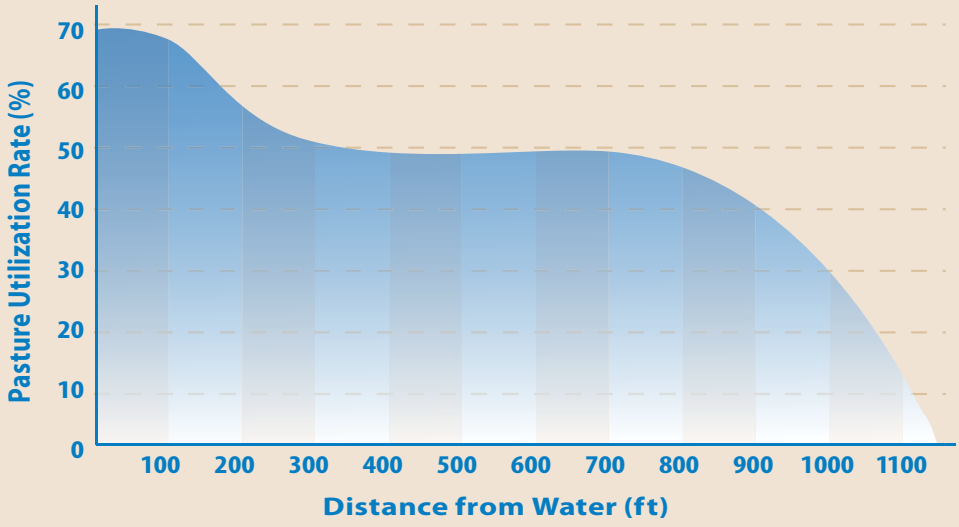
Animal Travel

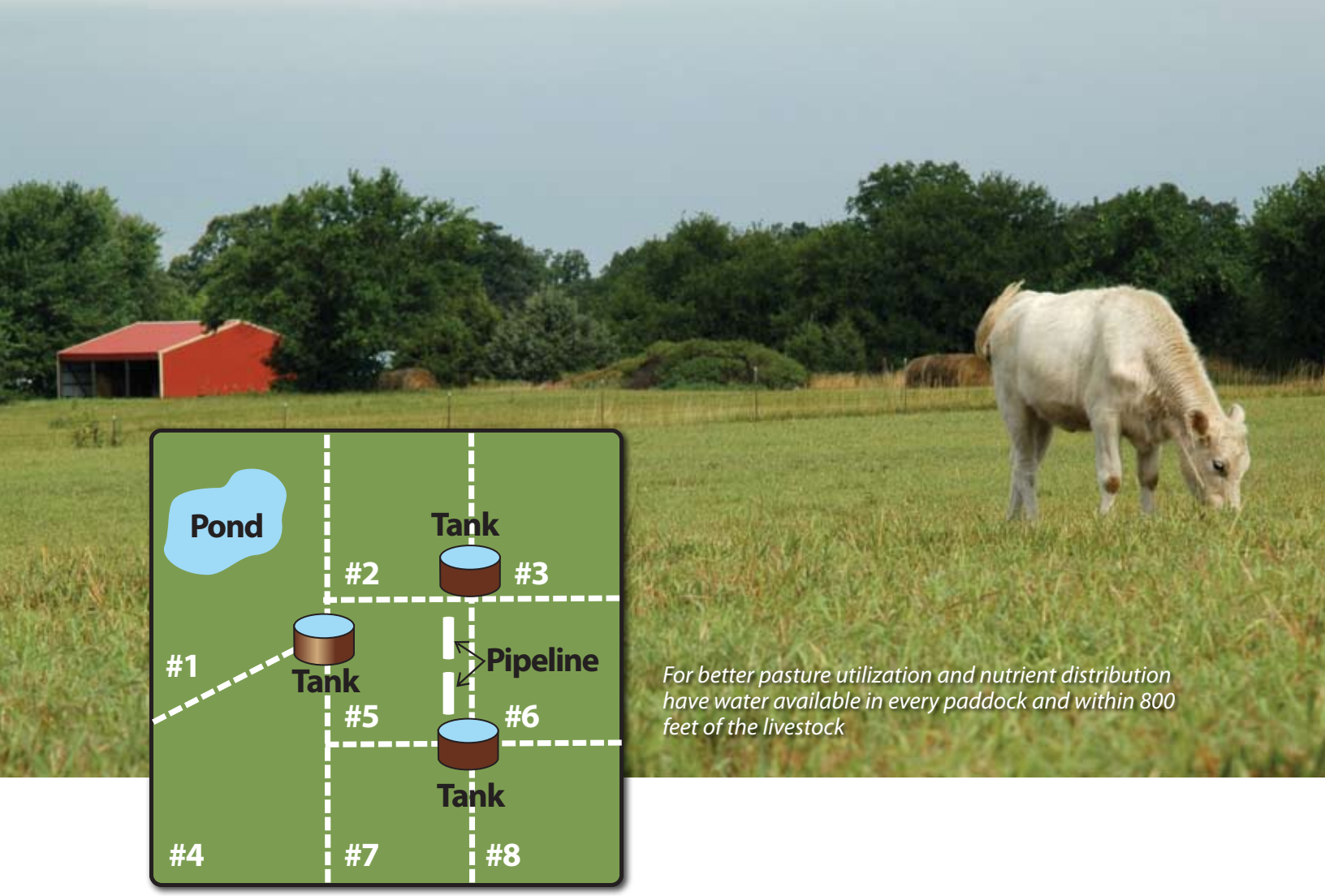
Livestock should never have to travel more than 800 feet to get a drink. When the distance from the far end of the pasture to water is greater than 800 feet, getting a drink becomes a social event; the entire herd goes together. This is especially true when animals have to go through gates and down lanes to get water. When water is located in each pasture, and the animals can stay within sight of the herd, they are more likely to drink as individuals. That reduces the strain on water supply systems and reduces the need for large tanks, which are more costly to install.

Excessive distance from the pasture to water also causes a decline in pasture utilization. A lower percentage of available forage will be eaten because areas close to the water will be overgrazed while forage in the far ends of pastures is undergrazed. Excessive distance also causes manure and urine to be concentrated close to water sources. And, when animals have to go down lanes to get drinks, about 15 percent of the manure is deposited in the lanes. Nutrients provide little or no benefit there.

When planning water facilities for grazing systems, every effort should be made to put water in each paddock. The Oklahoma-based Noble Foundation

Impact of distance from water on pasture utilization rate in rectangular 10-acre paddocks





For better pasture utilization and nutrient distribution have water available in every paddock and within 800 feet of the livestock

reported that grazing systems with one watering point per 10 paddocks had 10-20 percent bare ground in the paddocks. When each paddock had water, only 1 percent of the ground was bare. In the latter situation, the watering points could be moved to allow water tank areas to be rested.

The best situation is a combination of permanent and portable watering points. The permanent watering points should be freeze-proof tanks that can be used year around in conjunction with hydrants to provide water to the remaining paddocks. Many times it is possible to water two, three or more paddocks or grazing strips from the same tank when it is located in a fence line.

Winter Water

When locating winter watering points, consider placing freeze-proof tanks facing south to protect them from cold, north winds. Livestock can travel farther to water in cooler weather, so permanent winter watering points could be located in lanes.

Slope

Establishing watering points on steep slopes can be challenging. Steep slopes make it difficult to level tanks, and make it difficult for livestock to drink. If watering points cannot be moved to level areas, it might be necessary to use heavy equipment to create level pads on slopes.

Cost

Costs should not dictate every aspect of how systems are set up, but rather how they will perform in the future, how flexible they will be and how they meet the needs of livestock and resources. Invest the minimum amount necessary to meet the needs of the forage and the livestock.

Installing Pipelines

Decisions regarding installing pipelines may be the most important decisions ranchers make in designing their water-delivery systems. Well-designed pipelines take dependable water to the livestock on pasture, making them the key point in future operation and flexibility of grazing management.

Design Considerations

There are many things to consider in selecting routes for livestock-water pipelines. Here are some of the most important considerations:

- Locate water tanks on solid ground with good drainage. Some styles of tanks need to be located where it will be easy to manage tank overflow.
- Select pipeline routes that minimize the number of high and low spots in the lines. High spots may require air valves, and low spots in shallow lines may require drains.
- One pound of pressure equals 2.31 feet of elevation change in water. Water pressure will decrease when tanks are uphill from the sources, and booster pumps may be needed to access high hills. Getting water to tanks that are downhill from the sources may require pressure reducers or valve limiters to keep from damaging tanks, floats, pipes, etc.
- Avoid landslide areas, and avoid crossing watercourses that are eroding. Route pipelines to avoid shallow and very rocky soils if possible.
- Consider future expansion to systems. If pipeline extensions are anticipated, then pipe sizes and ratings should be appropriate for the ultimate extensions.
- Make sure that pump installers know where water needs to go so they recommend the right size pumps, pressure tanks and pressure switches.
- Locate large stock tanks or storage tanks where heavy equipment can be used to install them.

Route Surveys

The type of survey information required for pipelines depends on the characteristics of the routes. For example, a spring development with a 300-foot pipeline and a total fall of only four feet between the spring and the tanks may require a very detailed survey to ensure that the pipe grade and tank elevation will allow the system to operate properly.

On the other hand, a mile-long pipeline that drops 100 feet from the source may only need a careful study of contours on a U.S. Geological Survey (USGS) quadrangle map to get enough information for an adequate design.

Determine the freeze depth for your area and dig pipe trenches at least that deep to protect pipelines from freezing

And in a third example, a mile-long pipeline traveling over gently undulating topography with total elevation differences not exceeding 25 feet may need a detailed profile run with an engineer's level.

The difference in these installations is that installers must predict where air can collect in the pipe systems, and provide ways to release it. Defining where these problem locations are dictates the types of surveys necessary.

Use onsite, detailed surveys when water pressure is low and where many small undulations in the terrain make it difficult to locate all of the high and low spots. A good set of survey notes also is a valuable reference for future expansions of the systems.

Using Geological Survey Quad Maps

For long pipelines with major elevation changes, it is usually adequate to use contour elevation data from 7-1/2 minute series USGS quadrangle maps. The contour interval on most quad sheets of interest in Missouri is either 10 or 20 feet. Fairly accurate interpolations can be made to elevations of five to 10 feet, which is usually adequate for high pressure pipelines. It is extremely important to accurately locate ground locations on the maps. If there is any question as to location, other methods of determining elevations should be used.

Horizontal distances can be estimated from the maps to the nearest 100 feet. Because of elevation changes, the actual pipeline length will be longer than horizontal distances measured from the maps. Corrections must be made for the additional distances.

Reduce guesswork by physically measuring the route distance. Depending on the accuracy needed, pipeline length can be measured by pacing, using tape measures, string measures, measuring wheels or GPS units.

Installation Considerations

Buried pipelines provide water during all types of weather, and they are located out of harm's way. Surface pipelines offer more location flexibility and the ability to be moved. Systems that combine buried lines and surface lines provide optimum flexibility.

Buried Lines

- Identify possible buried utilities, and contact utility companies for technical guidance if routes must be located where they will intersect the utility routes. Missouri One Call System, Inc. (1-800-344-7483; **http://www.mo1call.com/**) can aid in locating buried utilities.
- Routing pipelines over moderately sloped terrain makes it easier to trench.
- Determine the freeze depth for your area, and dig trenches at least that deep. Soils need to be deep enough for trenching to the design and freeze depths.
- In rocky or gravelly areas of trenches, bed the pipes in dirt, sand, lime or pea gravel to protect the pipes from sharp projections.
- Offset all attachments (tanks, hydrants, etc.) from main lines with 'T' connectors. This prevents having to break into main lines to gain access.
- Install 'T' connectors with short lengths of pipes and caps glued on anywhere there is a possibility of tapping into lines in the future. It is much easier to dig down, saw the caps off and take off in another direction than to try to tap into main lines. In addition, the short pipes absorb the shock of water hammer when valves and floats are shut off.
- Install blind stubs at the ends of lines to make future extensions easier.
- Install manifold systems with shutoffs on each branch line at wells or other water sources. This prevents having to shut down whole systems to repair one item.
- Install shutoffs so whole lines do not have to be shut off for tank repairs. Use full-flow shut off valves, like ball valves, to avoid flow restrictions. Valves may be buried with faucets, drains, etc., in separate manholes, access wells, or inside tanks where they can be easily reached.
- Under roads and heavy-use areas where ruts may form, place pipes inside larger pipes or bury them much deeper to avoid wear to pressure pipes.

- Be certain to install pressure fittings instead of lighter-weight drain fittings. Bell-end pipes speed the gluing process and reduce the number of joints and fittings.
- Pressure test systems for leaks before covering pipes.
- To avoid cracking pipes, always cover pipes by hand with at least six inches of soil before mechanically backfilling with rocky or chunky soil.
- Seed disturbed areas after grading the pipelines. The trenches will settle for a couple of years, and may need additional grading or fill. However, established grass will usually withstand moderate grading.
- Pipelines shouldn't freeze under good stands of grass, but they might freeze under lanes or gates. Consider putting foot-wide pieces of ground-contact foam over pipes in those areas before filling the trenches. The foam traps heat coming from underneath, and helps keep pipes from freezing.

Stream Crossings

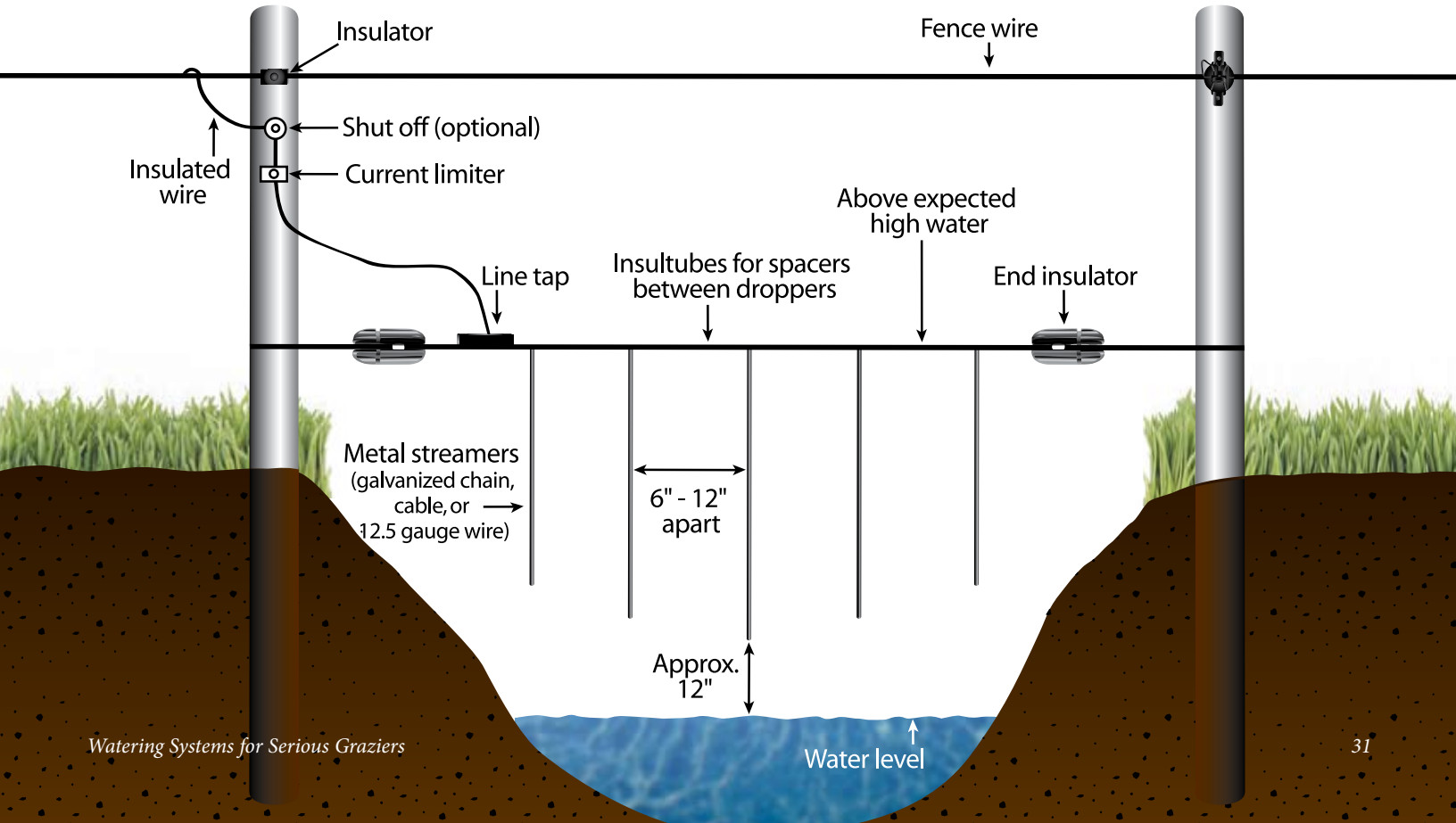
Crossing streams with pipelines may be relatively simple, depending on width, depth, drainage area and, especially, composition of the streambeds.

Selecting stable portions of streams is important, and pipeline alignment might need to be changed from a preferred location in order to accommodate this. Construct stream crossings first, then bring the rest of the pipelines to the crossings.

Cross gravel or earth bottom streams at right angles, and dig to the maximum depth possible. Freezing probably won't be a problem, but use burst-proof pipe if the possibility of freezing exists.

Crossing solid-rock-bottom streams is another proposition. Think carefully about site selection and installation methods. One method which has worked is to jack hammer trenches across the streams' rock bottoms. Trenches one-foot deep and as wide as a backhoe bucket have been suc-

Water Gaps (Flood Gates)



cessful. Place the water pipes in larger sections of heavy, thick-walled, steel pipes, and backfill with a mix of fine and larger materials. Consider pouring some concrete over the larger pipes.

Another method which has worked on rock-bottom streams is to place the water pipes in larger sections of thick-walled pipes, lay the pipes on top of the streams' rock bottoms, and cover them with stiff concrete mixes. The concrete will set up in the flowing water. The water flowing over the tops of the pipes protects them from freezing.

In either case, consider using burst-proof pipes and installing shut off valves in case there are problems.

Another thing to consider is to run the sections of pipes above streams at heights that are well above expected high-water marks. These pipelines would need to be shut down and drained during freezing weather.

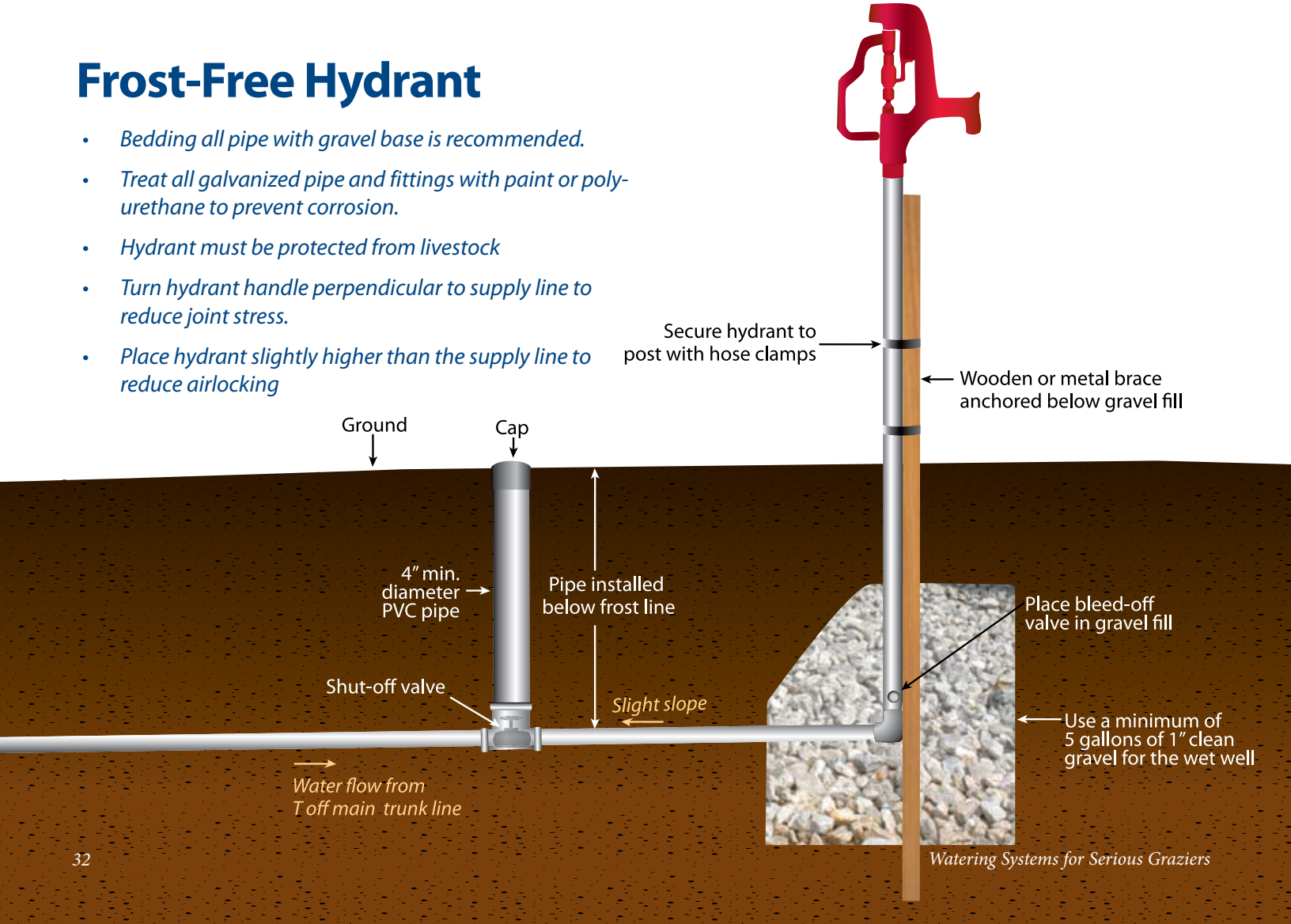
Keep in mind that some larger streams will require permits. Check with the U.S. Army Corps of Engineers to see if permits are required.

Hydrants

Install freeze-proof hydrants when crossing fences, near tanks and at other points along pipelines. Hydrants located at high points in lines can be used to bleed air pockets that restrict water flow. They also double as water-delivery points. The hydrants can be very handy for accessing water for many purposes, including surface pipes and tanks, for better grazing distribution. If possible, place hydrants close to hot wires so livestock won't crowd them. But keep the hydrants far enough away from the wires to prevent grounding the fencing systems.

Frost-Free Hydrant

- *Bedding all pipe with gravel base is recommended.*
- *Treat all galvanized pipe and fittings with paint or polyurethane to prevent corrosion.*
- *Hydrant must be protected from livestock*
- *Turn hydrant handle perpendicular to supply line to reduce joint stress.*
- *Place hydrant slightly higher than the supply line to reduce airlocking*



Lay above-ground pipe directly beneath fences to protect the pipe from livestock and vehicle traffic.

Use flexible hose to attach above-ground pipe to hydrants. Automotive heater hose has proven to work well.

Brace hydrant supply pipes and stand pipes. Hedge posts (or other long-lasting posts) put in the trenches as they are backfilled give good support and bracing.

Using Above-Ground Pipe

Thanks to advancements in technology, above-ground high density polyethylene (HDEP) rolled pipe is a viable option for seasonal livestock watering. This pipe is available in diameters of ¾-inch to two inches. Depending on the thickness of the pipe, it is available in rolls containing 100 to 400 feet, and it can withstand water pressures ranging from 100 to 160 pounds per square inch.

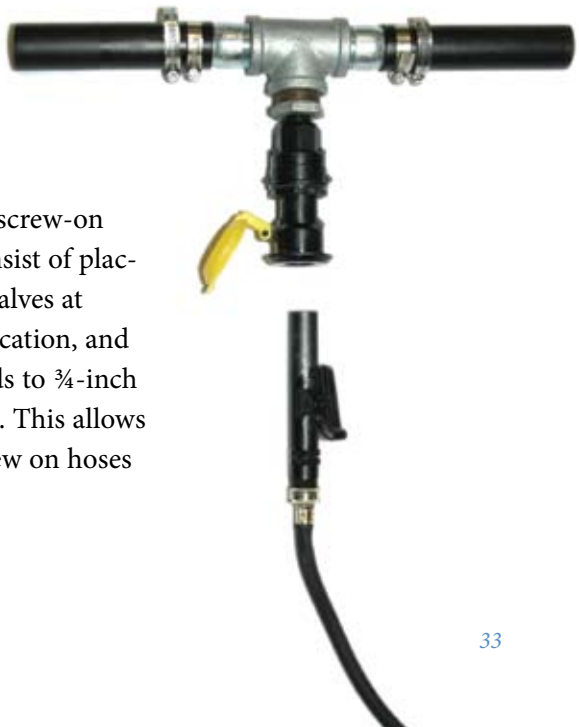
Lay above-ground pipe directly beneath existing fences to make it easier to locate the pipe. Lay the pipe in a snakelike fashion that allows it to expand and contract, which reduces the stress on joints and fittings. Grass growing over the pipe shades it from the heat and helps protect it. Where animal or vehicular traffic could damage pipe, slip it through larger pipes.

Place hydrants in all low spots so they can be drained in the winter. Also avoid extremely long runs of surface pipe. Longer runs require larger pipe. Smaller pipe is preferable because water is stored longer in larger pipe, causing the water to heat up in the summer. Larger pipe also stores more pressure, which can cause joints to separate.

It is imperative to unroll this type of pipe by simply rolling it across the top of the ground. That decreases the likelihood of kinks in the pipe. It also helps to use zip ties to secure the pipe to T posts. This helps keep the pipe in place and makes it easier to unroll and straighten the pipe.

There are many types of fittings available for use with polyethylene pipe. However, galvanized steel connectors are better than the plastic-barbed connectors sold at many stores. It is a good idea, especially with larger pipe, to heat the ends with small propane torches before inserting the connectors. Use two stainless-steel hose clamps on each side of connectors – with tightening screws on opposite sides of the pipe – to ensure leak-free connections.

Many types of tank connectors are available. Although quick-coupler connectors are convenient, they may not be cost effective unless the outlet will be used many times during the season. The screw-on types simply consist of placing plastic ball valves at each watering location, and adapting the ends to ¾-inch hose bib threads. This allows operators to screw on hoses to fill tanks.



Collecting Spring Water

There are many different ways to collect spring water. Several types of systems can be developed depending upon the type of spring, location, landscape, soils and other conditions.

The first step is to decide if a spring is worth developing. That process may take up to a year, especially if the history of the spring is not known. If the history is not known, it is important to record spring flow. Record the flow monthly – but not right after a heavy rain – by channeling the flow so that it can be captured in a bucket. Measuring the number of gallons that flow per minute into the five-gallon bucket will provide a good estimate of spring flow.

It is most important to know the flow during and immediately after the typically dry months of July and August, plus January and February when freezing may slow output. The months following a dry spell, such as September and October, also should be watched carefully because spring flows may be affected by dry spells months after the dry spells.

One gallon of flow per minute output equals 1,440 gallons per day. That's enough water for 50 cow-calf pairs. A larger tank will be needed for smaller spring flows.

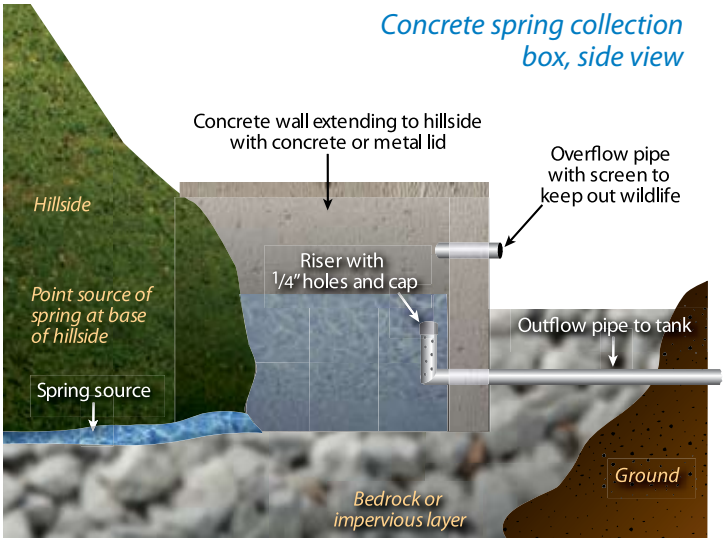
Another consideration is that there should be at least a four-foot drop in elevation to the place where tanks will be placed.

Install the water tanks and pipelines first to allow tank installation without dealing with the water flow from the spring. Since spring flow is continuous, install overflow pipes to carry excess water to natural ditches or to other tanks. Overflow pipes should be threaded at the floor of the tanks so they can be removed to drain the tanks when needed. Always put fences around springs and collection areas to exclude livestock and to protect the water sources.

Concrete Collection Boxes

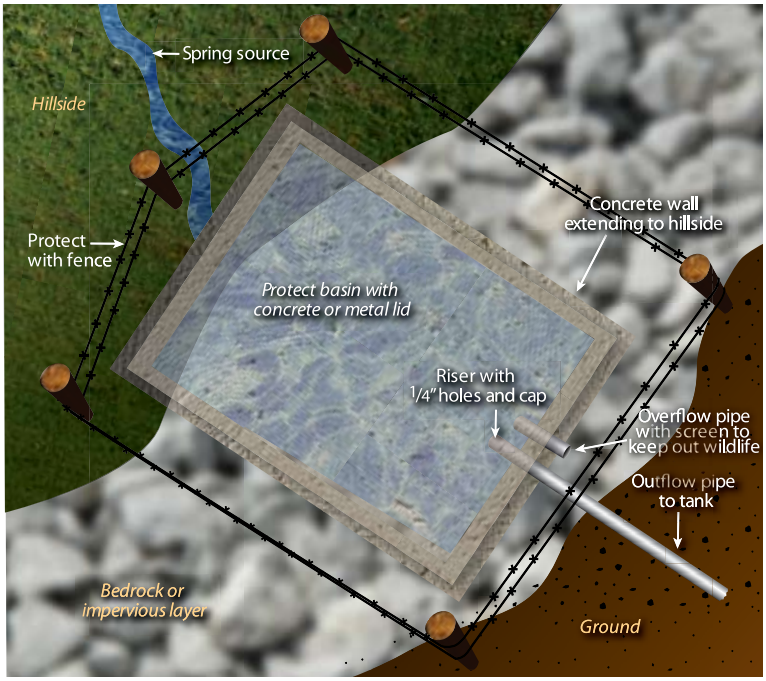
Collect spring water surfacing out of cracks in bedrock by forming and pouring concrete boxes around the spring heads, then piping the water to watering tanks. Follow these steps in constructing concrete collection boxes:

Concrete spring collection box, side view



- Clean the bedrock around the spring flow to provide a clean floor to the spring.
- Place a temporary stub pipe into the spring, and pack clay around it to divert the water through the pipe while forming and pouring the concrete box. This pipe will later serve as the supply pipe to the tank; it will go through the forms, and should rest at the bottom of the box.
- Form a three-sided box around the spring. The back side of the box will be the bedrock at the spring.
- Place a 4-inch-diameter plastic pipe in the form at the very top to provide an overflow pipe for the box. Pour concrete around this pipe so it becomes part of the wall.
- Pour all walls of the box.

- Separately form and pour a concrete lid. Place rebar handles in the forms before pouring.
- Place rebar or wire mesh in the walls and lid.
- When the concrete has set, remove the forms.
- Remove the clay dam formed earlier around the supply (diverting) pipe. Place a 90-degree elbow onto the end of the supply pipe; into the elbow, place a capped riser pipe with several holes drilled in it.
- Dig a trench to the watering tank and install the supply pipe.
- Place the concrete lid, constructed earlier, onto the spring box to keep dirt and leaves out, and to protect the spring from livestock and surface water flow.



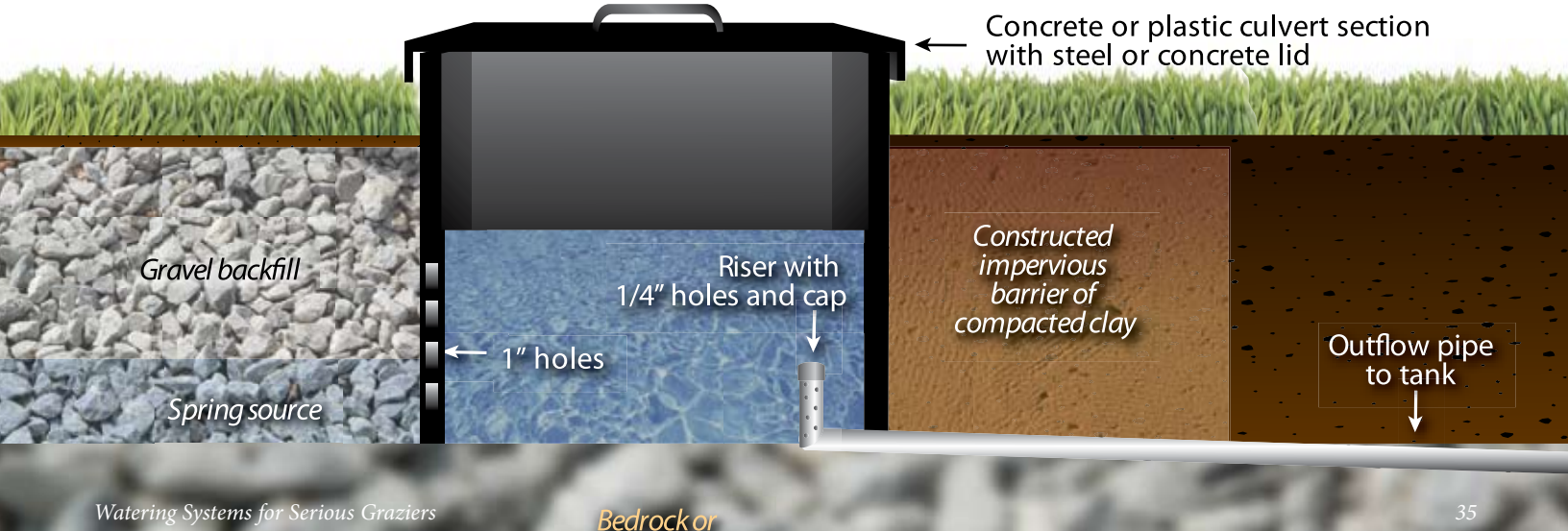
Culvert Collector Boxes

A concrete or plastic culvert can also be used to capture spring water. Use this method if the water flow is 5 to 15 feet wide.

Select a concrete or plastic culvert with a diameter of 2-6 feet and few perforations. The necessary culvert size depends on spring flow and planned usage. Concrete culverts not suitable for their originally intended use because of fabrication flaws often can be purchased at a discount from pre-cast concrete companies.

Here's how to install culvert collector boxes:

- Dig out the spring area to create a pool; dig down to gray clay or bedrock, if possible. This will be the collection pit for the system.
- Extend the supply pipeline into the center of the pool. This pipe will run from the collection culvert to the watering tank.
- The supply pipe should be at least 1¼-inch diameter. It will be installed below the bottom edge of the culvert. Glue a 90-degree elbow to the end of this pipeline where it will be inside the culvert.
- Build a standpipe by capping one end, and drilling a series of holes up and down the



sides to allow water to flow into the perforated standpipe. Insert this perforated standpipe vertically into the elbow installed on the end of the supply pipe. This standpipe should be 12-24 inches long, and it should not be glued. That way, the standpipe can be removed to drain the storage culvert quickly if repairs are needed.

- Prepare the culvert by drilling holes on one side of the culvert up to about 18 inches from the end, depending on the depth of the pool. The culvert should only be perforated for 2-3 feet at the bottom to allow spring water flow into the culvert collection box. If more than one section of culvert is needed, due to depth, use non-perforated culvert sections above the spring flow elevation.
- Notch the lip of the culvert on the end that is placed into the pool.
- Place the collection culvert over the standpipe, lining up the notch in the lip over the supply line to keep the culvert from crushing the pipe.
- Place a gravel jacket 1.5 to 2 feet thick on the water-source side of the culvert. Tamp the downstream side of the culvert with good clay or a combination of clay soil and bentonite. Place clay on top of the gravel jacket, 1.5 to 2.5 feet thick.
- Backfill all open trenches with excavated material.
- Backfill soil around the collection pit area; allow for settling of the soil.
- Install a fence around the spring and collection area to exclude livestock and protect the water source.
- For a pumping system, submersible pumps work very well. Install a supply line above the stored water level and below the frost line. Platforms to hold pressure tanks and fittings can easily be constructed inside the upper part of the larger diameter storage culvert.
- A good steel or concrete lid is essential to keep children and livestock out of the culvert.

Corrugated Perforated Pipe System

If spring water flows are 30-100 feet wide and perpendicular to the normal surface runoff flow direction, use corrugated perforated pipes that are 4-8 inches in diameter.

Dig a short test trench parallel to the water flow area that is about 2-3 feet above the wetland plant edge. The trench should be 3-4 feet wide and 4-5 feet deep. The soil type and texture is the key indicator of the proper depth. Digging to bedrock or into gray clay is essential. The grade of the trench should be surveyed so that humps and dips will not cause flow problems. Grade for the tile should be four inches of drop per 100 feet.

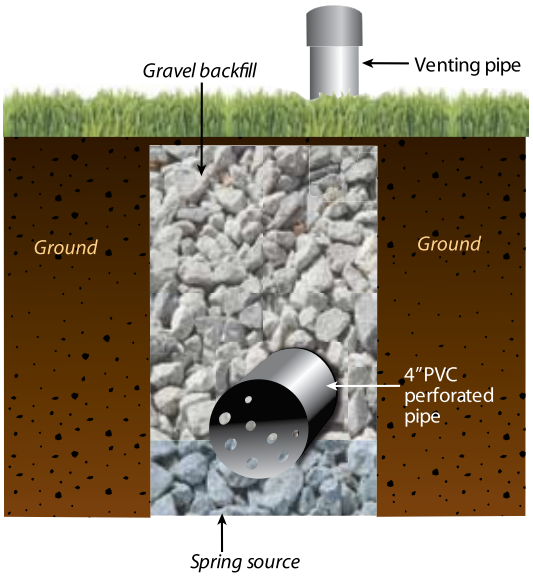
Once the depth is determined, the exact elevation of the gravity fed tank can be determined. This elevation can be predetermined if there is a large elevation change from the spring to the tank. However, if available space is limited, definite elevation plans must be made after the spring is exposed. In those situations, dig a trench towards the tank area, but divert it away from the tank installation area to keep the area dry. This trench often can be used with the final overflow pipe from the tank.

Install collection pipe as the trench is dug, placing gravel at the same time as the pipe. Continue placing segments of the collection tile and gravel until the entire seep area has been cut off. Then attach a cap with a one-foot long stub of PVC pipe to the end of the collection tile.

Dig a trench for the supply pipe and attaché pipe to the stub. Tamp a barrier of good clay to form a seal at the end of the seep area. Use bentonite if good clay soil is not available. This seal should be 4-6 feet horizontally and as deep as the trench. The supply pipe leading to the watering tank should be at least 1¼ -inch in diameter.

Rigid Perforated Pipe (French Drain)

A French drain is simply a cross trench with perforated pipe and clean rock that intercepts spring water and sends it into a supply line.



- To install a French drain, dig as close as possible to the spring without getting into the spring or in the outflow area. The collection trench should go from dry ground on one side, across the spring flow, to dry ground on the other side. Dig to solid rock or clay material to ensure as much water as possible without it going under the collection pipe.
- Surveying is essential to ensure positive grade in the collection pipe and the distribution line to the tank. The depth of the collection pipe may affect tank location. As a general rule, there should be at least a one-foot drop in elevation between the collection pipe and the water level in the tank. Do not allow water to stand in the collection pipe or to backup into it.
- Collection and distribution pipe should be 4-inch PVC (schedule 40 or 35) with bell ends. The bell ends should be placed upstream. Glue an end cap onto the perforated pipe or attach a vented stand pipe to keep air from being trapped in the system. Be sure to place the pipe so that the holes are facing to the sides of the trench.
- A straight line collection or a "T" collection can be used. Drill a single row of 3/8-inch holes through the pipe to collect water. Place the holes on the side to allow for settlement of fine sands and dirt in the bottom of the collection pit. A filter sock can be placed over the pipe if the spring is yielding sand.
- An upright pipe placed at the end of the perforated collection pipe allows for venting of the pipeline, inspection of spring flow or for cleaning and flushing the system.
- Attach the solid pipe at the end of the collection area, and continue laying the pipe to the watering tank site.
- Spread bentonite in the bottom of the collection pit along the back part of the trench away from the spring area. This will help force the water into the pipe.
- Backfill the collection pit with 1-inch, clean rock up past the collection pipe. Cover the gravel with a geotextile fabric, then place soil on top of the fabric. This will keep soil from seeping into the system.
- Backfill the rest of the trench with excavated material.
- Fence the collection area to keep livestock from damaging the system and to guarantee improved water quality.

A watering tank for springs is installed with inlet and outlet pipes to allow the continuous flow of the spring to fill the tank and flow out to a protected area away from the tank. Some producers plumb the outlet pipe into secondary tanks downhill, allowing for multiple watering tanks from the same spring.

Maintaining Water Delivery Systems

It is important to plan and schedule routine maintenance of water systems to avoid costly repairs and to ensure longer service lives of the systems. Here are a few things to do periodically to keep water delivery systems as trouble free as possible.

Wells

- Check that pressure tanks and piping, electrical switches and valves are all connected and working properly. This is especially important if wells are not used during the winter.
- Make sure that insulation remains installed, and replace worn door gaskets in the well house.
- Always keep extra sets of pump switches and pump fuses on hand.

Pipelines

- When systems are installed, create maps containing reference measurements from permanent structures. The maps help to easily locate buried lines if they develop leaks or to locate pipelines before drilling or excavating in the area.
- Check pipeline routes for leaks, especially in rocky areas that become wet.
- Check pipeline routes for adequate coverage of dirt for insulation. Soil coverage will settle 10 percent or more over time.
- Check shut-off valves to make sure they function properly.

Above Ground Pipe

- At the beginning of every grazing year, turn the water on and let the lines flush to remove water scale, debris and gravel before installing valves.
- Check all fittings used to connect pipelines to make sure that they have not broken during the winter.
- Keep hose bibs open during the flush sequence, then close them to see if they shut off properly.

Tanks

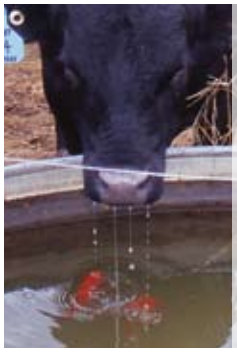
- Drain plastic or concrete tanks monthly
- Replace worn or broken balls, floats, and valves as needed.
- Check the flexible lines in plastic water tanks for wear or breaks, and replace worn seals.
- Check insulation around pipes and in insulated tanks, and replace it as needed.
- Make sure the bottoms of plastic tanks are caulked or sealed.
- When they are not in use, store portable tanks where livestock will not damage them.

Winter Care

- Install thermostatically controlled heat in well houses.
- Drain wells, tanks and pipelines when the tanks and pipelines are not being used.

Pads

- Rough up surfaces of concrete pads that have become smooth after years of use.
- Patch or replace broken pads.
- Add more gravel to gravel pads as needed. Geotextile fabric and geo-webbing will extend the life of gravel pads and reduce maintenance costs.



Algae Control

- Control algae growth in tanks by placing a few goldfish in them. The fish keep the tanks clean by eating algae. Goldfish seem to survive winters with no problems; some tanks have had the same goldfish for eight years.

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Helping People Help the Land in Missouri

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HYDRAULIC RAM MADE FROM STANDARD PLUMBING PARTS

Cooperative Extension Service/The University of Georgia
College of Agriculture and Environmental Sciences/Athens

There are a number of companies that manufacture hydraulic rams. While manufactured rams come pre-assembled and offer the highest degree of convenience and efficiency, they can be quite expensive. Fortunately, inexpensive ram pumps can be assembled from pipe fittings that are commonly available at most hardware and farm stores.

Assembly is fairly quick and easy. All that is needed is a pair of pipe wrenches, Teflon tape or other thread sealant, PVC cleaning solvent and PVC cement. Table 1. lists all of the parts shown in Figure 1. When assembling threaded fittings liberally apply thread sealant, or use 3-4 turns of Teflon tape and tighten all fittings securely to prevent leaks.

All ram pump fittings except the delivery pipe should be made of either of galvinized steel, brass, or schedule 40 or higher PVC. The delivery pipe can be made of any material provided it can withstand the pressure leading to the delivery tank. Make sure that the swing check and the spring loaded check valves are installed as shown in Figure 1. The flow direction arrow on the body of the swing check valve must point down. The valve below the pressure guage should be kept closed except while making readings in order to protect the guage from water hammers.

A bike, weelbarrow or scooter inner tube serves as an air bladder for the pressure tank. Insert the inner tube into the pressure tank and fill it slightly with air (less than 10 psi). Some inner tubes may need to be folded in order to fit them inside the pressure tank casing. The sealed volume of air contained in the tube prevents either water-logged or air-logged conditions in the pressure tank.

There are several nonessential, but useful parts included in this ram assembly. The ball valves, union fittings, and guage assembly are all optional. The ball valves on both the drive and delivery pipes are helpful for starting the ram and controlling its flow. The union fittings, also on both the drive and delivery pipes, are helpful for removing the ram for maintenance and/or repairs. The gauge assembly is useful for making

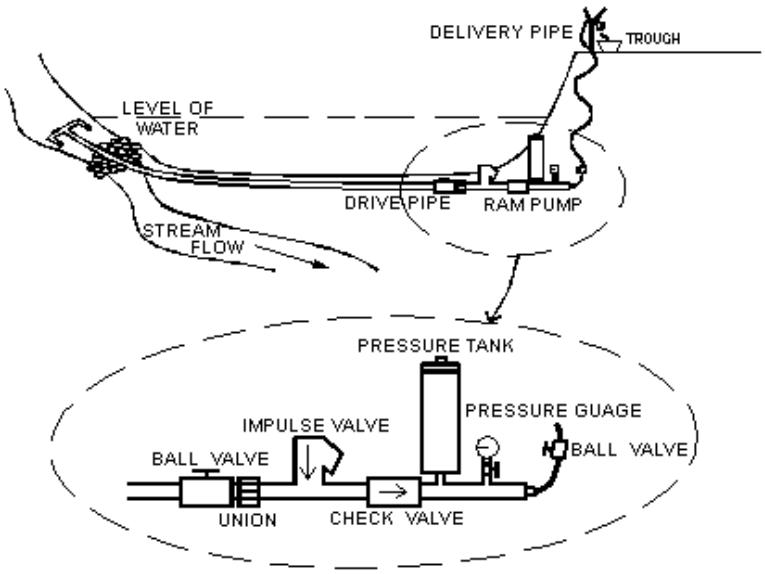

Figure 1. Hydraulic Ram Assembly

pressure readings, especially while starting the ram. Any or all of these fittings can be left out of the ram assembly without affecting pump performance. However, the absence of these parts will make it more difficult to start and maintain the ram.

With the exception of the pressure tank's air bladder, all air trapped in the drive pipe, ram assembly, and delivery pipe must be displaced with water before these rams will pump properly. A few minutes of manual operation, and several re-starts, may be required to displace the trapped air

Pumping to Low Elevations

If the discharge elevation (delivery head) is less than 30 feet, it may be necessary to install either a ball valve or an adjustable pressure relief valve on the discharge (watering trough) end of the delivery pipe. Either of these valves can be used to regulate the water flow through the delivery pipe, which in turn regulates the back pressure on the ram assembly. A back pressure of up to 10 - 12 psi (as read on the pressure gauge) may be required for proper ram performance.

Table 1. Parts List for Hydraulic Rams Made up of Standard Plumbing Parts

Metal Ram Pump
1. Screened water supply
2. 1¼" drive pipe
2. 1¼" ball valve
3. 1¼" x 2" nipple
4. 1¼" union
5. 1¼" x 2" nipple
6. 1¼" tee
7. 1¼" close nipple
8. 1¼" brass swing check valve
9. 1¼" close nipple
10. 1¼" spring loaded check valve
11. 1¼" x 2" nipple
12. 1¼" tee
13. 1¼" x 2" nipple
14. 4" x 1¼" reducing coupling
15. 4" threaded pipe 36" long
16. Inner tube (slightly inflated)
17. 4" pipe cap
18. 1¼"close nipple
19. 1¼" x ¾" reducing coupling
20. ¾" x 2" nipple
21. ¾" tee
22. ¾" x ¼" bushing
23. ¼" x 2" nipple
24. ¼" ball valve
25. Pressure gauge
26. ¾" x 2" nipple
27. ¾" union
28. ¾" x 2" nipple
29. ¾" ball valve
30. ¾" delivery pipe

PVC Ram Pump
1. Screened water supply
2. 1¼" drive pipe
3. 1¼" ball valve
4. 1¼"union
5. 1¼" slip x male adaptor
6. 1¼" threaded tee
7. 1¼" close nipple
8. 1¼" brass swing check valve
9. 1¼" close nipple
10. 1¼" spring loaded check valve
11. 1¼" slip x male adaptor
12. 1¼" slip x slip female tee
13. 1¼" male adaptor
14. 4" x 1¼" reducing coupling
15. 4" pipe 36" long
16. Inner tube
17. 4" pipe cap
18. 1¼" x ¾" reducing coupling
19. ¾" tee
20. ¾" x ¼" slip x female bushing
21. ¼" x 2" nipple
22. ¼" threaded ball valve
23. Pressure gauge
24. ¾" union
25. ¾" ball valve
26. ¾" delivery pipe

Adjusting the Ram

These rams can be adjusted in one of two ways. The swing check valve may be adjusted by first rotating it so that its pivot is in line with the drive pipe and then twisting the valve and tee away from the vertical by as much as 30 degrees. This allows the swinging flap to partially close, which shortens the stroke period. The other way to adjust these rams is to alter the length of the drive pipe. Lengthening the drive pipe will increase the stroke period. Conversely, shortening the drive pipe will shorten the stroke period.

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The University of Georgia

Hydraulic Rams For Off-Stream Livestock Watering

Cooperative Extension Service/The University of Georgia
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The benefits of off-stream watering are numerous. Watering livestock away from the water source can improve water quality, animal health, animal productivity, pasture utilization and manure distribution. As both pasture management techniques and pressure to protect the environment intensify, producers are being forced to look for new and better ways to water their livestock.

Recent cattle grazing studies show that off-stream watering significantly reduces stream bank erosion and lowers the amount of nutrients, sediment, and fecal bacteria entering the water source. In fact, many scientists feel that off-stream watering is a cost effective alternative to stream bank fencing.

For maximum production and pasture utilization, animals need plenty of water. By providing animals with easy access to water, off-stream watering helps insure that water is not a limiting factor to animal weight gains. These additional water sources also open up pasture management options, like rotational grazing, which can increase pasture carrying capacity and/or enhance forage utilization.

From the standpoint of animal health, some diseases are spread by animals coming into contact with urine and/or feces discharged from infected animals. Also, studies have shown that the incidence of foot rot and mastitis are greater among cattle herds that are allowed to enter wet, muddy areas. Off-stream watering helps solve these problems, by allowing

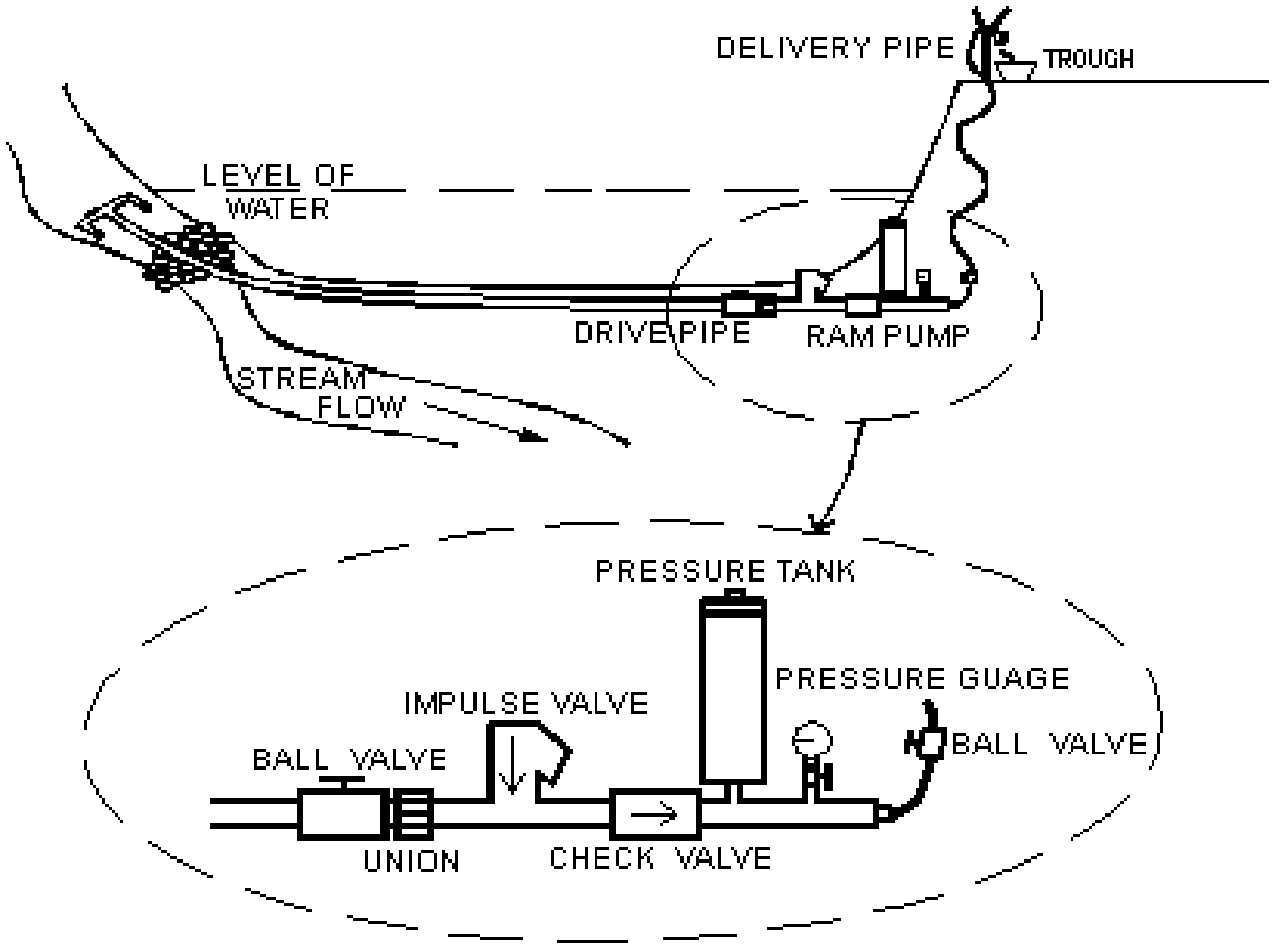


Figure 1. Hydraulic Ram Installation

producers to remove cattle from many of the areas that harbor disease organisms.

Were it not for the initial cost of setting up watering systems, escalating energy costs, and limited access to electricity, off-stream watering would probably be far more widespread than it is today. The hydraulic ram pump overcomes many of these obstacles. It is a motorless, low flow rate pump that uses flowing water as an energy source to operate the pump. Hydraulic rams are ideal for use where small quantities of water are required, such as for livestock watering.

PRINCIPLE OF OPERATION

A hydraulic ram uses the kinetic energy of falling water to pump water. The mechanics of the hydraulic ram are pictured (Figure 1) and described below. Water from a spring, creek, artesian well, or stream flows down the drive pipe and out through the impulse valve until its velocity is sufficient to close the valve. The sudden closing of the impulse valve forces a moving column of water to pass through a check valve and into the pressure tank. The momentum of the flowing water compresses the tank's air-bladder until the pressure of the trapped air is so great that the bladder begins to rebound, pushing water back down and out of the pressure tank. Water flowing out of the pressure tank forces the one way check valve to close which diverts all water flow through the delivery pipe to its destination. The closing of the check valve also creates a slight vacuum, which permits the impulse valve to reopen, and the pumping cycle begins again.

Table 1. Daily Water Requirements

Livestock (drinking)	gallons/animal/day
Milking cow	25-45
Dry cow	12-30
Calf	6-12
Beef animal	1.5/100 lbs. weight
Hog	4
Horse	10-15
Sheep	2
100 Chickens	4-5/100 birds
100 Turkeys	18/100 birds

PUMP SELECTION

A ram's size must be selected to produce a required flow rate while generating enough pressure to lift the water to the desired elevation. The fall from the water supply source to the ram must be at least 2 feet and the minimum flow of water needed is roughly 1-2 gallons per minute (gpm). The relationship between pump output and water source can be expressed as:

$$Q = \frac{V \times F}{E} \times 0.60$$, where:

Q = pumping flow rate (gpm)
F = vertical fall of the drive pipe (ft)
V = available flow through drive pipe (gpm)
E = vertical distance or eleveation that the water will be raised (ft)
0.60 = efficiency of a ram installation
** Each of these parameters is further defined below**

Note: The length of the delivery pipe is not considered in this equation because friction losses are normally small due to low flow rates. However, if the discharge pipe is extremely long or if the flow rate is high, friction losses in the delivery pipe will affect pump flow rates.

Pumping Flow Rate (Q)

Before installing a ram pump, you need to have an estimate of your water requirements. Use Table 1 to determine water requirements. Multiply the number of animals that the pump will serve by the daily water requirement for that animal in order to determine a total daily water requirement in gallons. Next, divide that number by 1440 to determine desired pumping flow rate (Q) in gallons per minute.

Measuring Available Water Flow (V)

If the flow of water from the source is small it can be measured by timing how long it takes to fill a bucket of known capacity with water from the supply source. However, for larger flows it may be necessary to use a weir or flow meter to measure available water. This measurement should be taken during the driest season of the year. Be sure that the flow (V) is calculated in gallons per minute.

Vertical Fall (F) & Lift Elevation (E)

The fall from the supply source to the ram can be determined using a leveling instrument or by using a carpenters level securely fastened to the top of a pole (*See Figure 2*). Starting at the proposed ram sight, place the pole-level on the ground and observe where the line of sight hits. Continue in this manner until you reach the level of the source. Add the measurements together to obtain the vertical fall of the water (F) in feet.

The same procedure can be used to determine lift elevation (E). In this case, measure from the proposed ram sight up to the point of discharge.

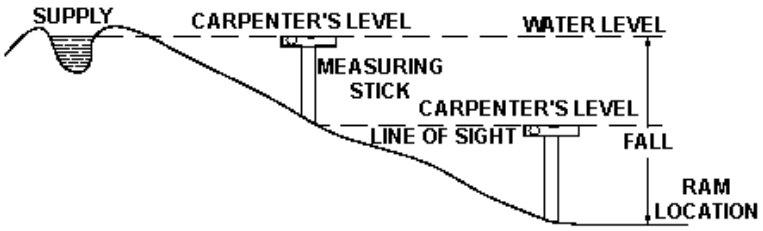


Figure 2. Determining Vertical Fall (F) and Lift Elevation (E) Using a Carpenter's Level

INSTALLATION & CONFIGURATION

Matching Rams to Available Water Flow

Hydraulic rams come in drive pipe sizes from 3/4" to 8" diameters, delivery pipe sizes from ½" to 4" inch diameters, and drive water requirements of $^{3}/_{4}$ to 400 gpm. Table 2 can be used as a guide in matching new pump size to available water flow.

Foundation

The ram should be bolted or securely fastened to a very stable and level foundation.

Source

The water source should be screened to prevent trash from entering the drive pipe and clogging the ram.

Drive Pipe

The drive pipe is probably the most important part of a ram installation. It carries the water from the source to the ram and contains the pressure surge.

- Should be galvanized steel or at least schedule 40 PVC
- Should be as straight as possible. Minimize bends and avoid elbows.
- Should be at least one size larger than delivery pipe
- Should be watertight and rigidly anchored
- The upper end of the drive pipe should be installed at least one foot under water in order to avoid whirlpools from forming and sucking air into the drive pipe

Table 2. Hydraulic Ram Specifications

Drive Pipe Diameter (inches)	Delivery Pipe Diameter (inches)	Min. Intake (gpm)	Max. Intake (gpm)
¾	½	¾	2
1	½	1½	6
1¼	½	2	10
1½	¾	2½	15
2	1	3	33
2½	1¼	12	45
3	1½	20	75
4	2	30	150
6	3	75	400
8	4	400	800

Determining Drive Pipe Length

Recommendations for drive pipe length are based on empirical data from systematic experiments. Calvert (1958) found that the output and stability of a ram installation depend on the ratio of drive pipe length (L) to diameter (D). He found that hydraulic rams will work satisfactorily if L/D is between 150 and 1000.

For example, to determine the minimum length of a drive pipe that has a 1½ inch diameter: L/D = 150, so D x 150 = L, or 1½" x 150 = 225" (18.75'). To calculate the maximum length for this same drive pipe: L/D = 1000, so D x 1000 = L, or 1½" x 1000 = 1500" (125').

When drive pipe length falls outside of this range both performance and stability are impaired. Increasing the drive pipe length within this range produces no change

in waste or output, but it does lower the beat frequency (fewer beats per minute.) Practical aspects such as valve wear, fatigue of pipe fittings, and the amount of noise generated all favor a low beat frequency, and hence a longer drive pipe than the minimum necessary for good performance.

Supply Pipe and Stand Pipe

If you have to go downstream for a great distance in order to obtain adequate vertical fall, a stand pipe and a supply pipe will need to be installed between the water source and the drive pipe with a tee joint *(see Figure 3).* The supply pipe and stand pipe will not be exposed to as much stress as the drive pipe. Therefore, the strength of the materials used in their construction is not as critical. It is not imperative that these pipes run on a straight incline. However, it is essential that they be sized to carry more water than the ram can use, so that air is not sucked into the drive pipe.

Supply Pipe

- Can be made from any material that will stand up to the pressure exerted by the water source
- Must be at least one size larger than the drive pipe
- Should run on a straight incline where possible
- The top of the supply pipe should be installed with a screen that is at least one foot under water

Stand Pipe

- Can be made from any material that will stand up to the pressure exerted by the water source
- Must be at least two sizes larger than the supply pipe
- The top of the stand pipe should be at least a few inches above the level of the water at the source of supply

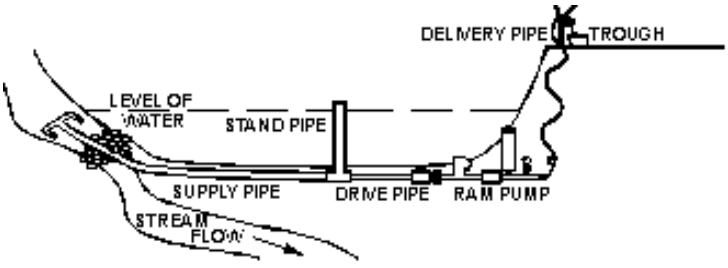


Figure 3. Hydraulic Ram With a Distant Supply

Delivery Pipe

- Can be made from any material that will stand up to the pressure of the water leading to the watering trough.
- Avoid right angled elbows wherever possible.
- To avoid excessive pressure losses due to friction, make sure that the diameter of the delivery pipe is large enough so that the velocity of the water running through it does not exceed 5 feet per second.

$$\text{Velocity} = \frac{Q}{2.45 \times D^2} \quad \text{where:}$$

Q = pumping flow rate (gpm)
D = inside diameter of delivery pipe (in)

Drain Tile

The total amount of vertical fall can often be greatly increased by sinking a ram pump deep into the ground and extending drainage tile to divert unused water. A frost pit or well casing can be used to bury a ram, but a drain tile is essential to carry off the waste water.

Installation of Two or More Rams

Rams are often installed in batteries or groups if a single pump does not meet the water requirement, or if available flow in the water source varies during the year. If two or more rams are installed alongside each other, each ram must have its own drive pipe, but all of them can pump into one common delivery pipe of sufficient size to carry the water (*see Figure 4*).

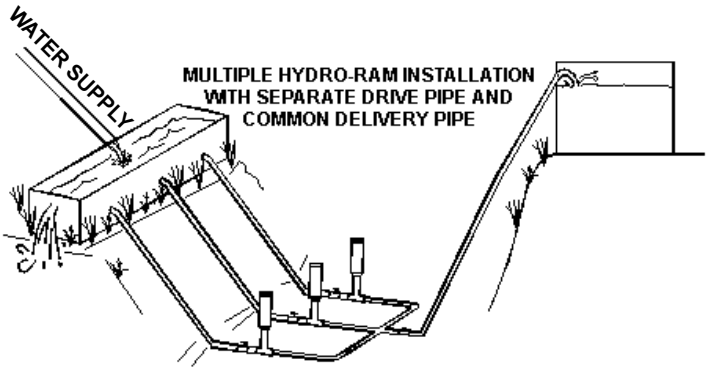
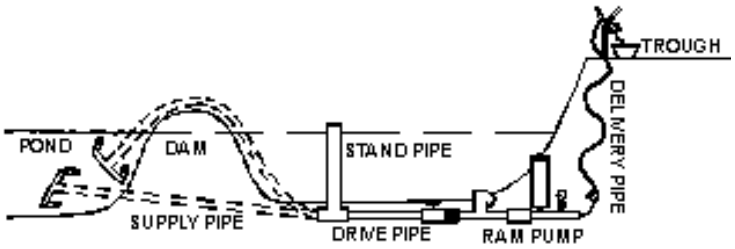


Figure 4. Installation of Hydraulic Rams in a Battery

Installation of a Ram Behind a Dam

Water from lakes, ponds and springs can be pumped by placing a ram on the backside of a dam. The water for the ram's operation can either be piped directly through the dam, or it can be siphoned over the dam. Because the pipe in a siphon system is bent, it should



be treated like a supply pipe. Therefore, a stand pipe should be installed between the siphon and the drive pipe with a tee joint (*see Figure 5*).

Figure 5. Installation of a Ram behind a Dam

STARTING A RAM PUMP

- If there is a valve between the ram and the drive pipe open it
- If there is a valve between the ram and the delivery pipe it should be closed
- Push down on the impulse valve for two seconds and release. Repeat this step until the ram begins to work automatically
- When the pressure in the storage tank reaches 10 - 20 psi, the valve between the ram and the delivery pipe should be opened slowly. A gauge installed between the pressure tank and the ball valve on the delivery pipe is useful for making these pressure readings *(see Figure 1)*.

HYDRAULIC RAM SIZING DATA SHEET

The following data sheet can either be used to help you correctly size a ram pump yourself, or you can fill it out and send it to a manufacturer, so that they will have the information needed to size it for you.

Site Characteristics:

1. Available supply of water (gpm)

_____

2. Vertical Fall (ft)

_____

(Measure the amount of vertical fall in feet from the water level of the source supply down to the level of the foundation on which the ram will rest.)

3. Distance from source of supply to ram (ft)

_____

4. Vertical distance or elevation that water will be raised (ft)

_____

5. Distance from the ram to the watering trough (ft)

_____

6. Total daily water requirement (gallons)

_____

A PARTIAL LIST OF RAM MANUFACTURERS

B & L Associated Industries
Rt. 1, Box 118-B
Rusk TX 75785
903-743-5555

Folk Water Powered Ram Pumps, Inc.
2770 White Court, N.E.
Conyers GA 30207
770-922-4918

Rife Hydraulic Engineering Mfg. Co.
P.O. Box 367
Wilkes-Barre PA 18703
1-800-227-8511
The Ram Company
247 Llama Lane
Lowesville VA 22967
1-800-227-8511

Mention of these companies does not constitute any endorsement by The University of Georgia nor does it imply any exclusion of other companies that provide similar goods or services.

ACKNOWLEDGEMENTS

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Fencing Options for Grazing Systems

John W Worley

One of the challenges of establishing a grazing system is building a fencing system that allows you to easily rotate cows from one grazing site to another. Ideally, this fencing system will be inexpensive, easy to build, and easy to maintain. In reality we sometimes have to sacrifice one or more of these goals to achieve another. Sometimes, for instance, it is better to put a little more into a fence to start with in order to lower long-term maintenance. Many times, "temporary" fences become permanent fences with high maintenance requirements. This presentation will attempt to give some pointers on choices of building materials, equipment, and construction methods that will reduce the overall cost of fencing systems.

Types of Fences

Rotational grazing fences usually fall into one of the following categories:

1) Field fence (also known as woven wire, page wire, or hog wire) – Excellent holding power with low maintenance, but high initial cost. Usually used for perimeter fencing.
2) Barbed wire – Lower cost (about half that of field fence), good holding ability as long as tension is maintained. Also good where vegetation tends to interfere with electric fencing.
3) Electric
    a) Permanent – about half the cost of barbed wire, excellent holding power with good maintenance. Vegetation control and monitoring are necessary.
    b) Temporary – Low cost, fast installation. Cost may be higher per foot than permanent because of higher priced materials, but flexibility is improved. This is especially beneficial for temporary cross fencing.

Wire

One of the most significant innovations in fencing has been the introduction of high-tensile, Class III galvanized steel wire. "High-tensile" means that the steel is much stronger than standard steel. The cost is usually less than standard steel wire because of the smaller wire size, yet the smaller wire is stronger than the larger standard steel wire. Perhaps more important than the cost difference is the fact that high-tensile steel wire is much more likely to stretch under stress (cows pushing against it, trees falling on it) and then return to its original length than is standard steel wire, which tends to stretch and stay stretched. As a result, **if the fence brace assemblies are adequate**, line posts can be spaced much farther apart (20 to 25 ft) than posts in standard wire fences (10 to 12 ft). Many people have reported cutting fallen trees off of high-tensile wire fences and watching the fence spring back to its original position with little or no repair work necessary.

Class III galvanizing is simply an extra thick coating of zinc on the wire. This typically gives the wire about twice the life that it would have with standard (Class I) galvanizing.

High-tensile, Class III galvanized wire is available in single wires (electric fencing), barbed wire, and field fence. There is one drawback to this type of fence wire. Since it is a harder, stronger wire, it is also harder to work with than standard steel wire. It is hard to bend, tends to break if you bend it too sharply, and is hard to cut. You need a cutting tool designed to cut this steel wire, else the cutting blades will be quickly dulled. If you have a pair of wire cutters designed for high-tensile steel wire, you must be careful not to twist the cutters or use them for pulling laterally since the cutting edges are very hard and therefore brittle, and they will break rather than bend. Once you learn how to work with high-tensile steel wire and have the right tools, I think you will find that its advantages (lower cost, longer life, resiliency, fewer line posts) outweigh its disadvantages.

For temporary fences, conductive ropes or tapes are generally recommended because they are very flexible and easy to roll up, move, and reinstall. Ropes seem to last longer than tapes, but tapes are more visible which is important when cattle encounter a fence where they are not accustomed to seeing it. Vinyl coated wire is another useful option on permanent electric fencing because it adds to the visibility of the fence. Vinyl coating is available in a conductive form so that the electric wire is still effective at shocking.

Posts

Traditionally, treated wood posts have been the most commonly used fence posts. Posts should be labeled for ground contact, which means they have enough chemical added to prevent rot when in contact with the ground.

Steel posts are another popular option, and the relative market price of steel vs. wood determines which is the best buy. One of the biggest problems with steel posts is that they are commonly painted rather than galvanized. A painted post will begin rusting in a very few years, resulting in rusting and early failure of the wire. A wire that should last 30 to 40 years may have its life cut in half by rust from non-galvanized metal posts, not to mention the degradation of fence appearance. If possible, I would obtain Class III galvanized posts so that you can take advantage of the full, expected life of the Class III galvanized wire. If wooden posts are used, use Class III galvanized staples for the same reasons.

High-density fiberglass posts are another good choice for electric fencing since they do not require insulators, have a long life, and are very strong. These posts are made from “sucker rod”, a byproduct of the oil industry, and are sometimes readily available, and sometimes hard to find. Their cost is similar to a wooden line post. These posts should be handled with gloves, especially after they are exposed to the weather for a few months because they are made of fiberglass, and the glass fibers will easily penetrate the skin.

For temporary fencing, there are a number of plastic and fiberglass “tread-in” posts available as well as small metal posts with insulators. These posts typically don’t have much lateral strength, but for electric fences, as long as the fence is straight and properly energized, that doesn’t usually present much of a problem.

Chargers

For electric fences, one of the most expensive **and most important** components is the fence charger (also known as the energizer or controller). Probably the most important factor to look for in a charger is how well it holds up when the fence gets in poor repair (vegetation touching the fence, spider webs, broken insulators, etc.) ASABE (American Society of Agricultural and Biological Engineers) has established a standard for testing fence chargers. Basically, the voltage and the energy output (in Joules per pulse) are measured with the following resistors placed between the fence terminal and the ground terminal.

50,000 ohms (represents a fence in excellent condition)
5,000 ohms
500 ohms
100 ohms (represents a fence in very poor condition)

I would encourage you to look for a controller that has been tested by this standard and maintains a high voltage (at least 1,000 volts) under the extreme conditions of a 100-ohm resistor. This will assure you a strong charge even when the fence is compromised by vegetation and other maintenance factors.

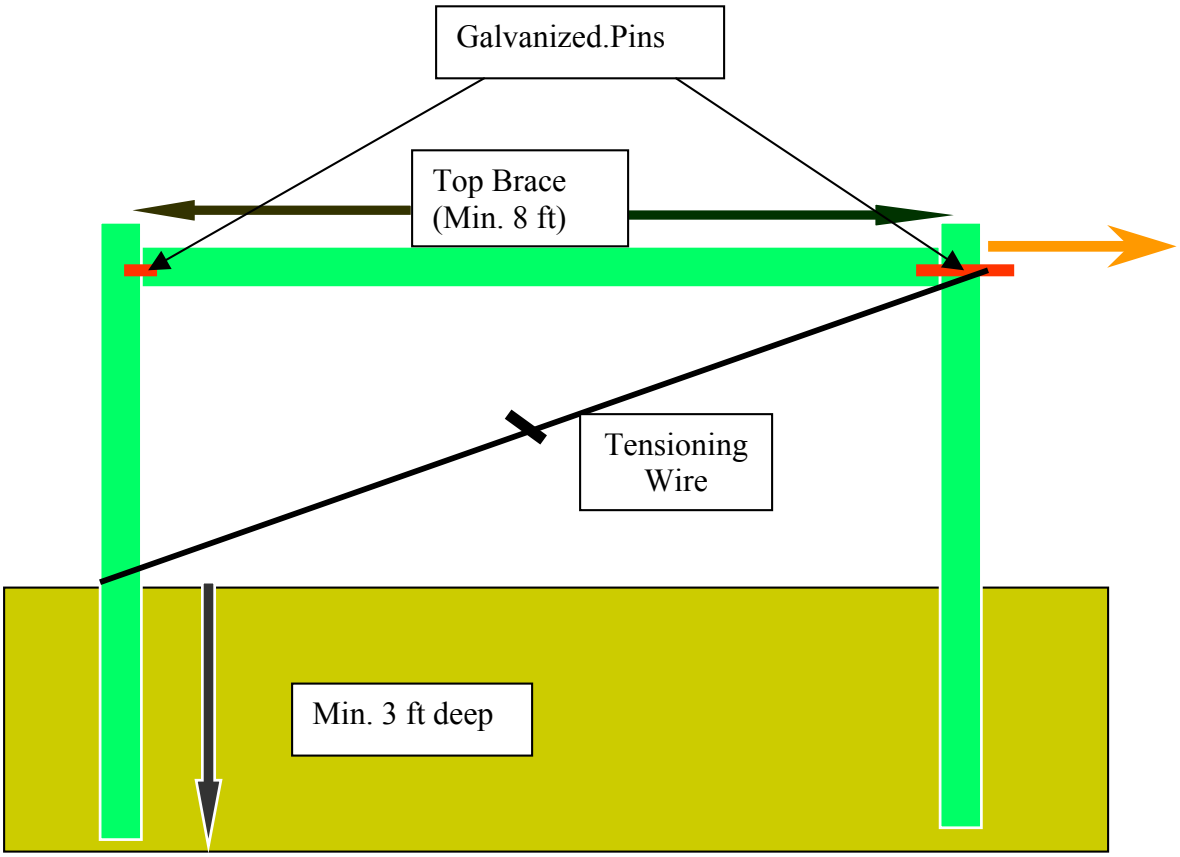
Construction

Building a fence is somewhat like building a house or a barn. Each component plays an important part in the success of the structure, but the one component that everything else depends on is the foundation. Without a good foundation, a building will lose its integrity regardless of how the rest of the structure is built, and the same is true of a fence. The foundation of a fence is the brace assemblies. Each section of fence is basically two brace assemblies with wire stretched between them and line posts to help keep the wires in the right position. Line posts are used to guide the wires along gentle curves, up and down over rolling terrain, and to keep the wires spaced properly. More line posts are needed for standard steel wire than for high tensile wire because standard steel will not recover its original shape as well and thus tends to sag more. High tensile steel will sag as well due to seasonal temperature differences, but if properly installed, can be retensioned easily.

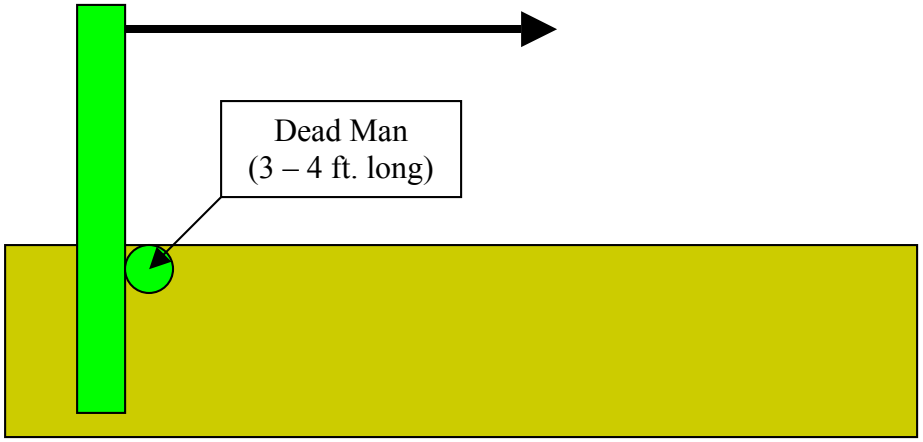
There are two common types of brace assemblies – the H-Brace and the Dead Man.

H-Brace: The H-Brace (shown below) works by transferring the load from the top of the corner post to the bottom through the horizontal brace post and the tensioning wire. There are two keys to making the H-brace work to its maximum advantage that are often overlooked.

1. The top (horizontal) brace post must be held in place. Over time, the ground tends to shift and cause the post to move so that it no longer supports the brace. The best way to accomplish this is to use small (1/2") galvanized pins as shown in the figure below. "Toenailing" with nails will not hold as well as this method.
2. The tensioning wire must be installed at a low angle with the ground. Otherwise, the wire will try to pull the corner post out of the ground when it is tightened. To assure the proper angle, the top brace post should be 8 to 10 feet long (for a 4-ft. high fence).



Dead Man Brace: The "dead man brace" uses a short post about 3 to 4 ft. long buried in the ground at the bottom of the corner post and perpendicular to the post and the fence (see illustration below.) The strength of this brace comes from the fact that the corner post must push the "dead man" through the soil in order to move in the direction of the fence pull. If a large corner post is used, this is a fairly effective brace, especially for short runs of a few hundred feet, and is cheaper and easier to build than the H-brace. For longer runs (up to a quarter mile), I would recommend using the H-brace.



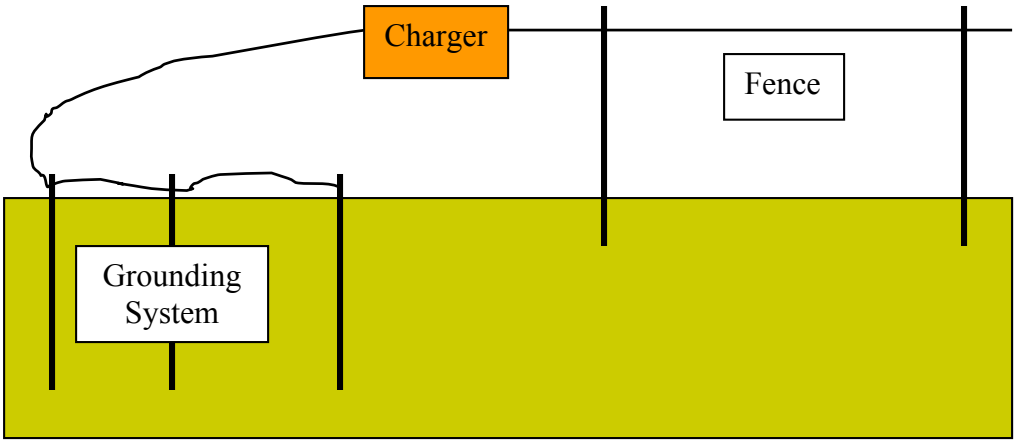
Post Installation: Wooden posts can be installed either by digging a whole and tamping dirt around the post or by driving it into the ground with a post driver. Driven posts tend to be stronger. If driven, the posts should be driven with the small end down. If tamped, it is important to put a small amount of dirt into the hole, tamp it, and then put more dirt in. You can't fill the hole up and then tamp it or it will not hold. Metal and fiberglass posts are best driven into the ground by hand or with a power post driver.

Staples: Again, I would recommend using Class III galvanized staples, and they should be 1 ¾" long if used in soft (pine) wood. Here are a few important tips to remember about the proper installation of staples.

1. Staples should be driven into line posts in such a way as to allow the wires to move under the staples. This allows the wire to move on impact or when heated or cooled by the weather, and then return to its original position. Staples should only be driven tightly on brace post assemblies.
2. Only horizontal wires should be stapled.
3. Staples should be installed with a slight rotation from vertical. Installing a staple vertically (parallel to the post) tends to encourage splitting of the wood. It is important that you rotate the staple in the right direction in order to cause the ends of the staple to spread out and greatly increase the holding power of the staple. There are two types of staples on the market, commonly referred to as right-handed and left-handed staples. Put the staple in your hand with the points aiming away from your body. If there is a slash (flat area) visible on the right-

hand point, it is a right-handed staple. Rotate it slightly to the right (clockwise) before driving. If the slash is visible on the left-hand side, rotate it to the left.

Fence Charger Installation: One of the most important things to remember about installing a fence charger is getting a **good grounding system**. Current can only flow through a complete circuit, and the completion of the electric circuit depends on getting current back through the ground to the grounding system and thus back to the charger. The better the grounding system is, the easier it is for the charger to accomplish this task. Follow the charger recommendations, but usually they recommend installing at least 3 8-ft copper-clad ground rods at least 10 ft apart and connected together with heavy (#6 or #8 copper) wire. This grounding system should be completely separate from any other farm grounding system to minimize the chance of getting stray voltage onto the farm electrical systems.

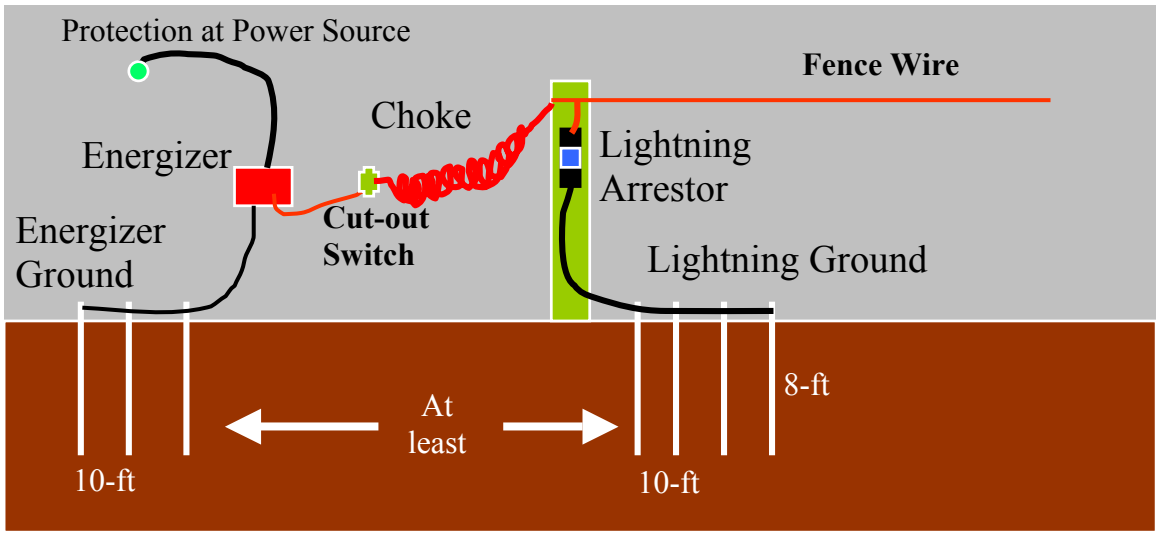


Another strategy that can help, especially in times of drought, is to **ground every other wire (connect them directly to the ground of the charger**.) When the ground is dry, it makes a poor conductor, and it is hard to get current to pass through cows and the dry ground and get back to the charger. If every other wire is a ground wire, then the cow only has to touch two wires, and the current will pass from the hot wire through the cow to the ground wire.

Lightning Protection: Another important issue for any fence, but especially for electric fences is lightning protection. Lightning will always find a path to ground, and it usually will find a number of paths. The goal is to get lightning to the ground through a path that will not cause harm to cattle or equipment. Here are a few things to remember about lightning protection:

1. Nothing is lightning proof! If it hits directly enough, it will destroy almost anything.
2. I recommend using lightning protection supplied by the fence charger manufacturer to protect the charger. That makes it more likely that their warranty will be honored (if they have a warranty against lightning damage).

3. It is a good idea to ground the fence about every ¼ mile by driving a ground rod and attaching it electrically to any grounded wires in the fence. This will provide multiple paths to ground for the lightning. Obviously, if you use metal posts, this would be unnecessary.
4. The figure below shows some guidelines for a good lightning protection system.



Summary

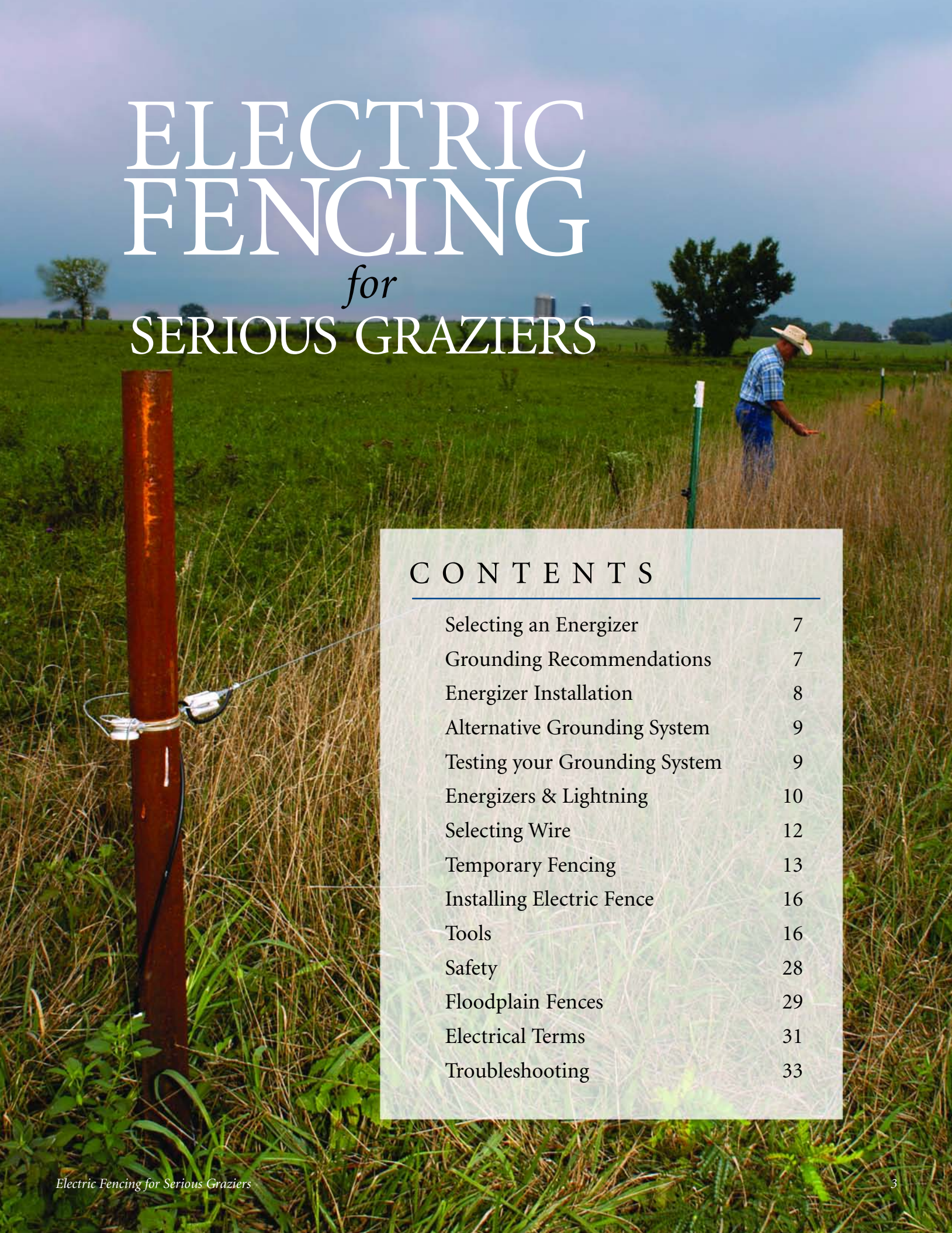
Desirable qualities of a fence are resiliency (springs back after being hit or stretched), high visibility, economy, and ease of installation. If you plan carefully, use the right materials, and put a little extra effort into the installation, your fence should be a good investment that will require a minimum of maintenance and will help make your rotational grazing system a success.

M I S S O U R I

ELECTRIC FENCING *for* SERIOUS GRAZIERS

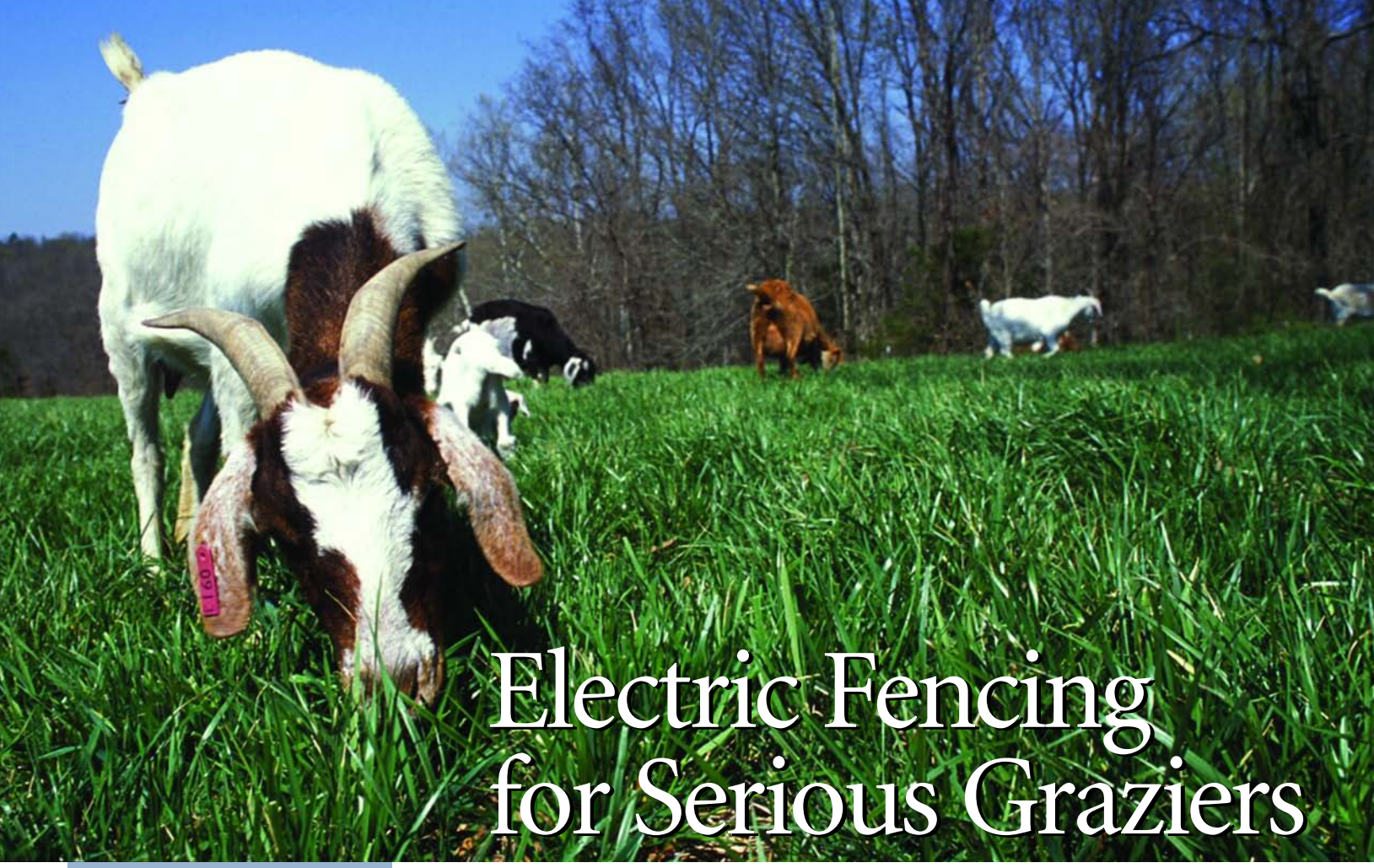
UNITED STATES DEPARTMENT OF AGRICULTURE

NRCS Natural Resources Conservation Service



ELECTRIC FENCING *for* SERIOUS GRAZIERS

CONTENTS



Electric Fencing for Serious Graziers

The information in this publication is based upon the experiences of NRCS personnel and graziers during the past 20 years. This is not intended as a detailed how-to manual about fence building. Those are available from numerous sources. Graziers should collect manuals from several fence companies to learn the techniques that could apply to their operations.

Techniques described here are primarily for producers installing one-wire and two-wire fences and permanent power stations using 110-volt energizers.

Approach electric fence construction with the same frame of mind and skills as you would with any other electrical wiring. Getting shocked by a modern energizer when you get careless won't kill you. But for a while, you might wonder!

Graziers should make every attempt to purchase the best quality products available, which doesn't necessarily mean the most expensive. For instance, there is little difference in the price for junk insulators and the price for quality insulators. People who purchase lower-quality insulators will probably regret it, especially when the substandard insulators start arcing and causing voltage problems. Purchase quality fence components that will last for the life of the fence.

tip:

For more information about getting started with electric fencing or how to improve your existing system, contact the NRCS office serving your county. Look in the telephone directory under "U.S. Government, Department of Agriculture," or access this website: ***http://offices.usda.gov***.

Reasons to Consider Electric Fencing

Electric fencing, sometimes called power fencing, is an effective way to control livestock on most farms. The only places where electric fences should not be used are in cattle-handling facilities where quick exits might be necessary or near the milking facilities of dairy operations.

Advantages

Electric fencing offers two major advantages over other types of fencing. One is cost. The cost to install a four-strand, barbed-wire fence is about $5,000 per mile. The cost to install a typical, single-wire, electric fence is about $1,600 per mile. If necessary, additional wires can be added to an electric-fence for about 10 cents per foot. There could be additional costs to install electric fencing in certain cases. For instance, Missouri law requires that property line fences be at least four feet tall and have posts at least every 12 feet.

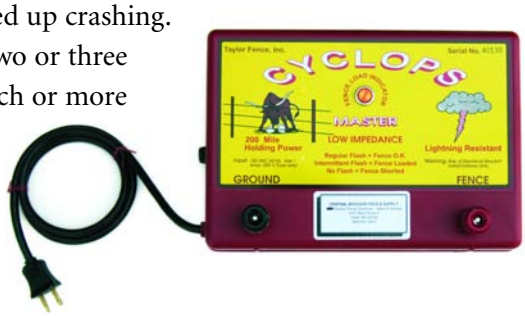
The other big advantage of electric fencing is its ease of construction, which improves forage management opportunities. Small pastures can greatly enhance harvest efficiency and increase the amount of forage produced from a grazing system because of the amount of rest that is introduced into the system.

tip:

Electric fencing is a cost effective and easy way to manage your grazing system.

Selecting an Energizer

The energizer is the heart of any electric-fence system, so select it carefully. A good unit will provide years of service if it is properly installed and maintained. Price should not be the determining factor. Many operators have started with farm-store specials that ended up crashing. The cost to purchase two or three cheap models is as much or more than the cost of purchasing a good one initially.



Purchase a low-impedance energizer with a minimum 5,000-volt output. It should produce 35-65 pulses per minute with each pulse lasting not more than 0.0003 seconds. Each pulse also should have an intensity of less than 300 mAmps.

Seek advice about energizers from experienced graziers, from sales people and from NRCS personnel. NRCS employees cannot recommend specific brands, but they can offer general advice. One of the best methods is to look at several operations similar to yours, and find out what those graziers are using and if they are happy with their units.

Consider the type of livestock to be controlled. For example, containing sheep, goats or horses may require special considerations for charger size and fence construction to ensure that the animals receive adequate shocks when they contact electric fences.

Purchase a larger unit (energizer) than you think you need because graziers usually expand their systems as they realize the benefits of modern electric fencing. Also increase the size of the energizer if you anticipate a high weed load near the fence.

All energizers should come with manuals that explain installation and operation. Study the manual carefully. Also refer to **Drawing 1**, page 8, for installation instructions.

Grounding Recommendations

1. Use galvanized ground rods when using galvanized wire and clamps for the grounding system. With stainless steel connectors on the energizer, copper can be used all the way. Use the same type of metal throughout; do not mix dissimilar metals.

2. Use good clamps and ground rods with a diameter of at least one-half inch. A rule of thumb is to drive at least three feet of rod into the ground per joule of output. Keep fencing ground rods at least 65 feet from the ground rods of any existing utilities. Place rods 10 feet apart to increase the probability of having contact with moist soil.

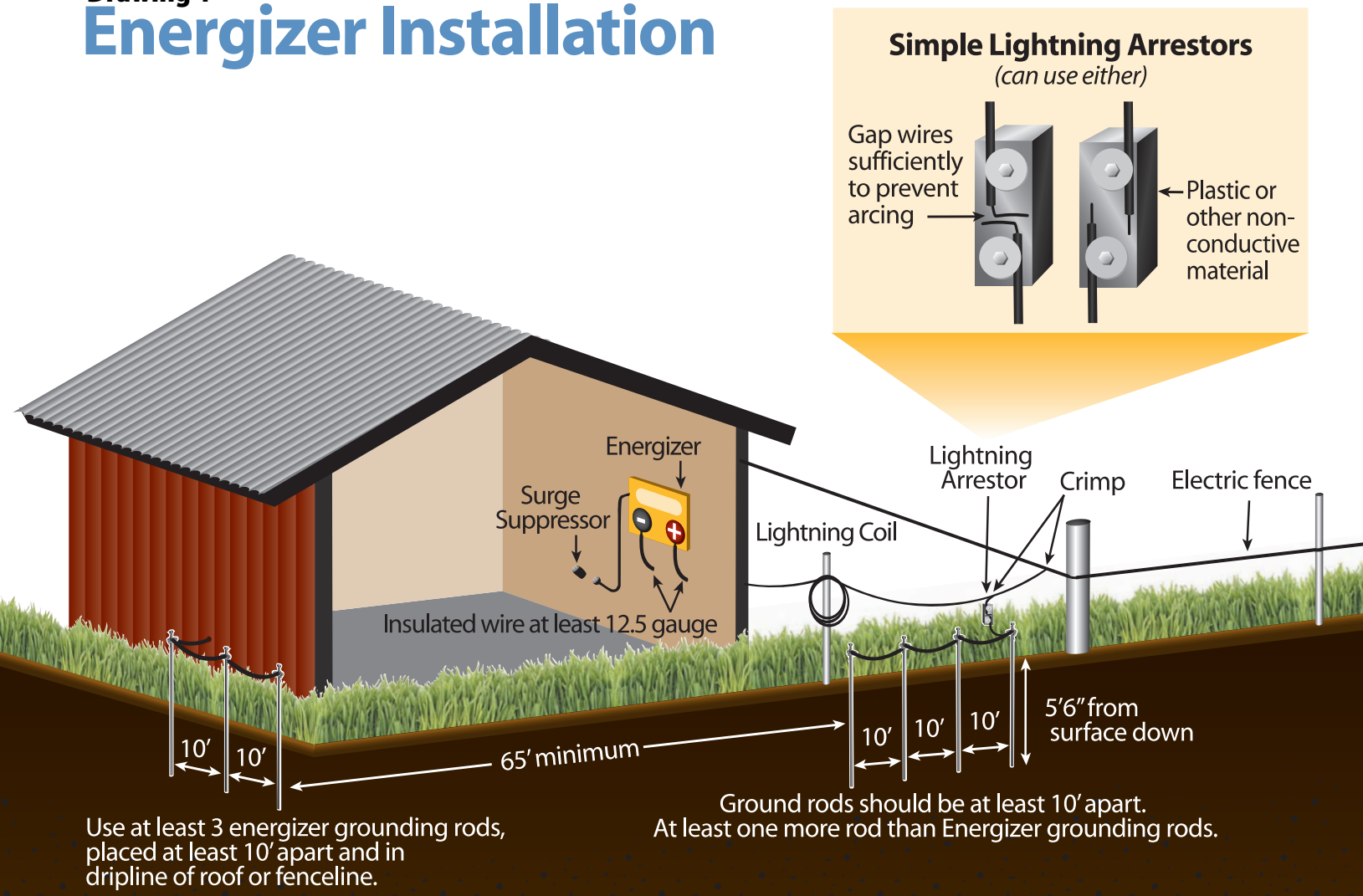
3. Some installers recommend driving ground rods at 45-degree angles in rocky soils. This enables the rods to glance off rocks and continue downward. Since the angle decreases depth, more rods may be necessary.

4. To eliminate the possibility of stray voltage at dairy operations, keep the energizers and grounding systems as far as possible from the milk barns.

5. Be aware of underground utilities and fuel-storage tanks. Avoid these by the greatest distance practical.

Drawing 1

Energizer Installation



Notes:

1. Protect energizer unit from exposure to the weather.
2. Ground rods should be 1/2 inch in diameter or larger and galvanized. Use proper galvanized clamps on rods.
3. As a minimum, install total number of ground rods as recommended by manufacturer of energizer.
4. Place energizer ground rods at least 65 feet from any existing metal structures or waterlines and from any utility company ground points (including building grounds).
5. Drive all ground rods at least 10 feet apart, and connect with a continuous wire of a minimum 12.5 gauge.
6. Keep tops of ground rods, clamps, and connecting wire above the soil surface. Do NOT bury.
7. Lightning protection grouding should be at least 65 feet from any other grounding system: This should have at lest one more grounding rod than the energizer system.

Alternative Grounding Systems

Here are a few alternatives to using metal rods or pipe in energizer grounding systems.

1. Burying a large metal object is a desirable option. A two-foot-by-eight-foot sheet of roofing metal, for instance, has a surface area of 4,600 square inches, while a one-half-inch diameter, eight-foot-long ground rod is only 151 square inches. The metal sheet is equal to 30 ground rods.

2. Clean rust and grease from any metal used, and weld a ground rod to the sheet. The rod promotes a good electrical connection by providing a way to attach a clamp to the sheet. The clamp is necessary to securely connect the wire from the energizer. The metal sheet still needs to be buried deeply. (In the shallow, rocky soils of Missouri's Ozarks region, creating an adequate hole probably will require more than a pick and shovel.)
3. Dig or drill three-inch diameter or larger holes at least 35 feet apart and at least four feet deep. Fill the holes with a wet mix of two parts bentonite to one part coarse rock salt. Insert a half-inch or larger stainless-steel rod in each hole. Add water to the holes during dry weather.

4. Plowing in lengths of wire as deep as possible and connecting them to a common point may be an alternative in some soil conditions.

tip:

Refer to the trouble shooting section on page 33, for more detailed information on testing your grounding system.

Testing Your Grounding System

Use a **digital volt meter** to determine the adequacy of a grounding system. Here's how to properly test a ground field:

- 300 feet from the charger, ground out the fence to 2,000 volts or less. You might need to lay three to six steel posts on the fence to reduce the volts to this level.

- With the digital volt meter, check the voltage on the last ground rod in the system (not the posts used to ground out the fence for this test). The reading on the last ground rod should be zero, but most chargers can tolerate up to 300 volts. If the voltage is more than 300, add additional ground rods until the voltage is in the tolerable range. Make every effort possible to attain a zero reading.

Grounding Errors

Most electric-fence problems are caused by poor grounding, which can result from several errors.

1. **Not enough ground rods**
   A grounding system depends upon the surface area of metal ground rods contacting moist soil to complete a circuit. The grounding system does not function if too few rods are used or if the soil is dry.

2. **Dry soil**
   Anticipate a long, dry summer – the worst possible conditions – when selecting the grounding system location. A good location is on the north side of a building, under the drip line, with the rod driven at an angle back under the floor. Also consider wet areas, such as lagoons or ponds. The grounding system does not have to be located right next to the energizer. Move several hundred feet away, if necessary, to find the best location.

3. **Ground rods are not deep enough**
   It's not unusual for landowners to drive ground rods when the soil moisture is low, only get the rods a few feet deep, and then get discouraged and cut the rods off. If the ground is so dry that rods can't be driven, it's probably dry enough that the grounding system won't function anyway. Either finish driving the rods into the ground after the subsoil/fragipan gets moisture or move to a more desirable location. Do not cut the ground rods off.

Protecting Energizers from Lightning

With all energizer installations, install adequate lightning protection before constructing the fence.

1. Use a good surge protector on the utility power side of the energizer to protect it against power fluctuations. Most energizers are damaged from the power side, not the fence side.

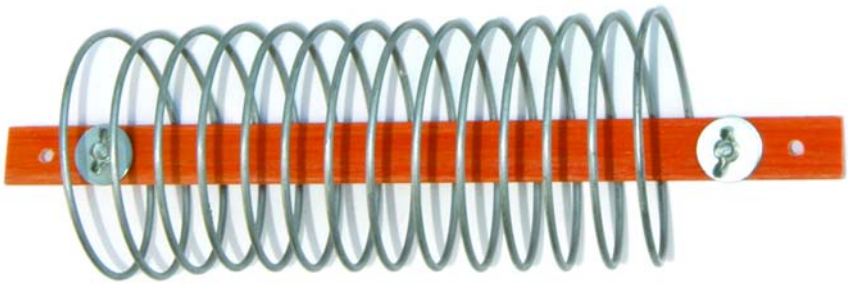
2. Install a lightning choke in the lead-out cable. You can purchase these or build them (**Drawings 2 and 3**).

3. Install a lightning arrestor in the lead-out cable that is connected to the powered fence. Then connect the arrestor to the lightning grounding system.

4. Install the lightning protection grounding system at least 65 feet from the energizer grounding system. The lightning protection grounding system needs to be a more efficient system than the grounding system for the energizer. Therefore, use at least one more ground rod in the lightning protection grounding system than is used in the energizer grounding system. Select sites for lightning protection grounding systems with care so that a lightning strike does not go to ground in the middle of a herd of cattle or where people are congregated.

5. It also helps to install ground rods and arrestors at permanent wet spots along lengthy fences because wet soil provides an excellent ground.

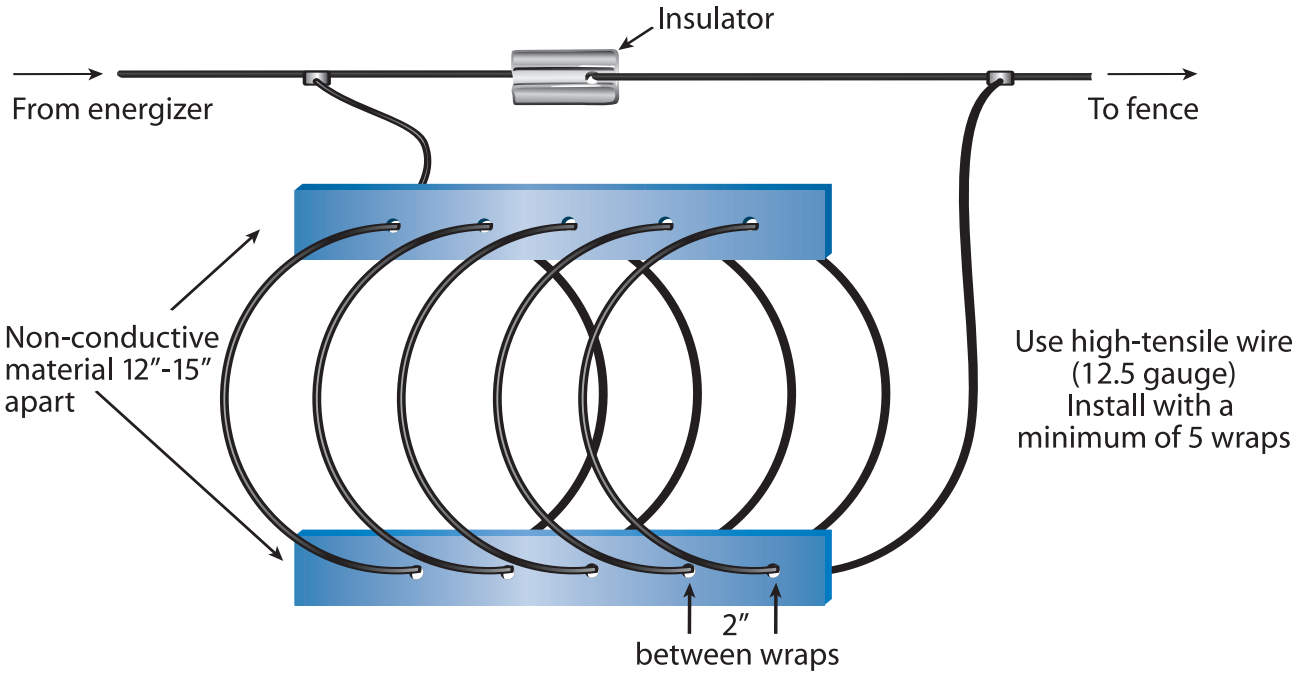
6. With multi-wire fences, be sure to connect all of the wires to the lightning arrestors. The top wire is the first line of defense against lightning damage.



Manufactured lightning choke

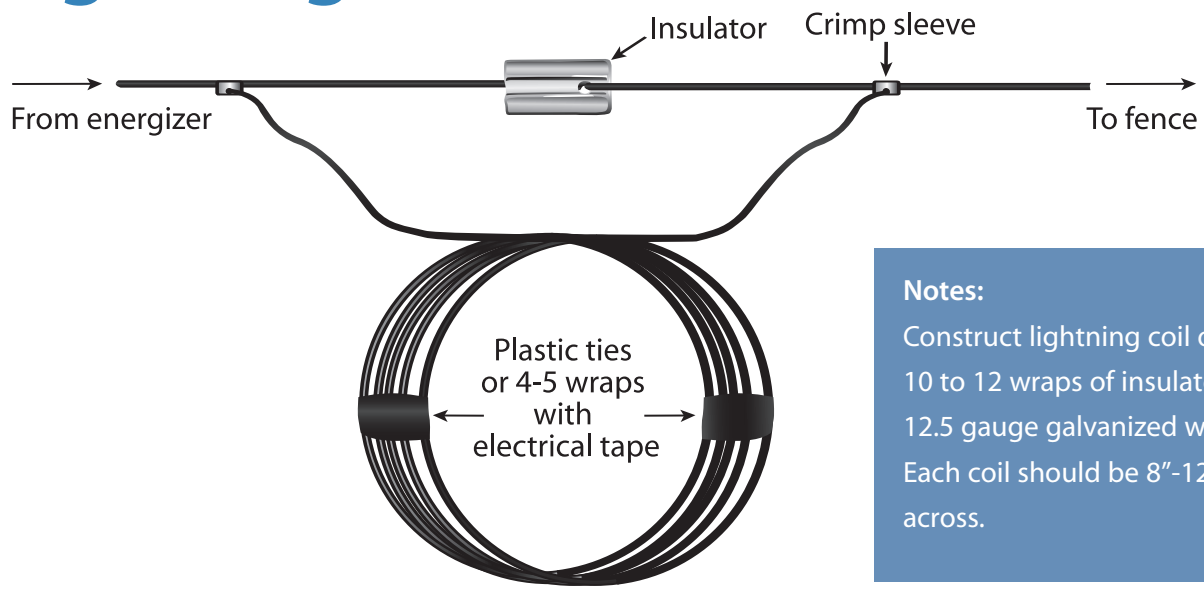
Drawing 2

Lightning Choke



Drawing 3

Lightning Coil



Notes:
Construct lightning coil of 10 to 12 wraps of insulated 12.5 gauge galvanized wire. Each coil should be 8″-12″ across.

Selecting Wire

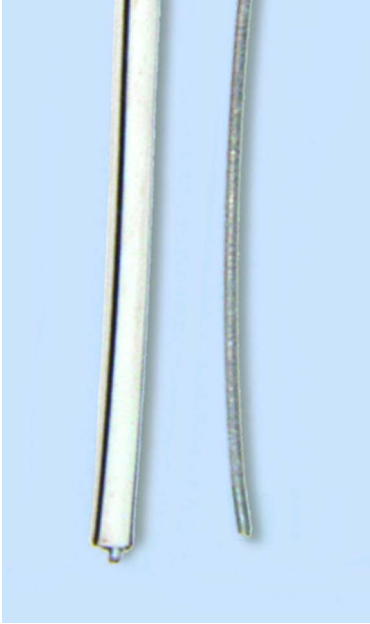
Use at least 12.5 gauge, high-tensile wire with type III galvanizing for permanent and semi-permanent fences. Avoid wire rated at 200,000 p.s.i or more, however, because it's very stiff and hard to handle. Wire that is smaller than 12.5 gauge has a high resistance to current movement, and on a longer run might necessitate the use of a larger, more expensive energizer. The following chart illustrates this point:

Gauge	OHMS/Mile
8	22.5
10	35.4
12.5	56.4
14	87.0
16	136.9

In other words, 16-gauge wire is 2.5 times as resistant to current movement as 12.5-gauge wire. Aluminum is four to six times as efficient as steel wire, but solid aluminum wire is soft and easily broken.

Aluminum-coated steel wire is available, and is a viable alternative. Aluminum is only 60 percent as efficient as copper, but the price of copper or copper-coated wire would be prohibitive.

Never electrify barbed wire because – in addition to being more costly – the barbs on the wire greatly increase the resistance of the wire, the wire is not galvanized adequately to prevent rust, and it is more likely for a person or animal to become entangled in it. Safety is of the utmost importance.



Plastic-coated horse wire (left) and 12.5 gauge high-tensile, galvanized wire are examples of permanent fencing wire. Plastic-coated horse wire is more visible and less likely to cut a horse that may run into it.

Temporary Fencing

Examples of temporary fencing wire

Polywire is a very useful product that most landowners can utilize for paddock divisions, strip grazing, etc. But the fine, metal conductors in polywire and polytape products create a very high resistance to current flow. Therefore, don't depend on it for long runs.

Use six-strand and nine-strand polywire with stainless steel conductors for temporary fencing. Six-strand polywire has a resistance of 9,700 ohms per mile, and three-strand polywire has a resistance of 16,000 ohms per mile.

tip:

A one-sixteenth-inch cable makes an excellent temporary fence. It is cheaper and more durable than polywire. The cable is also more effective than polywire at controlling deer traffic.

Example of a temporary fence post and wire

Graziers need temporary fencing to fine tune all grazing systems so that they get the most benefit from their forage. This is especially true in the spring, when forage plants are growing the fastest, and in the winter, when graziers are trying to stretch their forage the farthest. Here are some temporary-fencing tips to make the job quick and easy:

Temporary fence posts

1. **Use polywire that has at least six strands.**

2. **If you will be moving fences frequently, use treadin posts.** Select posts that have small-diameter spikes and wide tread plates because they will be easier to get in the ground. Polywire is light, so large, sturdy posts are not necessary. A post every 40-60 feet will usually maintain the desired wire height.

3. **When grazing stockpiled forage, start on the end closest to water.** Don't worry about constructing a back fence to protect areas that have already been grazed because the grass won't grow again until the next spring.

4. **Steel posts without braces are more than adequate for corners and gates.** Polywire is not strong enough to pull over a "T" post.

5. **Use the same end insulators and gate handles that you would use for high-tensile fencing.** Treadin posts and fiberglass posts will not require additional insulators, but the appropriate clips are necessary for attaching polywire to fiberglass posts.

Wire Splices and Joins

When making permanent connections in electrical fences, make sure that the joins make good electrical connections. One loose connection can equal a resistance of 500 ohms, and a few loose connections can cause a significant voltage drop.

Use good-quality crimp sleeves, crimped with the proper crimping tool, to make electrical connections. A round, hard material such as high-tensile wire does not make a good electrical connection when wrapped back around itself. Therefore, avoid knots and wraps unless the person constructing the system has the ability to make tight wraps.

Too many graziers depend upon their energizers being able to punch their way through loose wraps instead of taking a little more time to do it right. Wrapping wire properly requires practice. Keep in mind that a person's wrist gets fatigued after performing several hand wraps, which causes subsequent wraps to get increasingly looser.

Knots in high-tensile wire reduce the wire's effective strength by about 30 percent.

Make joins in polywire by twisting the metal conductors together separately rather than simply tying a knot with the plastic strands included.

tip: *Use at least three wires for sheep or goats.*

Installing Electric Fences

People installing electric fences often make the mistake of pulling the wire too tight. Pulling the wire tight requires big corner posts and braces that are overkill for one-wire and two-wire fences. Only tighten wires enough to take most of the sag out of them.

Along woodlands where trees or branches might fall on fences, it is a good idea to include tension springs to add some "give" to the fences. Consider using tension springs where deer traffic is heavy. Springs could prevent some damages to fences and also save the inconvenience of having livestock escape before the damaged fences are discovered and repaired. Also, by driving posts on alternate sides of the wire, only one insulator will likely be damaged if a deer runs into the wire.

Spacing for posts and stays may vary from 40 to 150 feet, depending on the terrain. The posts need to be closer on steep or uneven terrain. With spacing at 150 feet, install stays to maintain the proper wire height. The stays can be small fiberglass posts, three-eighths-inch diameter or larger, placed about 50 feet apart.

The wire height should be about two-thirds the height of the animal. In most situations, one wire will be adequate for cattle. However, two or three wires might be needed along lanes and crop fields. You also might need multiple wires to accommodate certain management practices, such as weaning across the fence. Use at least three wires for goats and sheep.

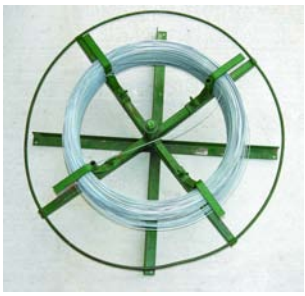
With multi-wire fences, consider using a current limiter or a flood-control switch on the lower wires if you anticipate a heavy weed load.

Electric fences do not need to be straight; they are flexible enough to be installed on soil boundaries or woodland edges.

tip:

Installing switches in fencing systems can save time because they can be used to isolate areas. They also allow a grazier to shut off one section of a fence to make repairs, instead of having to go back to the energizer and shutting down the whole system.

Necessary Tools



Spinner

A **spinner or reel** for high-tensile wire is definitely necessary. 12.5-gauge, high-tensile wire is packaged in tight coils, and cutting the last tie without having the coil on a spinner will result in something that resembles a 2,000-foot or 4,000-foot Slinky®. These spinners can be home-built, **Drawing 4**, or commercial, but they should be constructed with spring brakes to prevent wire from over running.

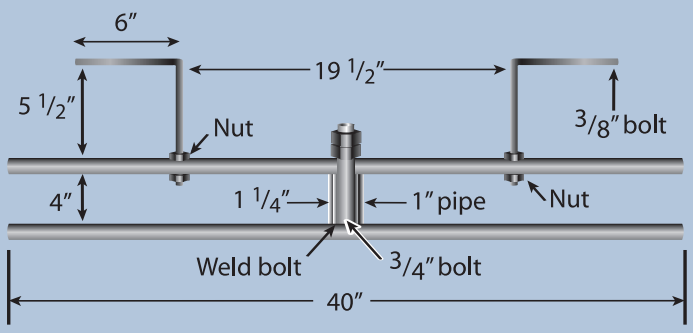
Crimper

You will need a **crimper** to make good electrical connections. The crimper should make a round crimp. Crimpers for splicing barbed wire make flat crimps that are not adequate on round, high-tensile wire (**Drawing 5**).

Drawing 4

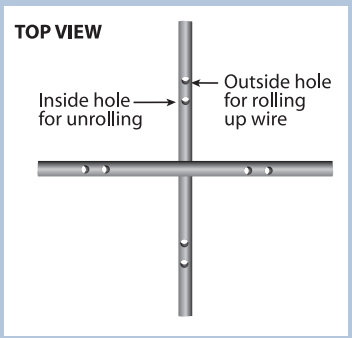
Home-Built Spinner

SIDE VIEW



Home-Built Spinner Notes:

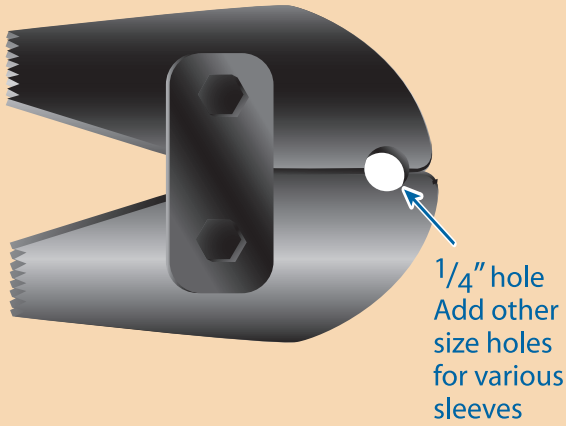
1. May be built out of typical scrap pile.
2. Use square tubing, angle iron.
3. No measurement is critical – needs to fit a roll of high-tensile wire and pivot freely.
4. Use bolt and pipe, old hub, etc., for pivot.
5. Base can be plywood, metal, or old tire with concrete. Bolted down or free standing can also be constructed to be operated vertically



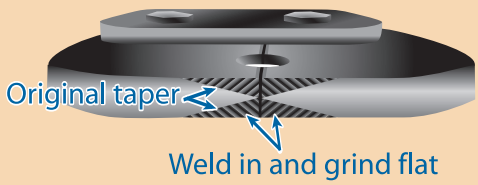
Drawing 5

Home-Built Crimper Using Bolt Cutter

SIDE VIEW - Jaws



FRONT VIEW - Jaws



A **digital volt meter** makes it easier to test grounding systems and to troubleshoot problems. Testers that have fault finders can greatly aid in locating subtle shorts.

Reels save time and increase the life of polywire. Purchase fence reels or use electrical extension-cord reels. Some fence reels hook on steel posts or over hot wire. Some reels have gears that make it much easier to roll up wire. Shop around and find the reel that will best fit your particular need.

Components

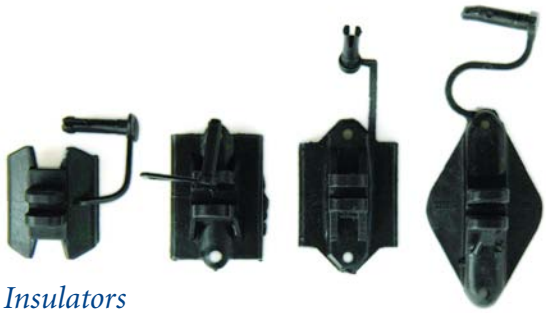
Insulators

Insulators may be made of glass, porcelain, or plastic.

Very few glass insulators are produced, and white porcelain insulators are cheap and do not stand up to the sun or today's high-powered chargers. Exposure to the sun's ultraviolet rays causes minute cracks to develop in porcelain insulators. The cracks then collect moisture that causes arcing.

Plastic insulators are most often used. Some plastic insulators are junk, while others are very good quality. Use only insulators made from high-density polypropylene or polyethylene. Black insulators appear to last the longest.

Before purchasing insulators, check the war-



Insulators

ranties. Only insulators with at least 10-year warranties are of sufficient quality. Many different configurations are available (end insulators, snap on, nail on, etc.). Steel "T" posts vary in size, so test snap-on insulators to make sure that they fit the posts in your fencing system before you purchase a large quantity of them.

Avoid the temptation to save money by using garden hose or discarded hydraulic hose as insulators. Some of these hoses conduct electricity, and most of them will break down from exposure to sunlight.

Insulated Wire (Underground Cable)

Insulated wire is normally used where wire is buried under gates and as leads from the energizer to the fence. It also can be used to construct a lightning coil. When purchasing insulated wire, look for double-insulated, 12.5-gauge wire. Some suppliers sell 16-gauge wire, which is not recommended because it restricts the flow of current.

Insulated wire is available as high-tensile or soft steel. In most situations where insulated wire is used there is no tension on the wire, so the soft-steel wire is quite adequate. It's also easier to handle.

Aluminum insulated wire is also available, but it is prone to break where the insulation is cut. It's not compatible with galvanized high-tensile wire because the dissimilar metals cause electrolysis.

Double- insulated underground cable

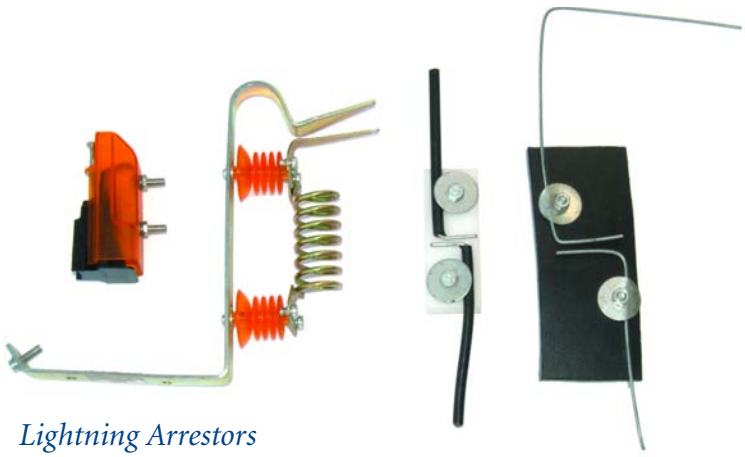
Never use insulated wire intended for normal 110-volt or 220-volt installation because it will be either copper or aluminum. Connecting the copper or aluminum to the galvanized wire will cause electrolysis. In addition, the insulation on these types of wires is not designed for the high voltage of a fencing system.

Insulated wire should run through a non-metal conduit where it is underground to prevent the wire from getting punctured by rocks (**Drawing 7**). Using three-quarter-inch gray electrical conduit and sweep elbows provides a good, water-tight passage for underground cable.

Lightning Arrestors

Lightning arrestors have air gaps wide enough to keep fence voltage from jumping but narrow enough for lightning strikes to pass.

Purchasing adjustable arrestors (see below) or making your own – using **Drawing 6** as a guide – are preferable choices.



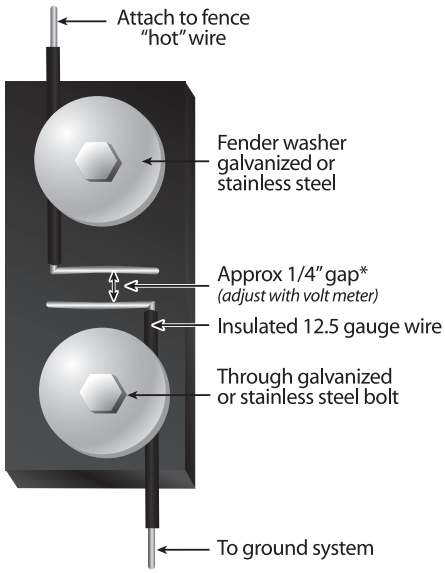
Lightning Arrestors

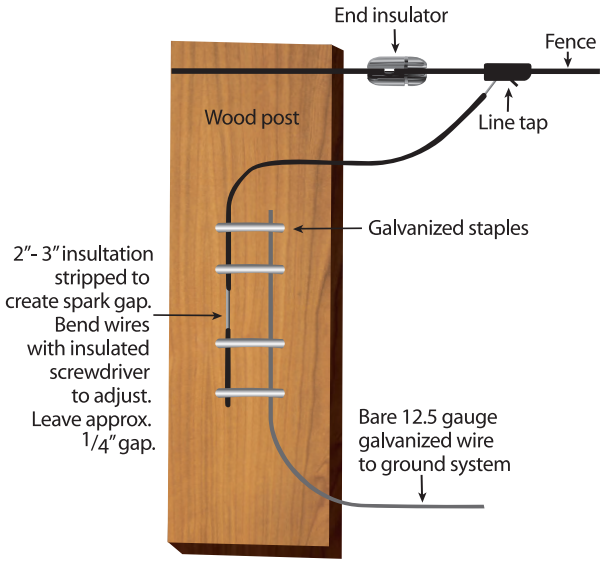
Surge Protectors

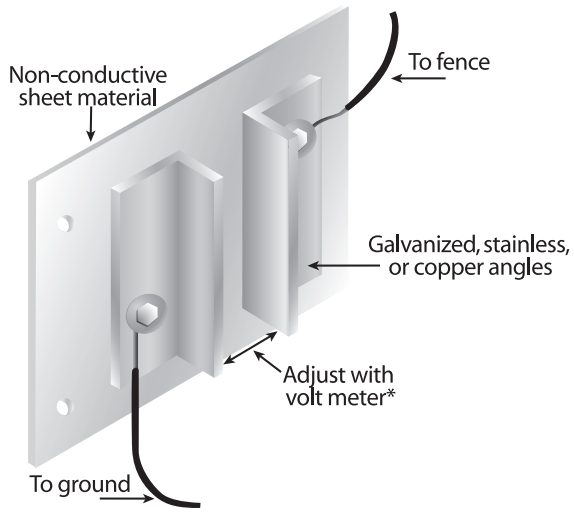
Install surge protectors at the same time as energizers. Many quality surge protectors are available. Some of the more expensive protectors even warranty the items they are protecting.

Drawing 6

Home-Built Lightning Arrestors







*Adjusting Gap with a Volt Meter

1. Set energizer to highest setting.
2. Secure lead from fence.
3. Leave lead to ground loose enough to slide.
4. Leaving lead to ground unattached at grounding end, clip volt meter to ground system then to end of lead.
5. Slide lead at arrestor apart until voltage is no longer read on volt meter.
6. Tighten lead on arrestor and then secure to grounding system (after removing volt meter).

Another method is to slide leads apart until arcing no longer occurs, then check with volt meter.

Ground Rods

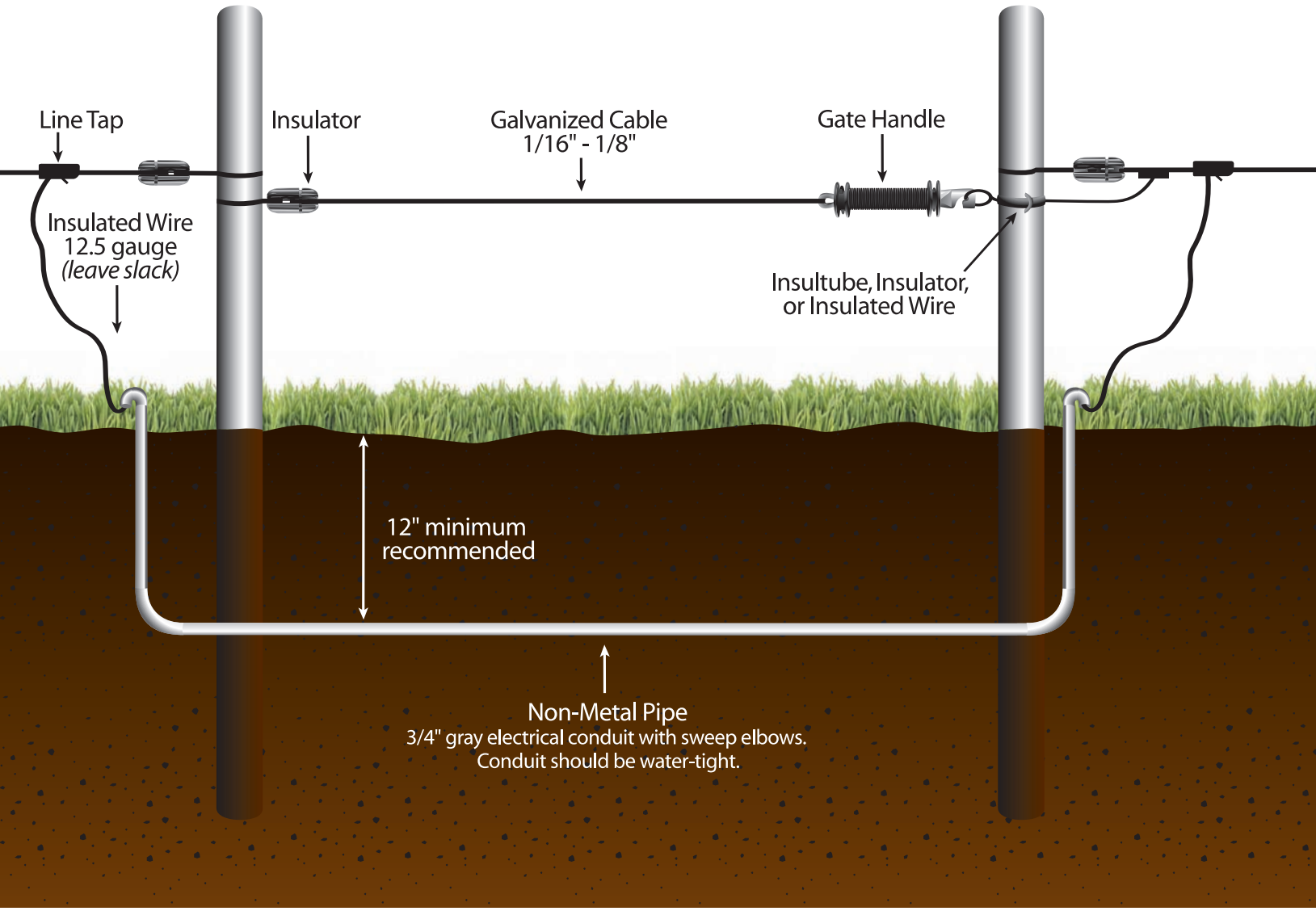

Ground rod

Most grounding systems for modern electric fences use rods. But clean, galvanized-steel pipe can be substituted. Rods as small as one-half inch in diameter can be used, but larger sizes may be easier to drive into the ground.

Use galvanized rods if high-tensile, 12.5-gauge wire is attached to the charger. In that case, clamps should also be galvanized. Copper wire, clamps and rods may be used if the energizer terminals are stainless steel. But do not mix dissimilar metals.

Drawing 7

Electric Gate (not hot when unhooked)



Crimp Sleeves

Sleeves and taps should be good quality, galvanized or stainless steel. Avoid the cheaper "gold-plated" sleeves because they rust quickly. The rust ruins the coating on the wire and causes the system to fail. To ensure a good electrical connection, be sure to purchase crimp sleeves that fit 12.5-gauge wire.

Line Taps

Line taps can be either the crimp type, which make a permanent connection, or the type that connect with a split bolt. Split-bolt line taps (pictured below) are recommended for gates and other areas that may need to be changed out occasionally. Galvanized components seem to be more resistant to rust than hot-dipped components.

Current Limiters

Current limiters are used for situations where high water, excess weed load, etc., could cause shorts. Current limiters shut down those portions of fences when shorts occur.

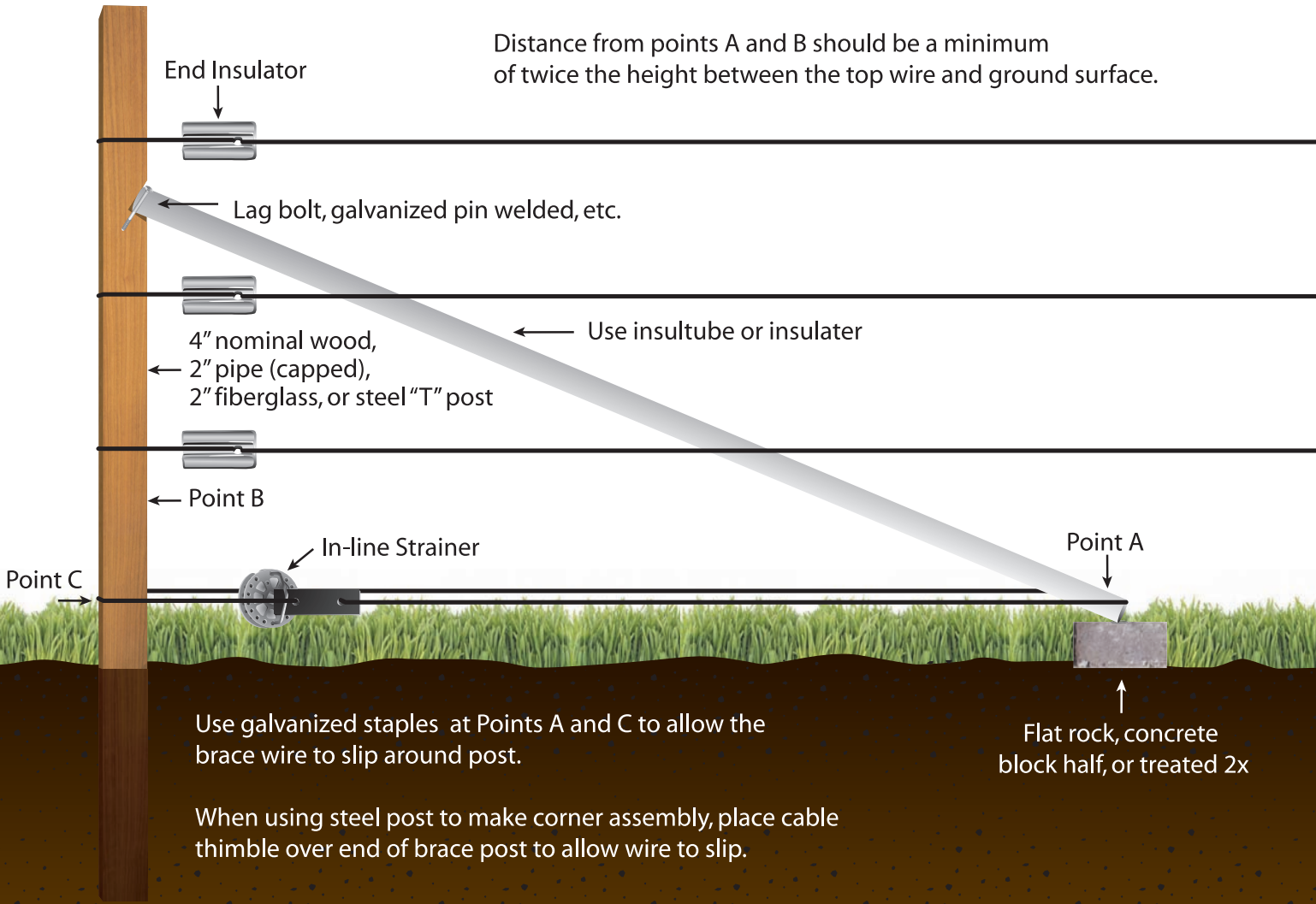
Posts

Many different types, configurations and brands of posts may be used with modern electric fences.

1. **Steel T posts** are used somewhere in most systems, and they work well if quality insulators are used.
2. **Fiberglass T posts** are fairly expensive, and they don't appear to last long.
3. **Wooden posts** of many different sizes and shapes can be used with quality insulators.
4. **Round fiberglass posts** with diameters of at least five-eighths inch are very satisfactory. The less expensive posts have an exterior coating that deteriorates after about a year. The deterioration makes it necessary to wear leather gloves when working with the posts, but the posts will still function fine. Clips for attaching wire to the posts are available for most sizes of posts.

Drawing 8a

Floating Angle Brace



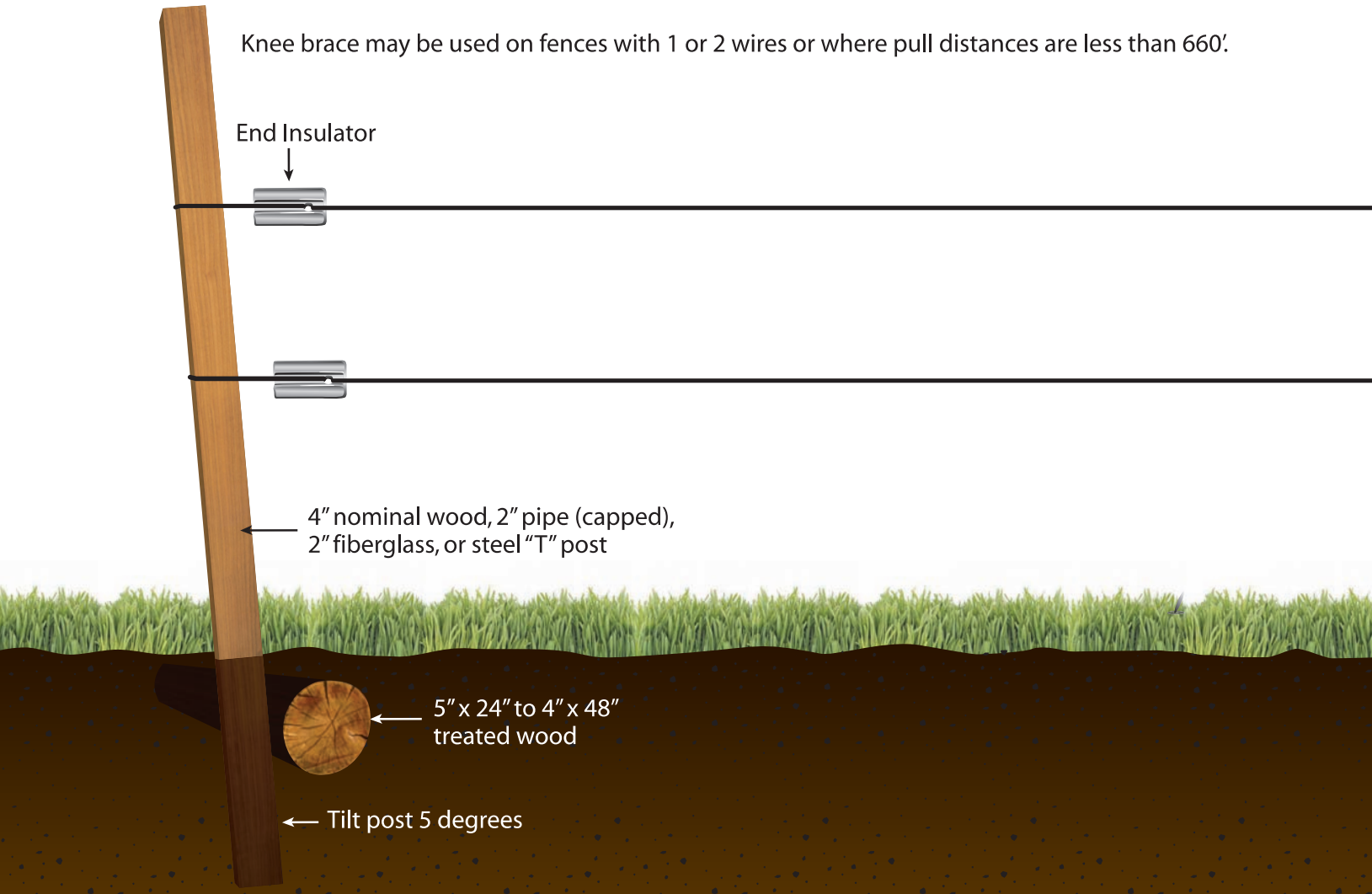
5. **Self-insulating plastic and fiberglass treadin posts** are available for "quickie" temporary fences. Some have a very small treadplate and/or a large spike that makes them difficult to install during dry weather.

6. **Several different installation methods for corner posts, gate posts and pull posts are illustrated in drawings 8a, 8b and 8c.** With one-wire and two-wire fences, the minimum sizes for corner, gate and pull posts are four inches for wood, and two inches for steel pipe and fiberglass.

7. **Here are several things to consider** when it is necessary to use trees as posts:
   - Wire should not be tied directly around a tree because the tree will grow around the wire, which will cause the tree to die prematurely;
   - Insulators nailed directly to trees will pop off as the trees grow;
   - Do not use screw-in insulators because they will cause shorting problems as the trees grow;
   - When using trees as corner posts, end posts or gate posts, screw 3/8 x 8" galvanized eyes into the trees to the depth of the threads, and fasten an end insulator to each screw eye;

Drawing 8b

Knee or Deadman Brace



- If a tree is used as a line post, use galvanized screws to attach a short section of treated 2 x 4 or 2 x 6 between the insulator and the tree.

Stays

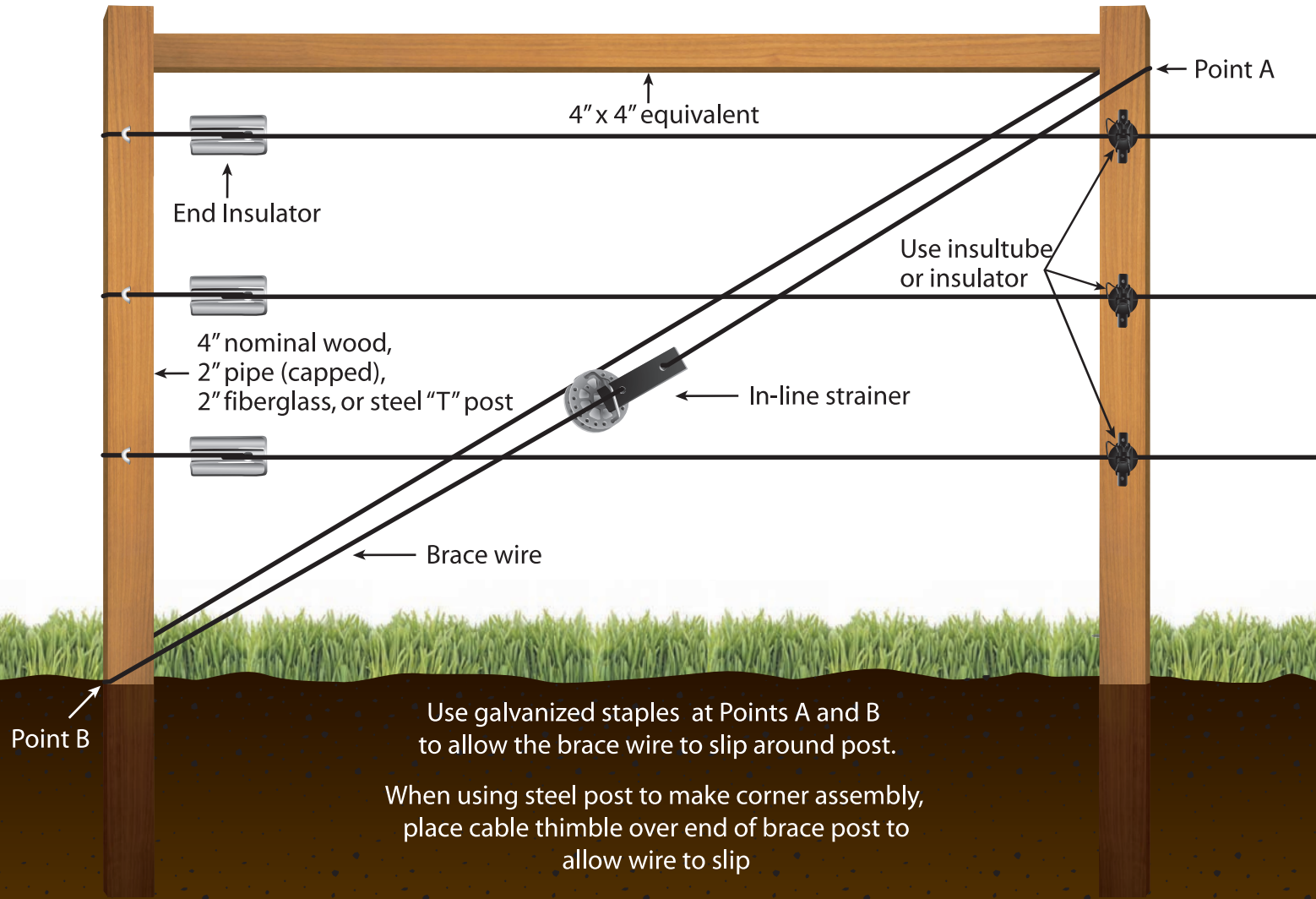
Since a stay's only function is to remove sag from a wire, a three-eighths-inch or one-half-inch round, fiberglass post works very well. Stays should be spaced about 50 feet or closer, depending on the lay of the land and the desired wire height.

Gates

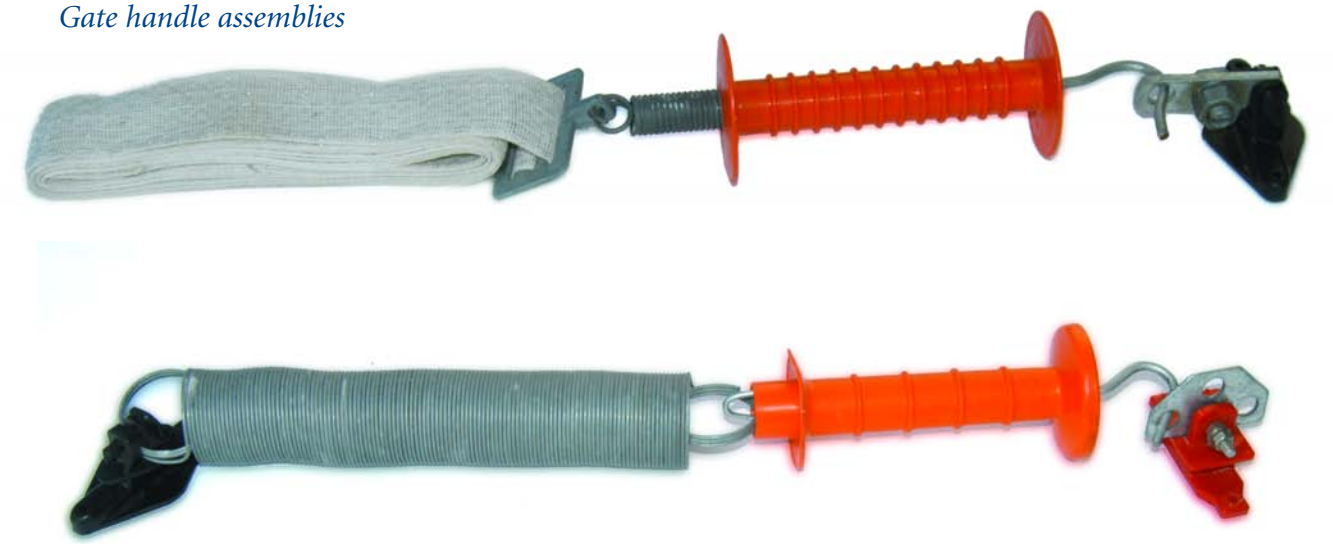
Gates should be wired so that they are dead when unhooked. Use double-insulated underground wire (placed in a pipe for protection) to run power under the gate. Seal ends or turn ends of conduit down to prevent moisture from collecting. Install the gate with an insulator, and power the gate through the gate handle. Use one-sixteenth-inch or one-eighth-inch galvanized cable for the gate because it is much more flexible than high-tensile wire. Use 12.5-gauge crimps for one-sixteenth-inch cable and 9-gauge crimps for one-eighth-inch cable. Gate construction is shown in **Drawing 7** (page 20).

Drawing 8c

"H" Brace



Gate handle assemblies



Gate Handles

Finding quality gate handles is a real problem. Some of the higher priced, name-brand handles don't appear to hold up any better than inexpensive ones. All steel components in the handles should be stainless steel or have a Class III galvanization rating. Some gate handles have compression springs in them. They sell for about the same price as stretch springs, but seem to be more durable.

Lightning Chokes

These may be purchased or homemade. A coil of insulated wire is compact, inexpensive, and very satisfactory. Choke construction is illustrated in **Drawing 2** (page 11).

Standoffs (Offsets)

Standoffs are very useful components which attach to permanent barbed or woven wire fences and allow "hot" wires to be installed along the permanent fences. Installing electric wires around property lines or field borders increases the life of the older, permanent fences because the electric wires keep cattle from pushing against the permanent fences. The electric wires also provide access to electricity for temporary or semi-temporary fences that can divide pastures into smaller units.

Only use galvanized steel wire with quality pin-lock insulators, and place the standoffs beside existing steel T posts in the permanent fences so that the standoffs will not sag. The wires should extend at least 10 inches from the existing fences, with standoffs spaced as close as necessary to maintain the desired wire height.

Water Gaps (Flood Gates)

Electric water gaps work very well. Use a main fence power wire that is high enough to be protected from water and debris with a secondary line feeding off of it. Install metal streamers that hang down to just above the permanent water level. Protect this part of the system with a current limiter. **Drawing 9** illustrates how to construct a water gap.

Flood gate controller

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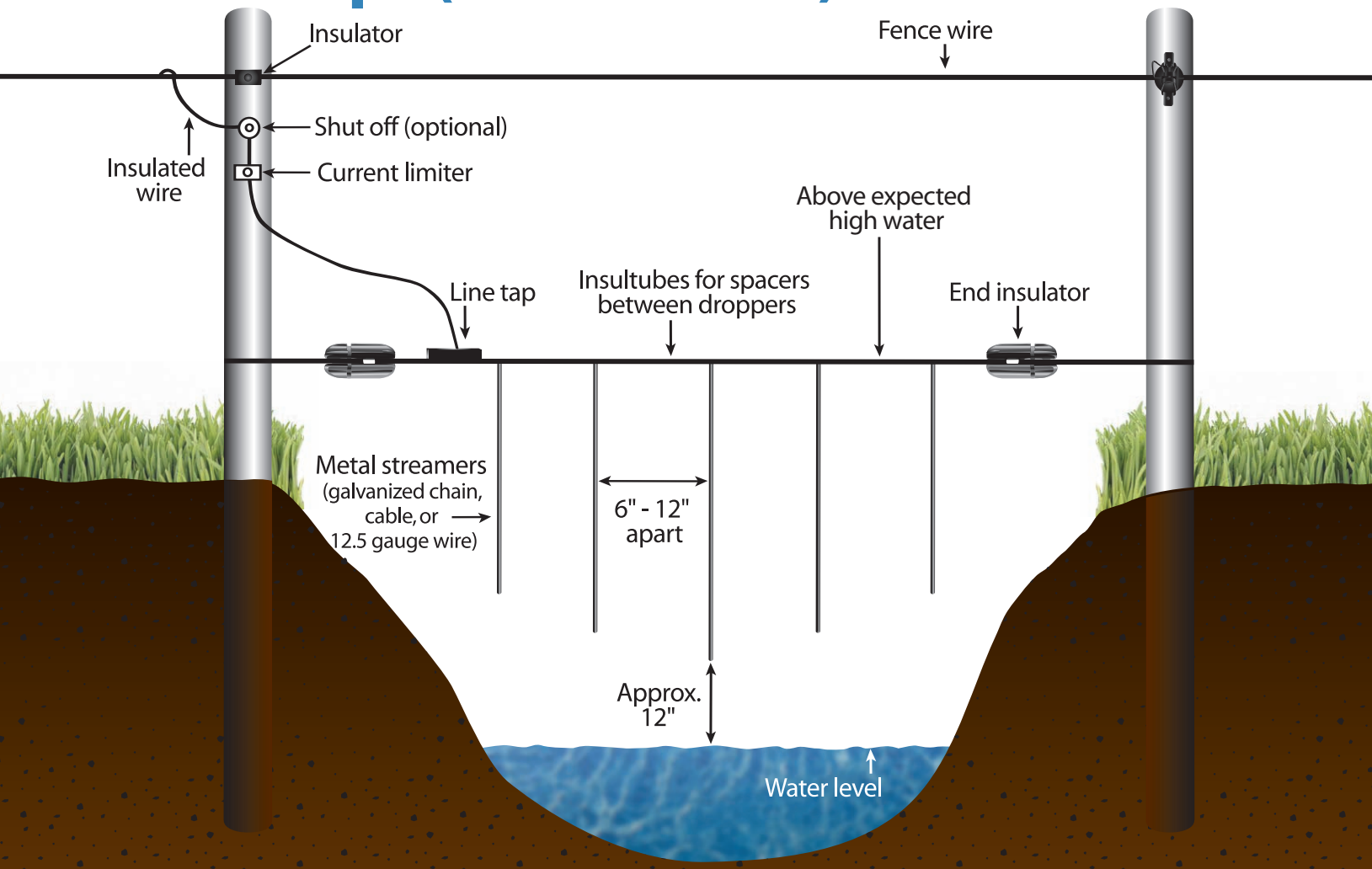
Miscellaneous

Many other fence components are being produced by fencing companies. The right components for about every situation can usually be found with some searching.

Producers should be innovative; there's nothing wrong with using a product intended for some other use as long as the quality and longevity is adequate. Examples of being innovative could include the electric cattle guard, floating electrical fence (**Drawing 11**) and the homemade spinner (**Drawing 4**) and crimper (**Drawing 5**).

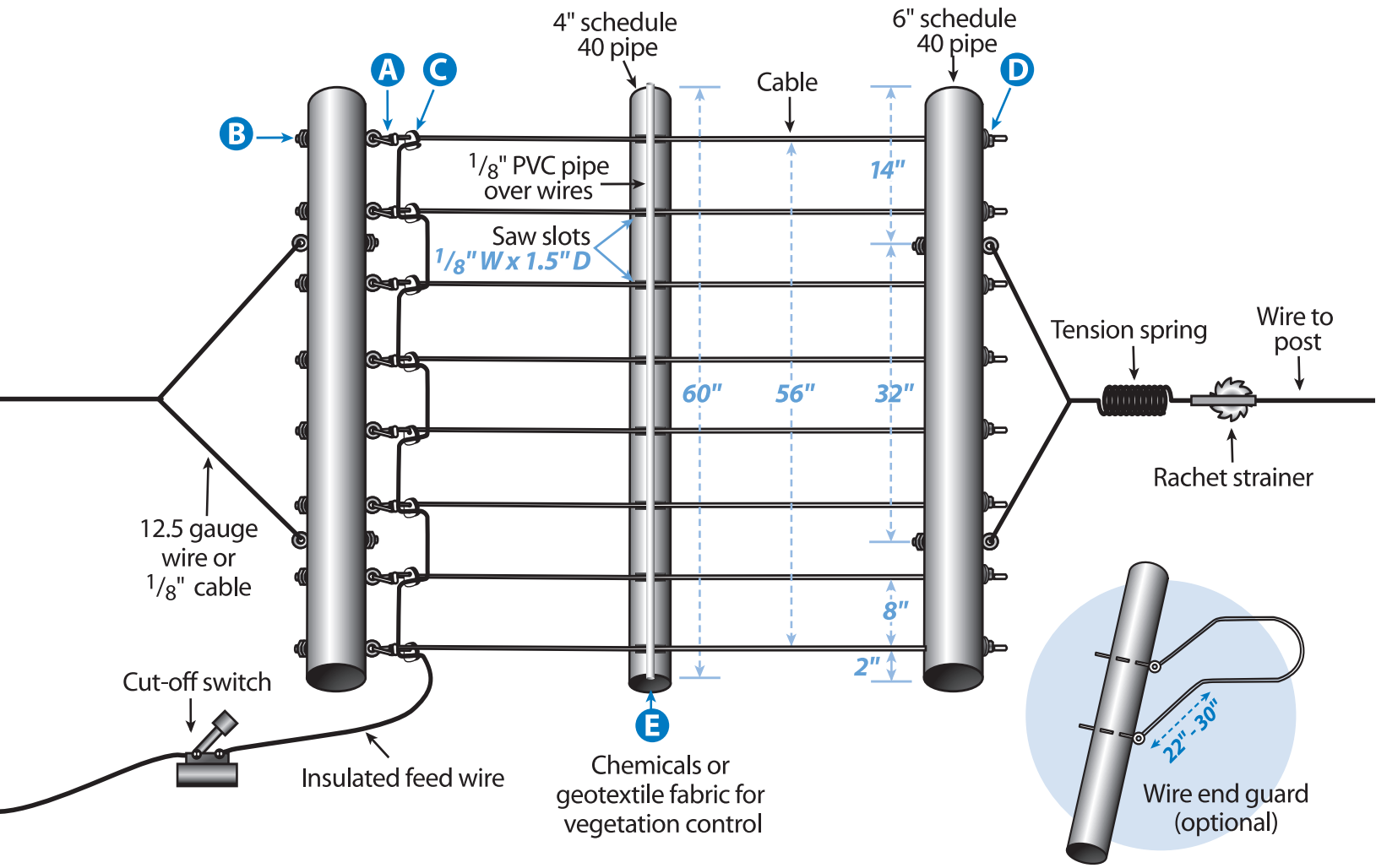
Drawing 9

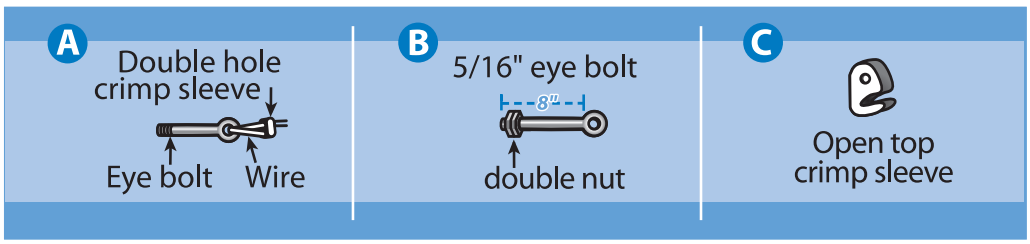
Water Gaps (Flood Gates)

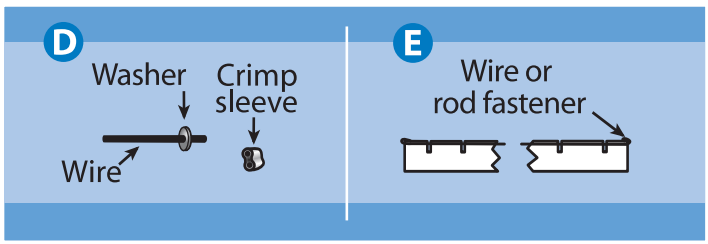


Drawing 10

Drive-Across Electric "Optional Length" Cattle Guard (portable)

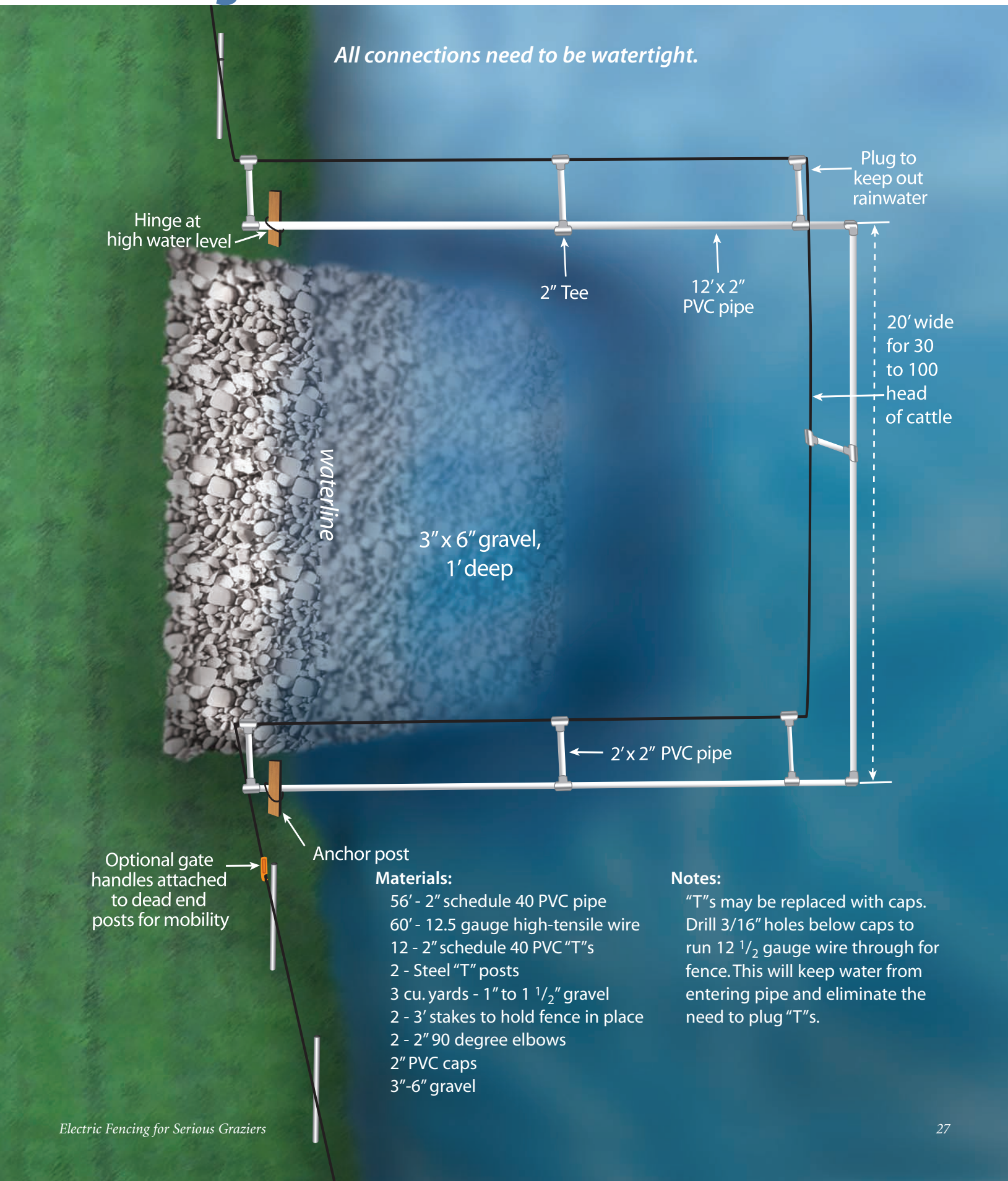






Drawing 11

Floating Electric Fence



Materials:

- 56′ - 2″ schedule 40 PVC pipe
- 60′ - 12.5 gauge high-tensile wire
- 12 - 2″ schedule 40 PVC "T"s
- 2 - Steel "T" posts
- 3 cu. yards - 1″ to 1 $^{1}/_{2}$″ gravel
- 2 - 3′ stakes to hold fence in place
- 2 - 2″ 90 degree elbows
- 2″ PVC caps
- 3″-6″ gravel

Notes:

"T"s may be replaced with caps. Drill 3/16″ holes below caps to run 12 $^{1}/_{2}$ gauge wire through for fence. This will keep water from entering pipe and eliminate the need to plug "T"s.

Electric Fence Safety

Here are some safety considerations to follow when installing electric fencing:

1. **Only connect one energizer to a fence;**
2. **Under unusual fault conditions electric fences can produce sparks.** Therefore, keep fences away from combustible materials. When droughts and other conditions create a high risk of wildfires, operate energizers on low power if they are equipped with that option, or simply turn energizers off.
3. **Grounds for energizers should be at least 65 feet from utility grounding fields;**
4. **Avoid running fences parallel to power lines, and try to install fences so that they cross power lines at right angles.** If you can't avoid parallel electric fences and power lines, offset the fences at least 30 feet from the power lines, and make sure the top fence wires are no more than six feet high.
5. **Do not attach fence wires to utility poles.**
6. **Landowners are responsible for preventing audible interference with telephone lines.** Therefore, try to avoid installing electric fences under telephone wires, and minimize the distance that electric fence wires run parallel to underground telephone cables.
7. **Keep electric fences as far away from radio antennas as possible.**
8. **Don't touch fences with your head or mouth.** People with pacemakers or other heart problems also should consult their doctors before working with or near electric fences. No humans or animals have died from electric, grazing-system fences without becoming entangled in them. However, some precautions are necessary.
9. **Never use barbed wire for electric fence wire because people or animals could more easily become entangled in it.**
10. **Post warning signs at least every 300 feet where the public has access to electric fences, such as along roads.**

Keep young children away from electric fences.

tip:

All types of wire may break and recoil when stretched. Always use hand and eye protection when handling high-tensile wire.

Floodplain Fences

Assuming that fences along streams will eventually wash out or collect debris and become useless, most landowners simply don't build fences in floodplains. However, since there are several programs that provide cost-share funds to install fencing systems that exclude livestock from streams, it is necessary to address methods for constructing floodplain fences.

Modern, one-wire electric fences designed to break at selected locations, if necessary, seem to be working satisfactorily (**Drawing 12**).

With floodplain fencing systems, select sites where very sturdy, wooden, pull posts can be set deep. At least half the length of each post should be underground. Select higher points along streams, avoiding obvious areas where streams flow during high water. If possible, these posts should be 300-400 feet apart. Do not use braces, other than knee braces, since they tend to collect debris.

Between these pull posts, use lighter posts, such as metal or fiberglass "T" posts, round fiberglass posts, etc.

Use only 12.5-gauge, high-tensile wire to construct each section between the pull posts. Place the wire 28-30 inches above the ground for average-sized animals.

Begin placing wire by running it around a heavy-duty, wrap-around insulator at the upstream pull post. Since maximum strength is needed at this point, use double-crimp sleeves. Leave a short, loose "jumper" section of wire that will be needed later to connect the power.

You will end this section of fence with a weaker connection at the closest downstream pull post. While leaving some sag in the high-tensile wire, pull an end insulator to the downstream pull post with 14-gauge soft wire. That's where the fence should break if a floating tree or other debris hits this section of fence during

tip:

As with any electric fence, maintenance is important. Therefore, check for limbs, debris and any broken sections of fence after each flood. If possible, set the fence far enough from the bank, trees, etc., so you can pass a bush hog on the stream side of the fence. Mow this strip seasonally, at times friendly to wildlife, to keep weeds and brush out of the hot wire.

high water flow. If the fence breaks at the downstream end rather than somewhere in the middle, it should be simple to salvage the wire and line posts.

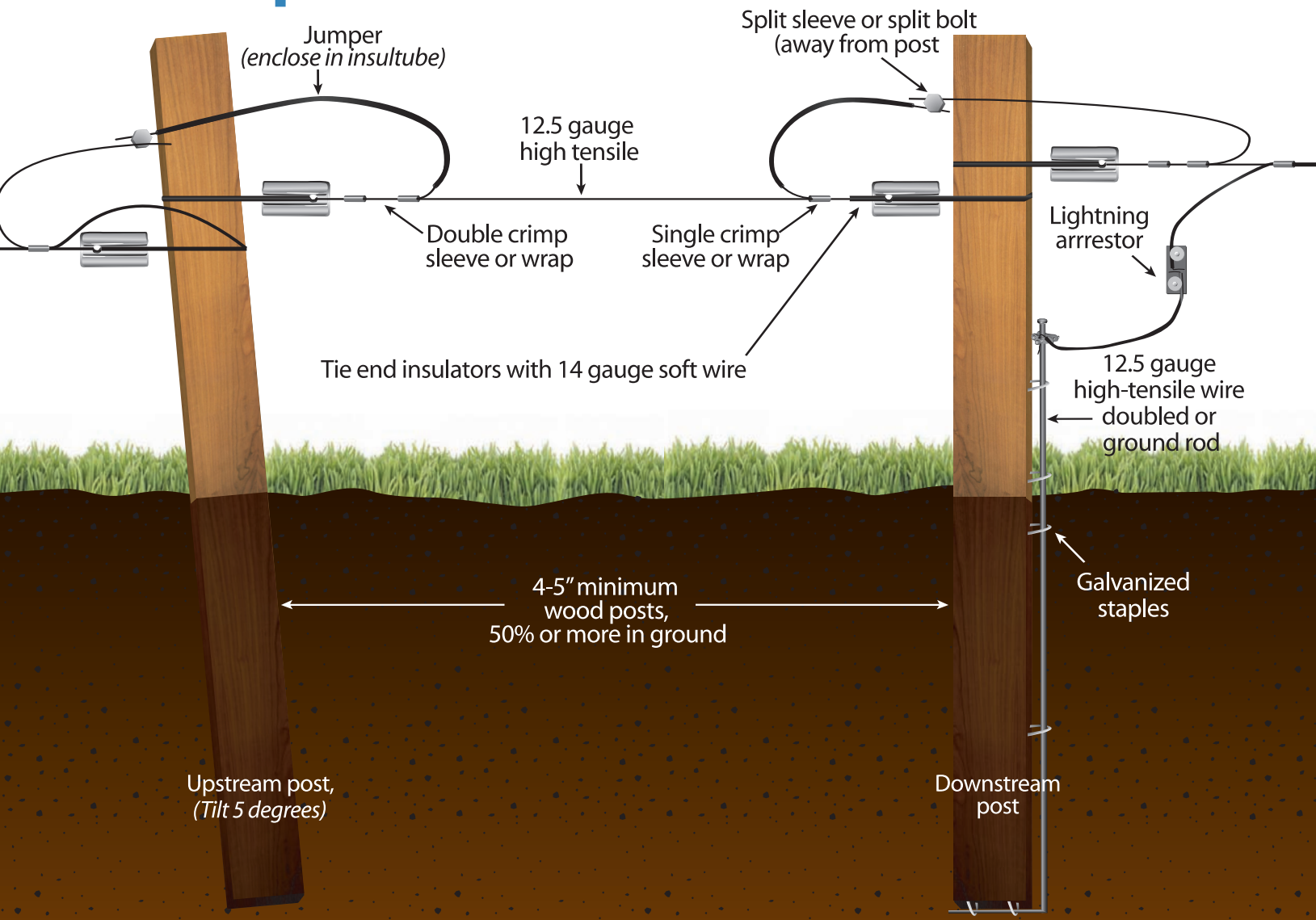
To complete the fence, use split-sleeves and insultube to connect the wire to the loose jumpers left at the upstream end of each section. Split sleeves ensure good electrical connections and are physically weak, so they turn loose when a section of fence breaks.

To protect the system from lightning strikes, use an arrestor. The moisture and types of soils in floodplains make them good places to install lightning arrestors. And, if you expect that a fence will be subjected often to floodwaters, consider using a current limiter.

As with any electric fence, maintenance is important. Therefore, check for limbs, debris and any broken sections of fence after each flood. If possible, set the fence far enough from the bank, trees, etc., so you can pass a bush hog on the stream side of the fence. Mow this strip seasonally, at times friendly to wildlife, to keep weeds and brush out of the hot wire.

Drawing 12

Floodplain Pull Posts



Electrical Terms

Resistor: An electrical component which, due to its material or shape, offers resistance or restriction to the flow of electricity. The degree of restriction is measured in electrical units called ohms. The amount of resistance that will limit the flow to 1 amp when a pressure of 1 volt is applied equals 1 ohm.
Volts/amps = ohms.

Conductor: A substance that allows electrons to flow freely. The less resistance a conductor offers, the better the conductor. The unit of conductance is called Mho (ohm spelled backwards). This unit is the reciprocal of the ohm.
Amps/volts = Mhos.

Insulator: A substance that will not allow any electron flow, and is used to stop electricity from leaking. Most insulating materials have a critical pressure for given thickness. If the critical pressure is exceeded, the insulating material suddenly punctures.

Leak: A low-conductance (high-resistance) path from the fence line back to the energizer earth terminal. Leaks are caused by cracked insulators, foliage entangled in the live wire, a length of live wire on the ground, or animals touching the live wire.

Shorts: High-conductance (low-resistance) paths between the live wire and either dead wires or earth-return wires. These are commonly known as wire-to-wire shorts. This condition constitutes the largest threat to the reliability and effectiveness of an electric fence line.

Volts: Units of electrical pressure (similar to how pounds per square inch are units of physical pressure). One volt is the force necessary to cause a current of 1 amp to flow through a resistance of 1 ohm.
Ohms x amps = volts.

Amps: Units of electrical rate of flow (similar to how gallons per hour are units of rate of physical flow). One amp is a flow rate of 6.28 x 10 to the 18th power electrons per second.

One amp is the rate of electron flow that results when a pressure of 1 volt is applied across a resistance of 1 ohm.
Volts/ohms = amps.

mAmps: Units of electrical flow equal to 1/1000 of an amp (a "milli" amp).

Ohms: Units of electrical resistance or restriction to the flow of electrons (similar to how a long, thin pipe causes physical resistance or friction to the flow of water through it). One ohm is the amount of resistance that will limit the flow rate to 1 amp when a pressure of 1 volt is applied.
Volts/amps = ohms.

Coulombs: Units of electrical quantity (similar to how one gallon is a specific quantity). One coulomb is 6.28 x 10 to the 18th power electrons, a flow rate of 1 amp for 1 second.
Amps x seconds = coulombs.

Watts: Units of electrical rate of doing work (similar to how horsepower is a physical rate of doing work). One horsepower can lift 1 pound vertically at the rate of 550 feet per second, or heat 1 pound of water at the rate of 0.7 degrees Fahrenheit (0.39 degrees C) per second.

46 watts equals 1 horsepower. Therefore, 746 watts can lift 1 pound at the rate of 550 feet per second, or heat 1 pound of water at the rate of 0.7 degrees Fahrenheit per second. A flow rate of 1 amp at a pressure of 1 volt produces 1 watt.
Amps x volts = watts.

Joules: Units of electrical energy [similar to how 550 foot pounds (which is equal to 1 horsepower for one second) is a specific amount of physical energy]. 746 joules equals 550 foot pounds. One joule is the amount of energy required to do approximately 0.74 foot pounds of work. One joule is the energy required to produce 1 watt for 1 second.
Watts x seconds = joules.

Energy: The capacity or ability to complete a particular amount of work (see joules). It is largely the quantity of joules released by an energizer during each pulse that determines the energizer's effective power.
3,600,000 joules = 1 kilowatt-hour.

Capacitor: An electrical component capable of storing and releasing electrical energy and approximating a reservoir, the volume of which is stated in electrical units called farads (micro farads). If 1 amp flows into a capacitor for one second and this causes a rise in pressure of 1 volt, then the volume of the capacitor equals 1 farad.
Amps x seconds/volts rise = farads.

Quick Reference

Ohms = Volts/amps

Mhos = Amps/volts

Volts = Ohms x amps

Amps = Volts/ohms

mAmps = 1/1000 of an amp

Coulombs = Amps x seconds

1 horsepower = 46 watts

Watts = Amps x volts

Joules = Watts x seconds

1 kilowatt-hour = 3,600,000 joules

Farads = Amps x seconds/volts rise

746 joules = 550 foot pounds

1 amp = flow rate of 6.28 x 10 to the 18th power electrons per 1 second.

1 coulomb = 6.28 x 10 to the 18th power electrons, a flow rate of 1 amp for 1 second

- One horsepower can lift 1 pound vertically at the rate of 550 feet per second
- One horsepower can heat 1 pound of water at the rate of 0.7 degrees Fahrenheit (0.39° C) per second.
- 746 watts can lift 1 pound at the rate of 550 feet per second
- 746 watts can heat 1 pound of water at the rate of 0.7 ° F per second.

Troubleshooting

Problem 1

Energizer is not on or there is no voltmeter reading across the energizer output terminals with the energizer disconnected from the fence.

1A. Probable Cause: Mainline power outage or blown fuse on input circuit
Solution: Restore power or replace blown fuse

1B. Probable Cause: Energizer is switched off
Solution: Check energizer "on-off" switch.

1C. Probable Cause: Dry cell batteries are dead; wet cell batteries are discharged
Solution: Recharge or replace batteries

1D. Probable Cause: Battery terminals are corroded
Solution: Clean terminals

1E. Probable Cause: Energizer is faulty
Solution: Have energizer serviced

Problem 2

Energizer is on, but voltmeter reading is low across the energizer output terminals when disconnected from fence.

2A. Probable Cause: Energizer is switched to "low" setting
Solution: Check energizer output switch

2B. Probable Cause: Weak batteries
Solution: Recharge or replace batteries

2C. Probable Cause: Battery terminals are corroded
Solution: Clean battery terminals

Problem 3

Energizer is operating, but there is no voltmeter reading on the fence with the energizer connected

3A. Probable Cause: Ground-return wire is disconnected or broken
Solution: Connect or repair ground-return wire

3B. Probable Cause: Feed-wire terminals are corroded, disconnected or broken
Solution: Connect or repair feed wire terminals

3C. Probable Cause: Broken, corroded or disconnected live wire or ground-return on fence
Solution: Connect or repair live wire or ground-return on fence

3D. Probable Cause: Soil is dried out
Solution: Install ground-return wire

Problem 4

Low voltmeter readings at several locations on fence

4A. Probable Cause: Energizer is on low setting or is inadequate for length of fence
Solution: Switch energizer to high setting; install more powerful unit

4B. Probable Cause: Weak batteries
Solution: Recharge or replace batteries

4C. Probable Cause: Terminals corroded
Solution: Clean terminals

4D. Probable Cause: Ground system is inadequate or deteriorated
Solution: Repair or replace ground system

Improper installation of an electric fencing system can cause a number of problems.

4E. Probable Cause: Soil is dried out
Solution: Install ground-return wire

Problem 5

No voltmeter readings at several locations on fence

5A. Probable Cause: Broken or disconnected fence wire, jumper wire or ground wire
Solution: Connect or repair wire; remove cause of short; replace jumper connection

5B. Probable Cause: Broken or faulty insulators
Solution: Replace faulty insulators

5C. Probable Cause: Ground connection rod deteriorated
Solution: Replace ground connection rod

Problem 6

Voltmeter reading on one wire is higher than on another wire, or there is no reading from one live wire to ground-return or soil

5A. Probable Cause: Broken or disconnected fence wire, jumper wire or ground wire
Solution: Connect or repair wire; remove cause of short; replace jumper connection

5A. Probable Cause: Broken or faulty insulators
Solution: Replace faulty insulators

5A. Probable Cause: Ground connection rod deteriorated
Solution: Replace ground connection rod

Problem 7

Radio, TV or telephone interference

5A. Probable Cause: Ground system inadequate
Solution: Increase grounding capacity

5A. Probable Cause: Antenna too close to fence
Solution: Relocate antenna or telephone wires

5A. Probable Cause: Fence is parallel with antenna wires or telephone lines
Solution: De-electrify or relocate segment of fence that is parallel to or too close to antenna or wires

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September 2005

Helping People Help the Land
in Missouri

Section 9

Review of Research Results from the Better Grazing Project

Dr. Dory Franklin, UGA

Section 10

Legume Nitrogen Fixation

Dr. Dennis Hancock, UGA

2017 Georgia Grazing School:

N Fixation in Legumes

Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist

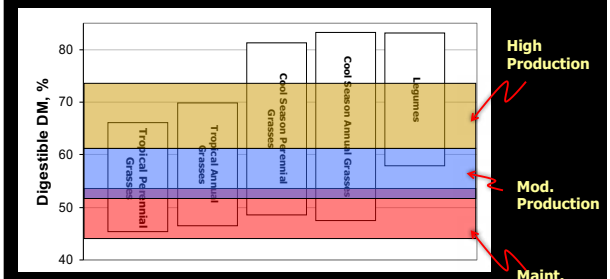
Nitrogen Fixation in Legumes

Dennis Hancock, PhD.
Extension Forage Agronomist
Crop and Soil Sciences

Overview

- Benefits of using legumes in forage systems (brief)
  - Forage quality needs
  - Fertilizer value
- Nitrogen fixation and inoculation (detailed)

Quality Differences in the Major Forage Species



Old N Products

Rhymes in History

Used Fairly Extensively in the Southeast until about 60 yrs ago.

Photo courtesy of Dr. Ray Smith, TAES

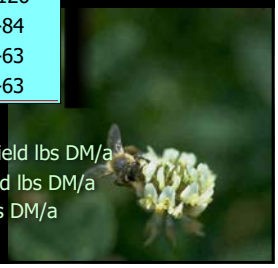
Benefits of Adding Legumes

A valuable source of N (time-released).

Species	Annual lbs (N/acre)	N value at $0.42/lb. of N
Alfalfa	200-300	$84-126
Red clover	100-200	$42-84
White clover	100-150	$42-63
Annual clover	50-150	$21-63

Estimate your own:

White clover N_{fix} lbs/a = 0.031 x Yield lbs DM/a
Red clover N_{fix} lbs/a = 0.026 x Yield lbs DM/a
Alfalfa N_{fix} lbs/a = 0.021 x Yield lbs DM/a



Nitrogen Transfer

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N Fixation in Legumes

Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist

Nitrogen Transfer

Nodules slough off and decay

Exudates from the nodules and roots

Nitrogen Transfer

Animal Deposition

Nitrogen Transfer

Organic Matter Decomposition

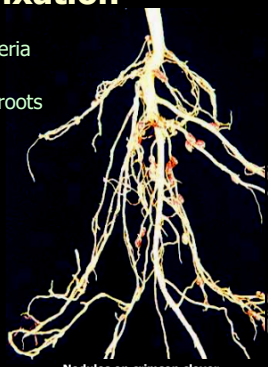
Nitrogen Fixation

Legume plants and *Rhizobium* bacteria form a symbiotic relationship

- Rhizobia colonize nodules on the roots of healthy legumes
- Absorb nitrogen from the air (N_2)
- Fix it into ammonia (NH_3).

Relationship is mutually beneficial:

- Plant gets N from bacteria
- Bacteria get energy from plant



Nodules on crimson clover.
(*Photo Credit: Dr. Gerald Evers, TAMU*)

Legume-Rhizobium Specificity

Legume plants have a relationship with specific rhizobia

Groups and Types	Legume Species	Rhizobium Species
I. Alfalfa Group		
Type A (AL)	Alfalfa	*Sinorhizobium meliloti*
Type N	Annual Medics	*Sinorhizobium medicae*
II. Clover Group		
Type B	Ball, red, and white	*Rhizobium trifoli* subgroup B
Type O	Arrowleaf	*Rhizobium trifoli* subgroup O
Type R	Berseem, crimson, & Persian	*Rhizobium trifoli* subgroup A
Type WR	Rose and subterranean	*Rhizobium trifoli* subgroup WR
III. Pea & Vetch Group		
Type C	Austrian winter pea and vetches	*R. leguminosarum* ss. *viciae*

Legume-Rhizobium Specificity

Legume plants have a relationship with specific rhizobia

Groups and Types	Species	Rhizobium Species
IV. Bean Group		
Type D	Garden beans, etc.	*R. leguminosarum* ss. *phaseoli*
V. Soybean Group		
Type S	Soybeans	*Bradyrhizobium japonicum and others*
VI. Cowpea Group		
Type EL	Alyceclover, cowpeas, hairy indigo, lespedeza	*Bradyrhizobium* spp.
Type P	Peanuts	*Bradyrhizobium* spp.
Type GU	Guar	*Bradyrhizobium* spp.
VII. Lupine Group		
Type H	Lupines	*Rhizobium* spp.
VIII. Other		
Birdsfoot trefoil		*Mesorhizobium loti*

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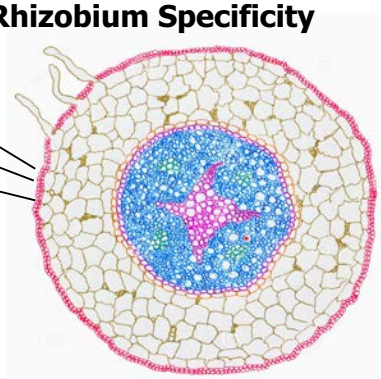
Assoc. Prof. & Forage Ext. Specialist

Legume-Rhizobium Specificity

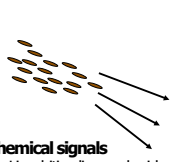
Chemical attractants
- (iso)flavonoids
- betaines
- others



Cross-section of a root

Photo credit: Pitsanu Kraichana, Dreamstime

Legume-Rhizobium Specificity



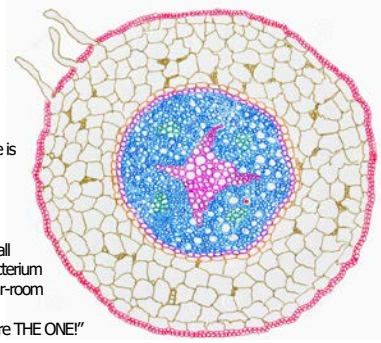
Chemical signals
- Lipochitin oligosaccharide "Nod factors"
- *"I'm here, Big Boy! Come wrap me in your lovin' arms!"*
- *"bow-chica-wow-wow"*
- *"All. Night. Long! All night! Oh yeah! All night!"*

Cross-section of a root

Photo credit: Pitsanu Kraichana, Dreamstime

Legume-Rhizobium Specificity

Chemical signals
- Gene transcription cascade is species-specific
- "You're my kinda root!"
- "You're my kinda Gram-negative soil bacterium!"
- "Oh, I bet you say that to all the Gram-negative soil bacterium that come through that bar-room door!"
- "Of course not, baby! You're THE ONE!"



Cross-section of a root

Illustration credit: Pitsanu Kraichana, Dreamstime

Legume-Rhizobium Specificity

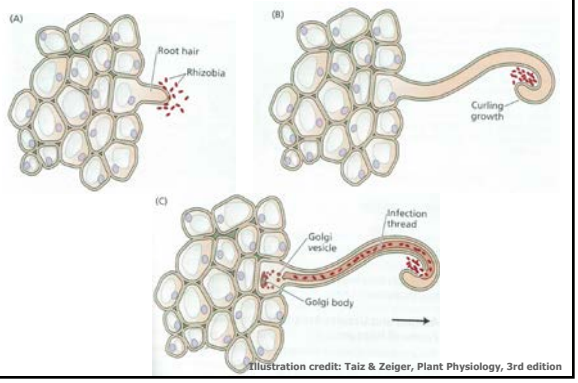


Illustration credit: Taiz & Zeiger, Plant Physiology, 3rd edition

Legume-Rhizobium Specificity

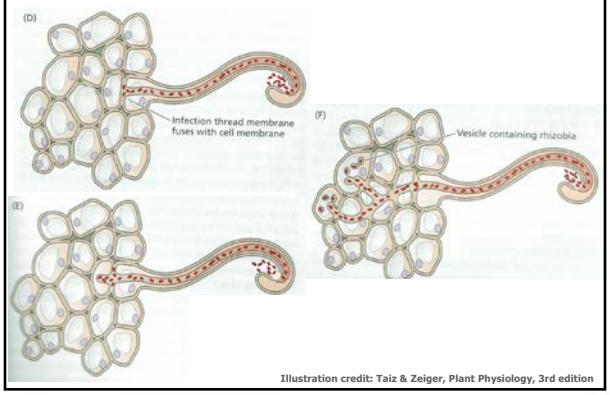
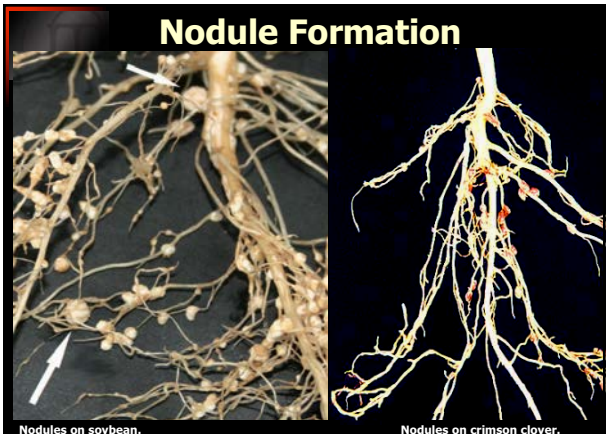


Illustration credit: Taiz & Zeiger, Plant Physiology, 3rd edition

Nodule Formation



Nodules on soybean.
(Photo Credit: Rodriguez-Navarro, 2011. Agron. Sust. Dev.)

Nodules on crimson clover.
(Photo Credit: Dr. Gerald Evers, TAMU)

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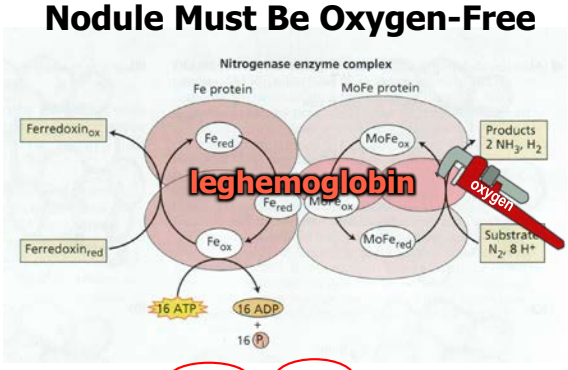
Nodule Must Be Oxygen-Free

Interior of healthy nodules will be pink-red

leghemoglobin

Photo Credit: Flynn and Idowu, 2015. NM State Extension

Nodule Must Be Oxygen-Free



$N_2 + 8\ H^+ + 16\ ATP \rightarrow 2\ NH_3 + H_2 + 16\ ADP + P_i$

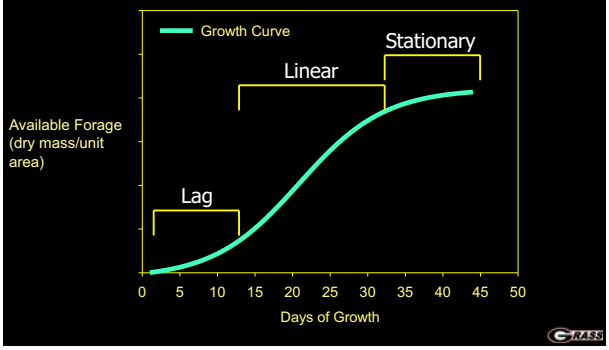
Illustration credit: Taiz & Zeiger, Plant Physiology, 3rd edition

N_2 Fixation is Expensive

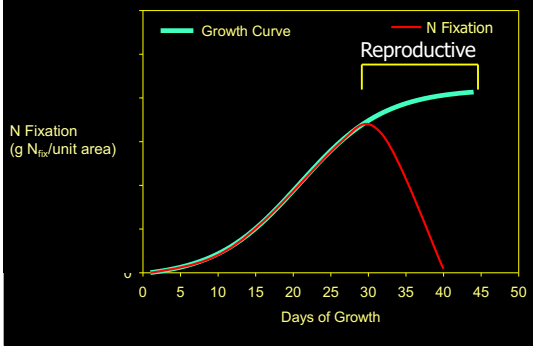
16 ATP -> 2 NH_3 Is an expensive proposition!

Carbon cost per unit of fixed N varies with species, growth stage, environment, and rhizobium strain

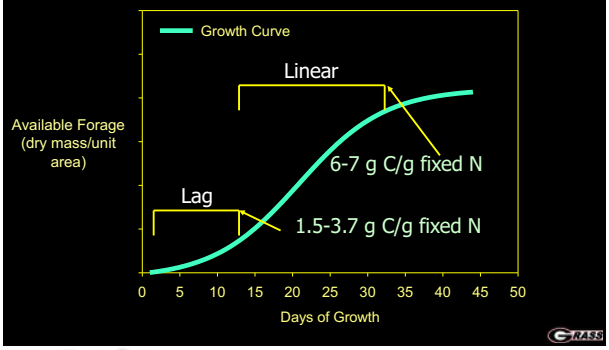
"How does your forage grow?"



"How much N does your symbiosis grow?"



"How does your forage grow?"



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Factors Affecting N_2 Fixation

1. Temperature

Temperature Effects on N_2 Fixation

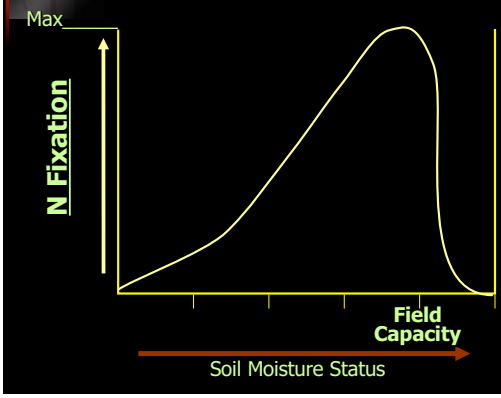
Legume species	N Fixation Minimum	Optimum	Maximum
		Temp, °F	
Alfalfa	36	68-86	104
Arrowleaf		77	
Birdsfoot trefoil	50	78	95
Cowpea	41	104	
Peanut			104
Red clover	36	78	95
Soybean	41	68-95	104
Subterranean clover	41	59-68	
White clover	48	70	

Adapted from: Liu et al., 2011. Sustainable Agriculture 2: 883-905.

Factors Affecting N_2 Fixation

1. Temperature
2. Soil moisture status

Soil Moisture Status Effects on N Fixation



Factors Affecting N_2 Fixation

1. Temperature
2. Soil moisture status
3. N concentration
4. Root zone pH
5. Plant nutrient status
6. Carbohydrate balance in the plant
7. Defoliation events

Effects of N Conc. on N_2 Fixation

- **As N conc. in the soil increases, N fixation decreases**
  - Energy savings to use available N
- **If N conc. is high** *(roughly equivalent of more than 25 lbs of N as ammonium nitrate/acre)*, **then legume nodulation and nitrogenase activity are decreased.**
  - Ammonium forms of N have less impact than nitrate forms.
- **But, sometimes "starter N" can help the plant if temperature or other nut. deficiencies inhibit N fixation**

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Factors Affecting N_2 Fixation

1. Temperature
2. Soil moisture status
3. N concentration
4. Root zone pH
   - As pH goes down, N2 fixation goes down
5. Plant nutrient status
   - If nutrients are deficient, N2 fixation goes down
   - Especially N, Mg, S, and Mo
6. Carbohydrate balance in the plant
7. Defoliation events

Use Legumes to the Extent Possible

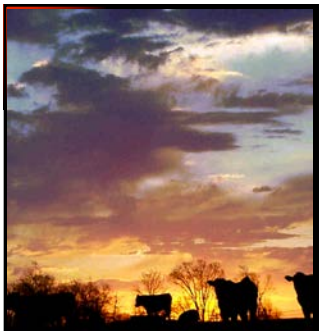
Georgia Forages: Legume Species

THE UNIVERSITY OF GEORGIA COOPERATIVE EXTENSION

Legume Management - Part IV

This is the fourth and final part of the lecture on legume use and management in Georgia. This part examines the forage yield and animal production response that can be expected when forage legumes are introduced into pasture and hayland mixtures. (georgiaforages006.mov).

POSTED BY DENNIS W. HANCOCK, PHD 0 COMMENTS



QUESTIONS?

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Section 11

Benefits of Crop Rotation and Multi-Species Mixtures

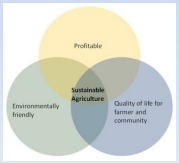
Julia Gaskin, UGA

Benefits of Crop Rotation and Multi-Species Mixtures

Julia W. Gaskin
Sustainable Agriculture Coordinator
Crop and Soil Science Department
College of Agricultural and Environmental Sciences
University of Georgia

Why Bother?

- Feeding the world's population
  - Population increase by 2.5 billion by 2050
  - Increased demand for protein
- Increased environmental cost
  - Climate change
  - Water scarcity and pollution
  - Peak oil?
  - Peak P - 2030? (Cordell et al. 2009)

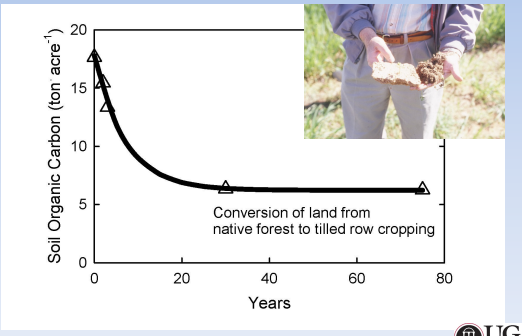


To Meet the Challenge

- Better varieties for N and water use efficiency
- Precision ag
- Variable rate irrigation
- New pesticides

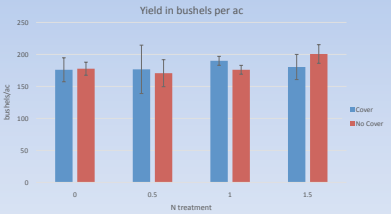
- What about the soil?
- Why aren't we doing the things we know will improve yields?

Soil Degradation



Adapted from Franzluebbers

Lost Productivity

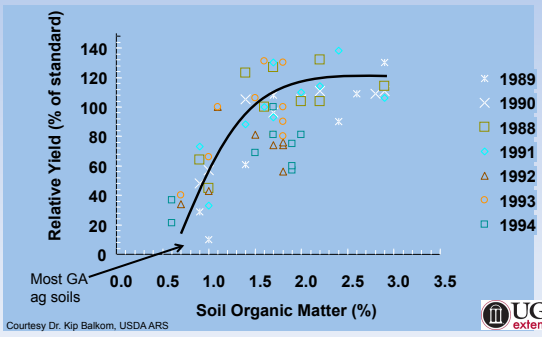


Average 178 bu/ac of grain corn from no cover/no N fertilizer plots!

Transition to certified organic production through 3 years of mixed fescue clover.

Soil Organic Matter and Yield

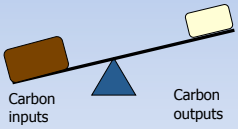
Alabama's Old Rotation Experiment 1896



Courtesy Dr. Kip Balkom, USDA ARS

Increasing Soil Organic Matter

Add more carbon than we lose



Reduce tillage **Crop rotation**

Cover crops Organic fertilizers

Add Animals

Quick Review of Crop Rotation Effects

- Traditionally used to reduce insect/disease pressure
- Include legumes to provide fertility
- Also used to rotate herbicide chemistries

Crop Rotation Effects

- **Increase SOC** with longer rotation. Why?
  - Increases plant residue
  - Increases variety in quality of residue
  - Increases above and below ground biodiversity over time

clover → corn → rye → soybean

Crop Rotation Effects

Meta-analysis of crop rotation:

- 21% increase microbial biomass (McDaniel et al. 2014)
- 15% increase in number of taxa in microbial community (Venter et al. 2016)
- 3.4% increase in microbial diversity (Venter et al. 2016)
  - Venter analyzed 27 studies, 9 positive, 14 no effect, 2 negative.

Crop Rotation Effects

- ***More complex rotation*** increased SOC more than simpler rotation with same plant biomass inputs
  - Soybean/Wheat/Corn + Red clover and Soybean/Wheat/Corn + Red clover/Cereal rye > Corn + Red clover (Tiemann et al 2015)
- Cover crop 8.5% increase in SOC (McDaniel et al. 2014)
- Greater N mineralization from longer rotation (Tiemann et al. 2015)

What Does This Mean?

- Ecology says biodiverse systems more productive and resilient (Hooper et al 2005; Tillman et al. 2006)
- Longer and more complex rotation:
  - Increased yield
  - Increases SOC
  - Probably increases number of taxa
  - May increase size of microbial community
  - Increased size and diversity of microbial community associate with:
    - Increased N cycling
    - May increase other nutrient availability
    - Lower plant diseases

What Does This Mean?

- Previously focused on amount of aboveground residue
- Need to focus more on roots and rhizosphere
  - Specific microbial communities associated with particular plants
  - These are native to soil
  - Different root exudates allow different microbe to grow and flourish

What Does This Mean?

- Strong evidence that spatial diversity of plants increases soil biodiversity
- Increasing evidence that temporal diversity (crop rotation) can also increase soil biodiversity

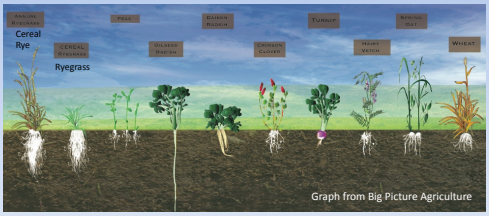
Cover Crop Mixtures

Pick cover crop based on what you want it to do:

- Grains – soil builders, nutrient scavengers, weed suppression
- Legumes – N fixers
- Brassicas – compaction, early flowering for pollinators/beneficial insects

What if I could get a little of everything!

Complementarity, Biomass & Rooting Structures



Idea from perennial systems that different plants occupy different niches so the sum is greater than the pieces.

Cover Crop Mixtures

Functions related to amount of cover crop biomass

- weed suppression, amount of N provided, amount of nutrients scavenged

Do mixes produce biomass equal to monocultures?

- Qualified yes from PA study (Finney et al. 2016)
  - Cereal rye – 7,591 lbs/ac
  - Canola, cereal rye, red clover and hairy vetch - 7,240 lbs/ac no diff
  - Forage radish, oat, canola, cereal rye – 5,655 lbs/ac lower overall more biomass in fall, but lower plant densities in spring

Cover Crop Mixtures

Do mixes produce biomass equal monocultures?

- Mixes did not necessarily produce as much biomass as **most productive monoculture**
- Can be effected by seeding rate
  - Substitutive seeding (monoculture rate divided by number of species) may not lead to maximum productivity
  - Need research on optimal seeding rates

Cover Crop Mixtures

Functions related to cover crop quality (C:N)
- N mineralization

Does cover crop mixtures increase this function?
- Qualified yes from PA
  - Legume monocultures supplied N
  - In some years, mixtures supplied N in others did not
  - Depended on mixture
    - Red clover, hairy vetch, oat and forage radish did

Cover Crop Mixtures

Functions related to amount of microbial biomass
- accessing nutrients in soil, protection from pathogens

Do mixtures increase microbial biomass?
- Cover crop increase soil microbial biomass (Finney et al 2017, McDaniel et al . 2014)
- Generally increase in microbial biomass increases with increasing aboveground biomass (Finney et al 2017)
- No increase of microbial biomass with mixtures (Finney et al 2017)

Cover Crop Mixtures

Functions related to cover crop species

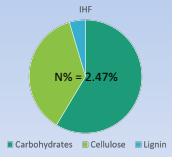
- Mycorrhizal fungi important for accessing greater volume of soil, pathogens protection, reduction of drought stress
- Associated with most plant species except brassicas
- Very important for grass species

- N supply – legumes of course

Cover Crop Mixtures

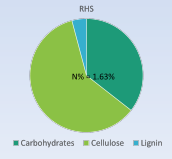
Do mixtures increase these functions?
- Rye and oats greater mycorrhizal fungi compared to no cover (Finney et al. 2017)
- Carryover into next corn crop (White and Weil 2010)
- Mixtures did not increase AM fungi above oats and rye (Finney et al. 2017)
- Mixtures did seem to support species specific associations (Finney et al. 2017)
  - Non- mycorrhizal fungi related to legumes (hairy vetch red clover)

Cover Crop Mixtures



Iron Horse Farm – Black-seeded oats/crimson clover
Boot stage/bud stage
Available N

4-Weeks after Termination	Cumulative
21 lbs/ac	28 lbs/ac



Hedrick Farm – Rye/triticale/oats/hairy vetch/ crimson clover/radish
Soft dough stage/seed stage
Available N

4-Weeks after Termination	Cumulative
10 lbs/ac	17 lbs/ac

Cover Crop Mixtures

- Function is related to species, weather, soil conditions, growth stage and management

Growing conditions influence which species dominate.

High N favor grains
Low N favors legumes

What If I Can Have It All!

- Tradeoffs
- Biomass critical for weed suppression, may not be as good with mixtures
- Biomass and C:N ratio important for N retention.
  - Cereal rye & canola performed best
  - **Mixture can improve this function** compared to legume monoculture
- Grasses known to promote mycorrhizal fungi
  - Another case where mixtures may improve function

What If I Can Have It All!

- Can't have it all but can have enough!
- Need to think about diversity in key functional traits and what your goals are
- Weather and soil conditions change what species perform best so proportions change. Can be good or not so good.
- Use long-term strategy to effect changes in soil function

Take Home

- Increasing evidence that aboveground biodiversity has big influence on belowground biodiversity but can't extrapolate from grassland/forest directly to ag systems (short term)
- Grazinglands have leg up here since perennial
- Crop rotation and cover crop can increase SOC and microbial biomass
- Limited studies indicate some functions can be improved with mixtures
  - Biomass – perhaps
  - N scavenging yes if more grasses compared to legume
  - N mineralization yes if incorporating legumes
  - Qualified yes on yields or productivity
- Just learning what we need to know to tweak systems for maximum productivity
- Experiment! And let us know.

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The University of Georgia

Crop & Soil Science Dept.

College of Agricultural and Environmental Sciences

Sustainable Agriculture Program

Section 12

Soil Web: Bacteria, fungi, and Nematode Populations in the Soil

Dr. Dory Franklin, UGA

Laura Ney, PhD student, UGA

Section 13

Get Your Hands Dirty! – Quick Hands-On Demonstrations

Dr. Dennis Hancock, UGA

SOIL DEMONSTRATIONS

Georgia Grazing School

Athens, Georgia
September 19 and 20th 2017

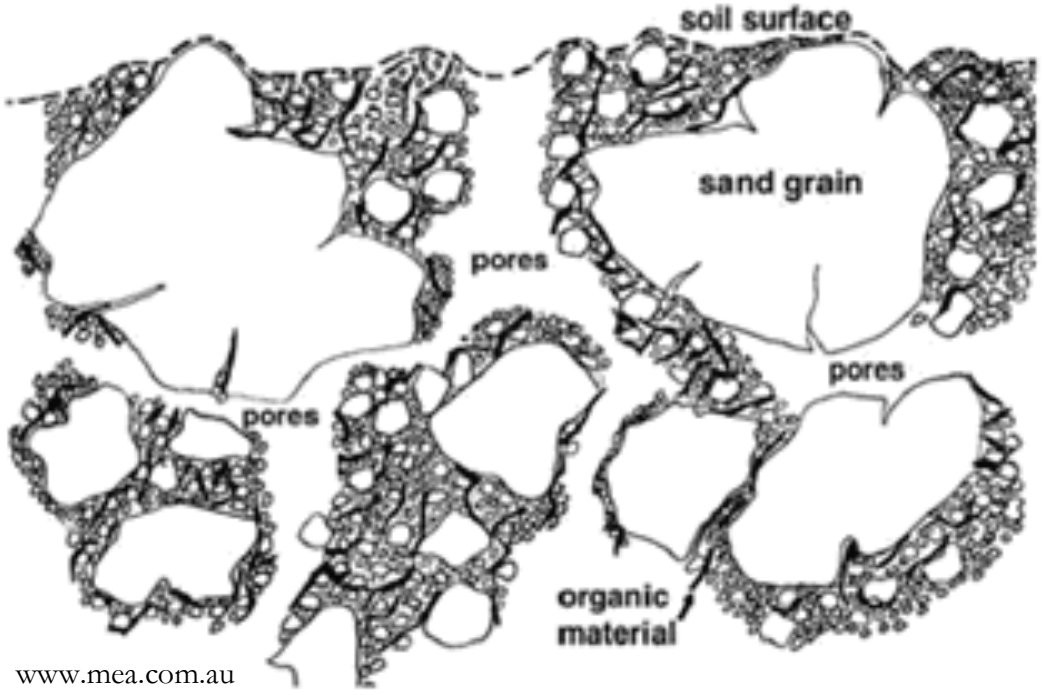
Demonstrations

Overview

A soil's structure is a very important and often overlooked aspect of the soil. The structure of the soil is determined by individual soil particles that are bound together to create larger soil **aggregates** or **peds**. When larger soil aggregates are formed from individual soil particles, spaces between the aggregates are formed called **pore spaces**. Pore spaces are important in that they essentially create roads within the soil that allow water, air, nutrients and roots to easily move through the soil.

Soil aggregates can be formed by various organic substances that act as "glue" to hold soil particles together. For example, root hairs of plants have the ability to not only create channels within the soil but also to help stabilize soil aggregates. Soil particles can also be cemented together through proteins created by fungi called **glomalin**, which act as a glue to hold soil particles together. *It is the gluing of the soil particles creating aggregates that help stabilize and maintain the many pores and channels within the soil that allow water and air to penetrate through the soil and allow the uptake of nutrients through plant roots.*

Several management practices can have a direct impact on the formation of soil aggregates and as a result, the amount of pore spaces within the soil. For example, frequent conventional tillage practices oxygenate the soil which cause the breakdown of beneficial organic substances, one of those being glomalin. The breakdown of glomalin and organic matter in the soil causes a breakdown in soil aggregates. *When soil aggregates are broken down, finer soil particles will settle into the pore spaces of the soil and "clog up" the many roads and highways that help water, air and roots to penetrate through the soil profile.*



www.mea.com.au

Example of a soil's structure. Individual particles can be seen held together by organic material. This creates pore spaces between soil aggregates. The pore spaces allow for water, air and nutrients to infiltrate through the soil.

Soil Glue

The purpose of the "Soil Glue" demonstration is to show the differences in aggregate stability among various management practices. This experiment will demonstrate that less disturbed soils will contain more soil glue than disturbed soils. It will also demonstrate that highly compacted soils can damage the soil habitat causing a decrease in pore spaces when compared to well managed land.

Observations:

No Till Land for 40 Years

Soil aggregates from land that has been in a no till management practice for many years should hold together very well. This is because the soil has been relatively undisturbed and the soil microbial population has been allowed to thrive. This thriving microbial population allows for the turnover of nutrients, which encourages more rooting within these zones. More root development means a greater production of large amounts of glomalin, which help stick the soil aggregates together. When the soil clod is immersed in water the many channels and pores in the soil allow water to penetrate through the soil clod without washing away all of the finer soil particles.

Well Managed Grazing Pasture

Similar results should be seen in a pasture that has been well managed. Plant roots, along with fungi, assist in the aggregation of soil particles and stabilization of pore spaces.

Frequently Conventionally Tilled Land

Soil that is frequently conventionally tilled not only mechanically causes the breakdown of soil aggregates but also accelerates the breakdown of organic substances, such as glomalin, that help stabilize soil aggregates. *When a soil is frequently tilled, the aggregates break apart into fine particles. This is because there is little soil glomalin to stabilize the soil pores and also the many fine soil particles clog the soil pores causing the water to not be able to penetrate into the soil.* This causes the outer edges of the soil ped in this demonstration to begin washing away much easier than in soils where there are larger quantities of glomalin.

Compacted, High Traffic Pasture Area

In contrast, soils that are not tilled frequently but reside in high traffic locations, such as under shade or around water troughs, can also have few soil aggregates. This is because *frequent foot traffic can cause a breakdown of the formed soil aggregates, this then forces the small soil particles into the pore spaces and not allow water to flow easily through the soil.* Soil peds from a high traffic area will break down when immersed into larger soil particles than a conventionally tilled soil but still not have the structural integrity to remain a soil aggregate because the water cannot penetrate through the soil clod.

Soil Air

As discussed earlier, soil glue is important to create pore spaces between soil aggregates. *The more pore spaces there are in a soil, the more water can infiltrate into the soil and the more aerated the soil can be.* Soil air is important in that it allows oxygen to penetrate the soil, allowing the roots to respire and metabolise, as well as allowing for the respiration and metabolism of the billions of organisms that live in the soil. Pore spaces within the soil also allow for the movement of potentially harmful gases such as carbon dioxide out of the soil to provide an optimal environment for plant growth. Properly aerated soil can also assist in decreasing development of some disease infections of the roots.

The purpose of this experiment is to visualize the amount of air that is found in a soil aggregate. Once sprayed with polyurethane spray, the soil aggregates will be immersed in water. Several bubbles should form along the outside of the aggregates. These are air bubbles that were found in the pore spaces that are being replaced by water. The more air bubbles, the more aerated the soil.

Observations:

No Till Land for 40 Years

Land that is relatively undisturbed will have very stable soil aggregates and in turn, very stable pore spaces. These pore spaces will be occupied with air and, when immersed in water will release many air bubbles into the water. This is a great indicator of a well aerated and healthy soil.

Well Managed Grazing Pasture

Similar results should be seen in a well managed pasture. Stable soil aggregates will form stable pore spaces and allow more oxygen to be present throughout the soil profile. This will be visible when the soil aggregates are immersed in water. Many air bubbles will develop as the pore spaces are filled with water.

Frequently Conventionally Tilled Land

Conventionally tilled lands would typically be thought of as well aerated during the tillage process. While this is likely true, the mechanical tillage of the soil along with too much exposure to oxygen will actually cause the breakdown of organic substances such as glomalin and destabilize soil aggregates. The unstable soil aggregates will collapse into the soil's pore spaces and over time actually cause a decrease in air found in the soil. While bubbles may be visible in this experiment, bubbles should appear smaller than in no tilled land. This is a direct reflection of the smaller pore spaces because of the unstable soil aggregates.

Compacted, High Traffic Pasture Area

Physical compaction of the soil in high traffic areas, such as under shade structures or near waterers or feeding stations can cause fine soil particles to settle into the pore spaces and allow little room for air to penetrate into the soil. These soils will have few bubbles when immersed in water. These soils will likely be bare land with little or no plant growth and water will runoff fairly readily.

Soil Infiltration Rate

It has already been discussed that soil structure is important for the movement of gasses, nutrients, and organisms through the soil. It is also very important in how rainwater infiltrates through the soil following a rain event. *Soils with large pore spaces and stable soil aggregates will allow rainwater to fill into the pore spaces and deep into the* **soil profile**. *Soils that have unstable soil aggregates and small pore spaces will cause water to fill into the spaces slowly and cause water to runoff much faster than well-aerated soils.* This is important not only to help curb erosion but also to ensure **infiltration** of recently applied fertilizers and prevent them from running off the land that was fertilized. Poor soil infiltration also makes it difficult for water to reach deep into the soil profile to interact with nutrients within the soil for plant uptake.

Observations:

No Till Land for 40 Years

It has already been established that land that has been undisturbed for many years has very stable soil aggregates and large pore spaces. How this affects water infiltration rate into the soil can be seen in this experiment. It should be observed that when a rain event is simulated, water will more readily infiltrate through the no-till soil profile than in tilled soils or compacted soils.

Well Managed Grazing Pasture

Similar results should be seen in well managed pastureland. Pasture that has been well managed has very stable soil aggregates and therefore allow rainwater to penetrate through the soil profile rather than runoff.

Frequently Conventionally Tilled Land

As previously discussed, conventionally tilled land is mechanically broken down and has much more unstable soil aggregates and pore spaces. Because of this, when a rain event is simulated it can be observed that it takes longer for rainwater to infiltrate through the soil. This is because there are fewer spaces between soil aggregates that allow water to filter through the soil. On a larger scale, this can cause water runoff issues.

Compacted, High Traffic Pasture Area

Soils that are highly compacted also make it very difficult for water to infiltrate through the soil. This can be observed in a simulated rain event. Water will have a difficult time infiltrating through the soil and remain on top of the soil. It should also be observed that the compacted soil will take much longer for water to fully infiltrate through the soil, if it infiltrates at all.

Earthworm Populations in the Soil

It is important to understand that soil provides a habitat for many organisms such as bacteria, fungi, worms, and insects. *These organisms can greatly contribute to the quality of a soil by not only physically mixing the soil and creating channels that assist in water infiltration and aeration but are also important in breaking down organic materials such as grass and leaf material into nutrients available for plant uptake and nutrient cycling.* Worms can also assist in degrading toxic substances within the soil. A healthy worm population is often a great indicator of a healthy soil.

Observations:

As you observe each of the jars, you should be able to observe mixing of the different soil types performed by the worms in the jar. You should also observe distinct channels created within the soil by the worms. This mixing of the soil not only assists in nutrient availability for plants but also transform organic nutrients found at the soil surface into mineral nutrients that can be taken up by the plant. The channels created by the earthworms also assist in water infiltration and soil aeration.

Testing Soil For Aluminum Toxicity

Maintaining proper **soil pH** is imperative for optimal plant growth. As you can see from the figure below, the pH with the greatest soil **nutrient availability** is around 6.2 – 7.3. When a soil has a low pH (pH<5), soluble Al^{3+} becomes available for plant uptake which is toxic to plants. Aluminum toxicity is typically presented as stunted root growth, which restrict plant nutrient uptake from the soil.

This experiment will demonstrate the differences in root development of plants in an acidic soil (pH<5), ideal soil pH (pH ~6) and an acidic soil that has been limed to raise soil pH.

Observations:

Soil pH ~6

Soil with an ideal soil pH should present itself with greater forage yields and a well developed root system. This is because the pH with the greatest nutrient availability is around 6.2 – 7.3 and will provide optimal conditions for plant growth.

Soil pH < 5

A highly acidic soil will have characteristics of stunted plant growth due to limited nutrient availability at such a low pH. Another characteristic of aluminum toxicity is stunted and abnormal root growth. These roots restrict the ability of the roots to explore through the soil for available nutrients.

Soil pH < 5 limed to pH ~6.5

In this soil, the liming helps to raise the pH and increase nutrient availability. The plants in this soil should have greater plant growth when directly compared to the acidic soil. The roots should have a more typical appearance with long roots and long root hairs.

Soil Type and pH Root Tubes

There are many properties of the soil that can affect root development in plants. As discussed earlier, soil pH can have a significant effect on nutrient availability. Another factor that contributes to root development and overall health of the plant is the **soil texture.** Soils with coarser textures such as sand can create larger pore spaces and make it easier for plant roots to penetrate through the soil. However, these large pore spaces can also increase the movement of water and nutrient leaching through the soil profile. In finer textured soils such as clay, the pore spaces are smaller and able to hold water and nutrients more efficiently than sandy soils. Soil texture also has an effect on the stability of soil aggregates found in the soil. In sandy soils, the larger soil particles cannot compact into stable soil aggregates. This causes the soil to not only be more susceptible to erosion but the constant shifting of the sandy soil can also have negative effects on the ability of the plant to anchor itself in the soil.

Observations:

Sandy Soil

In this demonstration, you are likely to see a root system that penetrates deep through the soil profile. This is because the large pore spaces in the sandy soil make it easier for the root system to penetrate the soil. However, in a sandy soil, the roots must also be deeper to find available essential nutrients in the soil. This is because the large pore spaces of the soil cause nutrients to leach out of the soil fairly quickly. Another observation would be that the root system, while long, may not be as branched as the root system as the clay soil. This is because the roots must expend more energy going deeper into the soil profile to find nutrients rather than branching out within the **soil horizon** as in clay soils.

Clay Soil

In the clay soil, you should observe a root system that also penetrates through the soil profile but may be more branched horizontally rather than vertically. This is because the smaller pore spaces in the clay allow the soil to maintain water and nutrients with less potential for leaching.

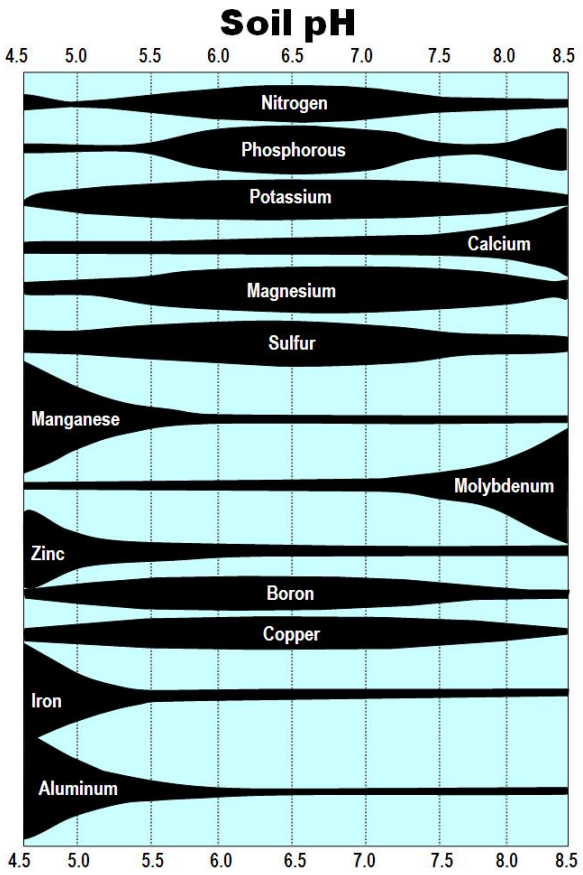


Diagram showing nutrient availability at various soil pH.

Acidic Soil

This demonstration is to show on a larger scale, the effects of aluminum toxicity and soil pH on the development of the plant. You should not only observe short, under developed roots, but also restricted foliage growth on the above ground portion of the plant.

Grazing Interval Root Tubes

A plant's root system is an important yet often overlooked aspect of the overall health of a plant. Roots not only act as an anchor that holds the plant in place, but are important in storage of carbohydrates in the plant. The roots also allow the plant to explore deep through the soil profile for essential nutrients. When a plant is cut or grazed, the nutrient reserves located in the root system are redirected to the above ground portion of the plant to regenerate/regrow leafy material which can then photosynthesize, and help the plant restore the depleted nutrient reserves in the root system.

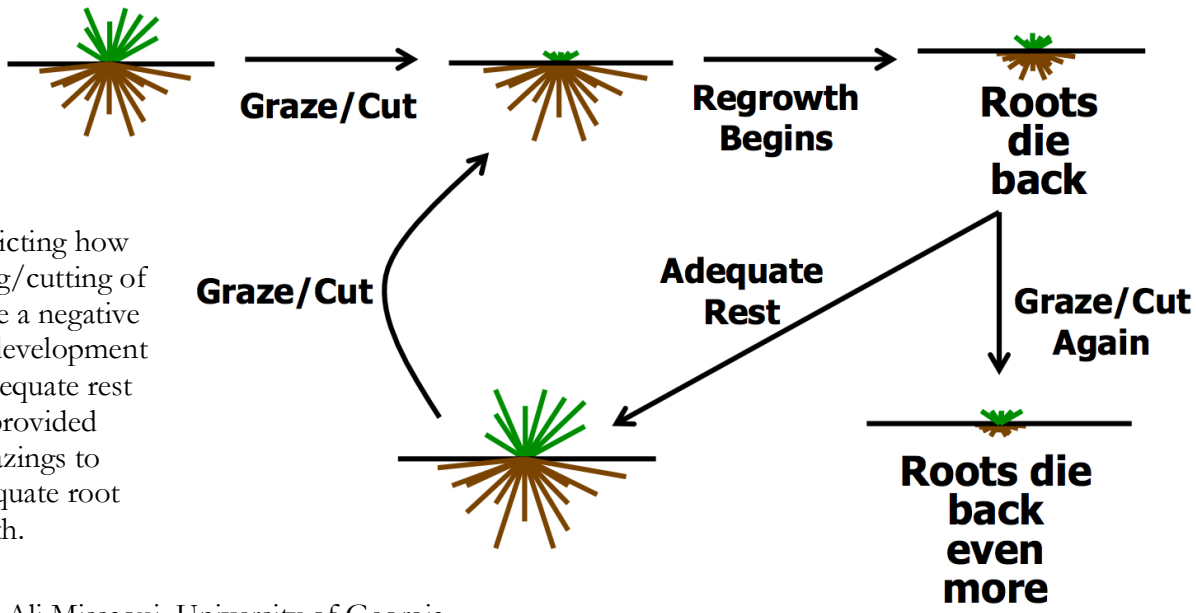
Continously over grazing a pasture can cause the roots of the plant to deplete its nutrient reserves and the roots to die back. When this happens the plant not only loses its nutrient reserves (which are important especially in harsh conditions) but the depth/amount of soil they are able to penetrate in search of nutrients is severely limited. Finally, when the root system is depleted, they are less effective as a natural anchor for the plant.

This is why it is important to understand that management practices can have a direct impact not only on the above ground portion of the plant but also the below ground root system as well. In this demonstration, you will be able to see the direct effects of different grazing practices on the root system in the plants.

Observations:

Two Day Cutting Interval:

The two day cutting interval simulates an over stocked and overgrazed pasture. When a pasture is over stocked, the grazing pressure on the plants is incredibly high. Livestock will be forced to graze the plants very frequently in order to obtain enough forage. In this frequent cutting interval, you should see a very shallow root system in the plants when compared to the seven and twenty-one day cutting intervals. This is because the nutrient reserves in the root system do not have enough



An image depicting how frequent grazing/cutting of forage can have a negative effect on root development of forages. Adequate rest should be provided between grazings to maintain adequate root growth.

Image Credit: Dr. Ali Missaoui, University of Georgia.

Grazing Interval Root Tubes

time to replenish their reserves before having to redirect more nutrients to the above ground portion of the plant and as a result, it will take longer for the plant to recover from grazing.

Seven Day Cutting Interval:

A typical continuously stocked pasture with proper stocking rates will likely result in a seven day rest period for plants. This will allow some rest for the plant to replenish nutrient reserves in the roots but still not as much as what can be observed in longer rest periods. In this demonstration, you should observe a root system that is deeper than the two day cutting interval but not as extensive as the twenty-one day cutting interval.

Twenty One Day Cutting Inverval:

In rotationally grazed operations, there is often a longer rest period between grazing on pastures. This allows the plant a significant amount of time to replenish its nutrient reserves and recover from grazing. In this demonstration you should see the deepest and most extensive root system of the three cutting intervals.

Glossary

Acid Soil A soil with a pH value <7.0. Usually applied to surface layer or root zone, but may be used to characterize a horizon.

Aeration, Soil The process by which air in the soil is replaced by air from the atmosphere. In a well aerated soil, the soil air is similar in composition to the atmosphere above the soil. Poorly aerated soils usually contain more carbon dioxide and correspondingly less oxygen than the atmosphere above the soil.

Aggregate (Soil) Many soil particles held in a single mass or cluster, such as a clod, crumb, block or prism.

Agronomy a specialization of agriculture concerned with the theory and practice of field-crop production and soil management. The scientific management of land.

Allelopathy The process by which one plant may affect other plants by biologically active chemicals introduced in the soil, either directly by leaching or exudation from the source plant, or as a result of the decay of plant residues. The effects, though usually negative, may also be positive.

Ammonification The biochemical process whereby ammoniacal nitrogen is released from nitrogen containing organic compounds

Ammonium Fixation The entrapment of ammonium ions by the mineral or organic fractions of the soil in forms that are insoluble in water and are at least temporarily nonexchangeable.

Biomass The total mass of living material of a specified type in a given environment

Buffering Capacity The ability of a soil to resist changes in pH. Commonly determined by the presence of clay, humus and other materials.

Bulk Density The mass of dry soil per unit of bulk volume, including the air space. The bulk volume is determined before drying to constant weight at 105C

Casts (Earthworm) Rounded, water stable aggregates of soil that have passed through the gut of an earthworm.

Cation Exchange Capacity The interchange between a cation in solution and another cation on the surface of any surface-active material, such as clay or organic matter.

Clay A soil textural class containing >40% clay, <45% sand and <40% silt. Also, a soil separate consisting of particles <0.002mm in diameter.

Claypan A dense, compact, slowly permeable layer in the subsoil having much higher clay content than the overlying material, from which it is separated by a sharply defined boundary. Claypans are usually hard when dry and plastic and sticky when wet. (See also, hardpan)

Clod A compact, coherent mass of soil produced artificially, usually by such human activities such as plowing and digging, especially when these operations are performed on soils that are either too wet or too dry for normal tillage operations.

Cultivation A tillage operation used in preparing land for seeding or transplanting or later for weed control and for loosening of the soil.

Ecosystem A dynamic and interacting combination of all the living organisms and non living elements of an area

Erosion The wearing away of the land surface by running water, wind, ice, or other geological agents. Also, the detachment and movement of soil.

Glossary

Eutrophication Nutrient enrichment of lakes, ponds, and other such waters that stimulates the growth of aquatic organisms, which least to a deficiency of oxygen in the body of water.

Fertility, Soil The quality of a soil that enables it to provide essential chemical elements in quantities and proportions for growth of specified plants.

Glomalin A protein – sugar group of molecules secreted by certain fungi resulting in a sticky hyphal surface thought to contribute to aggregate stability.

Hardpan a hardened soil layer, in the lower A or in the B horizon, caused by cementation of soil particles with organic matter or with other materials. The hardness does not change appreciably with changes in moisture content and pieces of the hardpan layer do not slake in water.

Humus That more or less stable fraction of the soil organic matter remaining after the major portions of added plant and animal residues have decomposed. Usually dark in color.

Immobilizaton The conversion of an element from the inorganic form to the organic form in plant tissues rendering it not readily available to other organisms or plants.

Infiltration The downward entry of water into the soil.

Leaching The removal of materials in solution from the soil by percolating waters.

Lignin The complex organic constituent of woody fibers in plant tissue that, along with cellulose, cements the cells together and provides strength. Lignins resist microbial attack.

Mineralization The conversion of an element from an organic form to an inorganic form as a result of microbial decomposition.

Micorrhiza The association, usually symbiotic, of fungi with the roots of seed plants.

Nematodes Very small (Microscopic) unsegmented round worm. In soils they are abundant and perform many important functions in the soil food web.

Nitrogen Fixation The biological conversion of elemental nitrogen (N_2) to organic forms readily utilized in biological processes.

Nutrient Availability That portion of any element or compound in the soil that can be readily absorbed and assimilated by growing plants.

Ped A unit of soil structure such as an aggregate, crumb, prism, block, or granule, formed by natural processes (in contrast with a clod, which is formed artificially).

pH, Soil The negative logarithm of the amount of hydrogen ion activity found in a soil.

Rhizosphere That portion of the soil profile in the immediate vicinity of the plant roots in which the abundance and composition of the microbial population are influenced by the presence of roots.

Root Nodules Swollen growths on plant roots. Often in reference to those in which symbiotic microorganisms live.

Soil A dynamic natural body composed of mineral and organic solids, gasses, liquids, and living organisms which can serve as medium for plant growth.

Glossary

Soil Air The soil atmosphere; the gaseous phase of the soil, being that volume not occupied by soil or liquid.

Soil Compaction The process or state of consolidation brought about by the application of mechanical forces to the soil which increase soil bulk density, and concomitantly decrease soil porosity. Often detrimental for plant growth and hydrologic soil functions.

Soil Organic Matter The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population.

Soil Quality The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

Soil Solution The aqueous liquid phase of the soil and its solutes, consisting of ions dissociated from the surfaces of the soil particles and of other soluble materials.

Soil Structure The combination or arrangement of primary soil particles into secondary particles, units, or peds. These secondary units may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades respectively.

Soil Texture The relative proportion of various soil separates in a soil.

Symbiosis The living together in intimate association of two dissimilar organisms, the cohabitation being mutually beneficial.

Section 14

The Role and Management of Dung Beetles in Pastures

Johnny Rogers, NCSU's
Amazing Grazing Program

The Role and Management of Dung Beetles in Pastures

Johnny R. Rogers M.S. PAS
Amazing Grazing Program Coordinator
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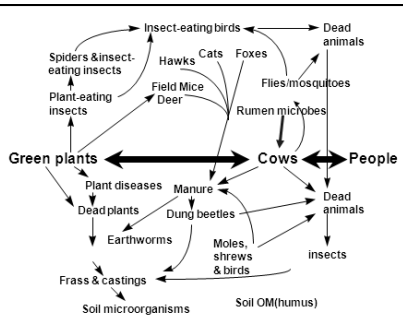
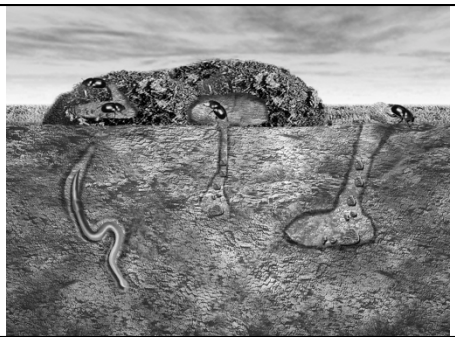
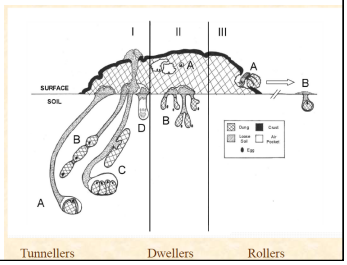
Dung Beetle Ecology in North Carolina



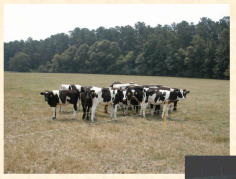


Dung Beetle Reproduction and Behavior

- Strong parental care
- Complex nesting
- Few offspring



Dung beetles in cattle pastures: Sanitation

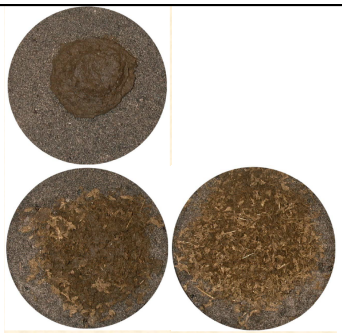


Pasture Fouling

John Feehan

Dung Removal

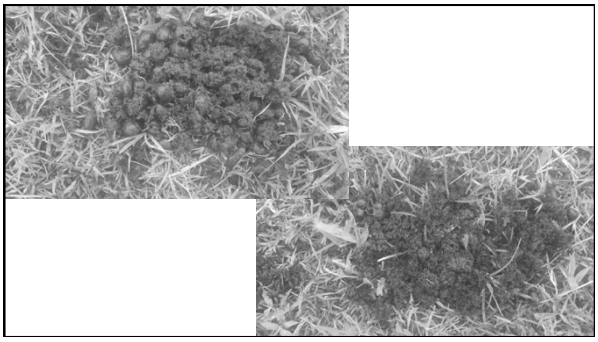
- 20 Beetles
- 3 days
- Food
  - Adults
- Burial
  - Brood



Soil Conditioning and Nutrient Cycling

- Improves Soil Permeability
  - percolation
- Improves Soil Tilth
  - Soil Mixing
  - Pack tunnels with soil
- Nutrient Cycling
  - nutrients passed in dung
  - beetles bury brood balls

Photos by John Feehan



The Role of Dung Beetles in Nutrient Cycling

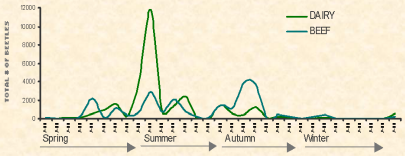
Table 2. Analysis of soil treatments, using Mehlich[3] Extraction (North Carolina Department of Agriculture and Consumer Services).

Treatment	P (mg/dm^3)	K ($meq/100cm^3$)	Mg ($meq/100cm^3$)	Sum Cations ($meq/100cm^3$)
Sandy-loam Pre-treatment	99.40	0.08	0.53	1.66
Sandy-loam + Dung	174.73	0.18	0.87	2.64
Sandy-loam + Dung + *O. gazella*	204.57	0.25	1.06	3.35
Sandy-loam + Dung + *O. taurus*	196.01	0.23	0.98	3.04

Pest Management: Is this biological control?

- Compete for resources with dung breeding pests:
  - Horn fly
  - Face fly
  - Gastrointestinal Parasites

Dung Beetle Activity in Eastern North Carolina



Imported Tunnellers

- *Onthophagus taurus*
  - Dominant NC species
  - 5/16 of inch in length
  - Distinct bull like horns
  - 2-4 generations/year
  - Active from March to November
  - Improves soil
    - Percolation
    - Compete with flies
    - Reduce pasture fouling

Native Tunnellers

- *Onthophagus hecate*
  - ¼ inch in length
  - Active March to November and occasionally in the winter.
- *Onthophagus pennsylvanicus*
  - 1/8 inch in length
  - Active from March to November

Imported Dwellers

- *Aphodius psuedolividus*
  - 1/8 inch in length
  - Active from March to November
  - Improve soil
    - Reduce pasture fouling
    - Compete with flies
- *Aphodius erraticus*
  - 1/8 inch in length
  - Active from March to July
  - Improve soil
    - Reduce pasture fouling
    - Compete with flies

Dung Beetles in Pastures

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AmazingGrazing
Pasture-Based Livestock Education Program

NC STATE UNIVERSITY

Dung Beetles of Central and Eastern North Carolina Cattle Pastures

Matt Bertone[1], Wes Watson[1], Mike Stringham[1], Jim Green[2], Steve Washburn[3], Matt Poore[3] and Mark Hucks[4]

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Dung Beetles (Coleoptera: Scarabaeidae and Geotrupidae) in Cattle Pastures

Dung beetles, in the insect families Scarabaeidae and Geotrupidae, are an important group of insects associated with the decomposition of animal manure around the world. They consume large amounts of dung as adults and larvae. Some species prefer woodland habitats while others are common on pastures. Their actions have been credited in reducing pasture fouling, adding nutrients to soil, aerating soil and competing for nesting habitat and food resources with flies (particularly the horn fly, *Haematobia irritans*, and the face fly, *Musca autumnalis*).

Beef cattle production in North Carolina is characteristically a small cow/calf herd, with less than 50 head of cattle on pasture. Many dairy producers use pastures to provide nutritional forage for young and yearling heifers. A growing number of dairy producers use pastures for lactating dairy cows on a rotational basis. Rotational grazing employs the periodic movement of cattle between paddocks to encourage plant growth, and provide nutritious forage for cattle. The practice tends to minimize overgrazing and conserves natural resources. Rotational grazing increases plant diversity, pasture yield, and utilizes animal manures efficiently. In the absence of dung-inhabiting insects animal feces can be slow to decompose and the benefits of good nutrient distribution may be reduced.

Dung beetles fall into three basic nest building categories, tunnelers (paracoprids), dwellers (endocoprids), or rollers (telecoprids) (Figure 1). Tunnelers consume the dung pat and burrow into the soil beneath the pat. The tunneling activity of *Phanaeus vindex* and *Onthophagus* species brings subsurface soil to the ground surface and fill the tunnel with loosened soil to protect the brood ball (Figure 1I). Manure dwelling beetles, e.g. *Aphodius* species, consume the manure pat and deposit eggs in the manure, or in the soil near the surface (Figure 1II). *Canthon* beetles are dung rolling beetles. These beetles tend to break the pat into brood balls that are rolled to a suitable site and buried (Figure 1III). Each dung beetle nest type improves the soil by increasing percolation, introducing organic matter into the soil, and reducing non-point sources of organic pollution.

Adult dung beetles vary significantly in size from small beetles no more than 1/8th of an inch in length (*Aphodius pseudolividus*) to large beetles measuring 1 ¼ inches in length (*Dichotomius carolinus*). Most dung beetles are brown to black in color. Occasionally, a

bright metallic green beetle appears and can be an easily identified as *Phanaeus vindex*. Many of the male dung beetles have distinct horns, for example, *Onthophagus taurus* horns resemble bull horns, while *Onthophagus gazella* has short spike like horns (Figure 3). Horn size is generally a product of larval nutrition. Major males have large horns while minor males have short horns.

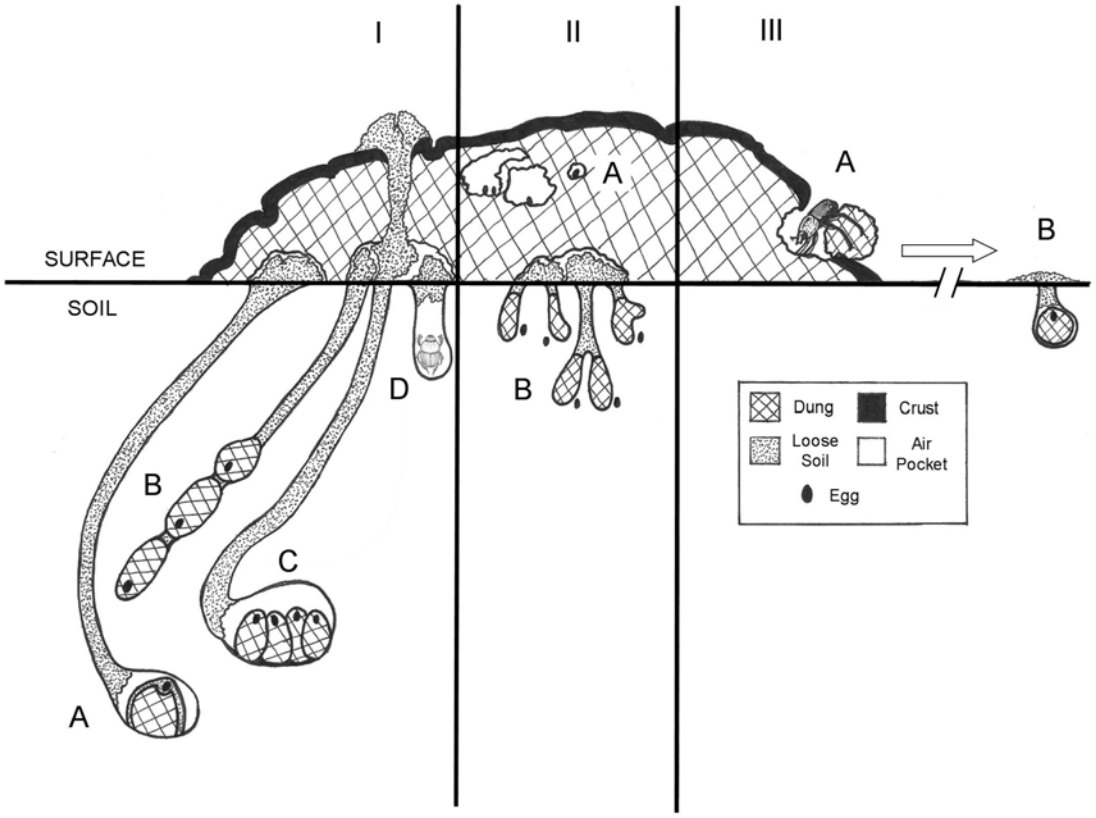

Figure 1. Cross section through dung pat depicting three nesting types:

Tunnelers I-A. *Phanaeus vindex* tunnel with single, soil-coated brood ball in single chamber; B. *Onthophagus* species tunnel with multiple brood masses; C. *Copris minutus* multiple brood balls; D. beetle excavating new tunnel (note subsurface soil is pushed through the dung pat crust)

Dwellers II-A. *Aphodius pseudolividus* eggs are laid singly or in groups inside dung pat; B. *Aphodius erraticus* bury dung under pat with eggs laid beside brood masses.

Rollers III-A. *Canthon pilularius* adult carving out dung into a ball; B. ball rolled a distance away from pat and buried shallowly.

Species Composition and Seasonality in Eastern and Central North Carolina

Twenty-eight species of dung beetles have been identified from beef and dairy pastures located at the Center for Environmental Farming Systems (CEFS), Goldsboro, NC. The CEFS pastures are characteristic of those in the NC coastal plain. Fourteen species of dung beetles were identified from dairy (Piedmont Research Station, Salisbury, NC) and

beef pastures (Nashville, NC) at the interface of the coastal plain and piedmont region of North Carolina. Dung beetles were more abundant at the eastern NC sites than on the Piedmont Research Station. For example beetle collections over an 18-month period from the CEFS dairy pasture were 57,025 while in contrast 4,111 specimens were collected from the Piedmont Research Station dairy. Although fewer beetles were collected in the winter, dung beetles were active year round (Figure 2).

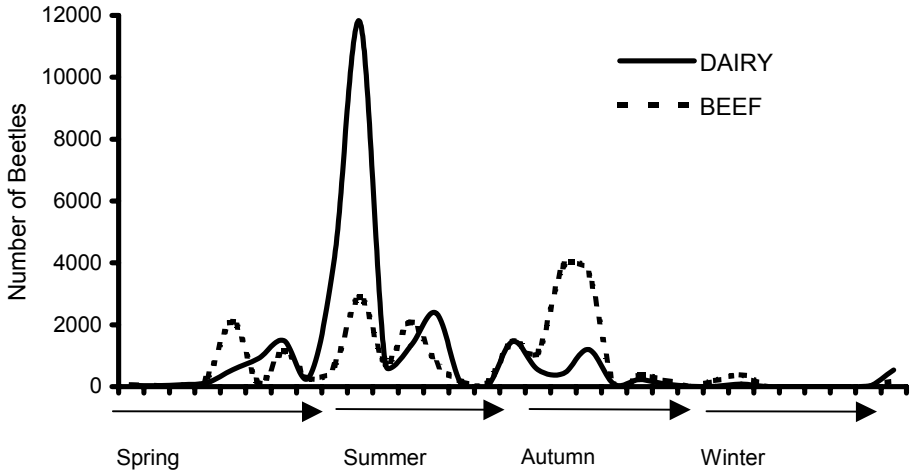

Figure 2. Annual dung beetle activity on beef and dairy pastures located in eastern North Carolina.

Species composition change seasonally

Some species, such as *Aphodius granarius* and *Aphodius erraticus* were present from late winter through spring, but were not collected in the summer and fall. *Phaneus vindex* is a large metallic green beetle that is found from spring to fall. *Geotrupes backburnii* activity increases in the fall and winter months. *Onthophagus gazella* was not present until the middle of the summer, and were most abundant in August, while others were active most of the year.

Four dung beetle species (Figure 3), *Onthophagus hecate, Onthophagus pennsylvanicus*, *Onthophagus taurus,* and *Aphodius pseudolividus,* were most abundant from March until October when fly breeding was highest and the forage production was greatest. The dwelling beetle, *A. pseudolividus*, does not incorporate manure into the soil but directly competes with horn flies for manure resources. The benefits of the *Onthophagus* species are twofold; dung buried in tunnels beneath the dung pat limit fly resources while providing nutrients for the plant growth.

Factors influencing the natural distribution of dung beetles are not well understood. Native dung beetles, *O. pennsylvanicus*, *O. hecate*, are widely distributed along the Mid Atlantic states. *Onthophagus gazella* was introduced from the Africa and released in

Texas and Georgia to facilitate pasture improvement, whereas *O. taurus* was an accidental introduction from the Middle East and Europe. *Onthophagus taurus* has been collected from New York to Florida. In North Carolina, *O. taurus* was the dominant species collected (Table 1). In contrast, no *O. gazella* were collected from the Piedmont Research Station and 8 specimens were found on the beef pastures in Nash County. Differences in beetle populations may be attributed several factors including, soil type (clay or sandy loam), climate, beetle dispersion or pesticide use.

Table 1. Percent species composition of dung beetle populations collected from North Carolina dairy and beef pastures located at the Center for Environmental Farming Systems (CEFS), the Piedmont Research Station, and Nash County.

	CEFS	CEFS	Piedmont	Nash Co.
	Dairy	Beef	Dairy	Beef
Aphodius pseudolividus	3.29	34.34	20.32	1.33
Aphodius erraticus	8.50	3.84	5.20	<1.00
Onthophagus taurus	78.78	43.01	67.71	84.76
Onthophagus pennsylvanicus	2.50	4.88	2.60	10.91
Onthophagus gazella	3.69	8.33	0.00	<1.00
Onthophagus hecate	1.41	0.47	0.92	1.48
Other species	1.80	10.00	3.20	0.60
Number Beetles Collected	28,095	22,846	3,695	20,584

The Role of Dung Beetles in Pasture Nutrient Cycling

Dung beetles have the potential to improve pastures through the incorporation of manure into pasture soils. Two dung beetles, *O. gazella* and *O. taurus*, were evaluated in the laboratory for improved soil quality. The test soil was a coastal plain sandy-loam, common to eastern North Carolina. Treatments included bovine dung alone, dung plus *O. gazella*, dung plus *O. taurus*, and a no-dung control. The presence of beetles improved levels of P, K, Mg, and the sum of the cations in soil beneath the dung pat (Table 2).

Table 2. Analysis of soil treatments, using Mehlich[3] Extraction (North Carolina Department of Agriculture and Consumer Services).

Treatment	P (mg/dm^3)	K ($meq/100cm^3$)	Mg ($meq/100cm^3$)	Sum Cations ($meq/100cm^3$)
Sandy-loam Pre-treatment	99.40	0.08	0.53	1.66
Sandy-loam + Dung	174.73	0.18	0.87	2.64
Sandy-loam + Dung + *O. gazella*	204.57	0.25	1.06	3.35
Sandy-loam + Dung + *O. taurus*	196.01	0.23	0.98	3.04

Dung Beetles and Insecticides

Managing pasture flies and promoting dung beetles is a delicate balancing act. Pesticides formulated in an ear tag have minimal impact on dung beetles. Pour-on formulations have a greater effect on beetles if the insecticide is excreted in the manure. Parasiticides in the macrocyclic lactone class (abamectin, ivermectin, eprinomectin, doramectin**)** kill flies and dung beetles in the manure (Fincher 1992, Holter et al. 1994, Floate 1998, Lumaret and Errouissi 2002). Similarly, manure excreted by cattle treated with a pour-on pyrethroid was toxic to dung beetles for 1 week following treatment (Kruger et al. 1999). Persistent use of these compounds will have a long- term negative impact on the dung beetle population. In contrast, moxidectin is less toxic to dung beetles and did not reduce dung beetle survival (Fincher and Wang 1992 Lumaret and Errouissi 2002). Occasionally, horn fly and/or face fly pressure on the cattle will require treatment to provide relief to the cattle, so some impact on dung beetle populations may be unavoidable. Fly control strategies that minimize negative impacts on dung beetles are the subject of current research at NCSU and at other universities.

Do You Have Dung Beetles in Your Pastures?

Unless there is a long history of pesticide use, (especially those listed above), you probably have dung beetles in your pasture. Walk your pastures and examine the dung pats. If you find holes in the surface of the pat, or pats appear to be shredded, you probably have dung beetles. To confirm their presence, open the pats with a spade, trowel or your boot and look for adult beetles or simply walk behind your cattle and observe any insect activity immediately following the deposition of a dung pat. Dung beetles usually arrive within minutes of the deposition of dung when temperatures are above 70^{o}F. The photo guide (Figure 3) will help identify common dung beetles present in your pastures.

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Lumaret, J. P. and F. Errouissi. 2002. Use of anthelmintics in herbivores and evaluation of risks for the non target fauna of pastures. Vet. Res. 33: 547-562.

Figure 3. Picture Guide to Dung Beetles Associated with NC Pastures
Males are indicated by the symbol ♂ and females ♀
Photographs by Matt Bertone

Aphodius distinctus
Size: 1/8-3/16”

Aphodius erraticus
Size: 1/4-3/8”

Aphodius fimetarius
Size: 1/4-3/8”

Aphodius pseudolividus
Size: 1/8-3/16”

Geotrupes blackburnii
Size: 3/8-3/4”

Onthophagus gazella (♀)
Size: 3/8-1/2”

Onthophagus gazella (♀)
Size: 3/8-1/2”

Onthophagus gazella (♂)
Size: 3/8-1/2”

Onthophagus gazella (♂)
Size: 3/8-1/2”

Onthophagus hecate (♀)
Size: 1/4-3/8”

Onthophagus hecate (♂)
Size: 1/4-3/8”

Onthophagus hecate (♂)
Size: 1/4-3/8”

Onthopagus pennsylvanicus
Size: 1/8-1/4”

Onthophagus taurus (♀)
Size: 1/4-3/8”

Onthophagus taurus (♂)
Size: 1/4-3/8”

Onthophagus taurus (♂)
Size: 1/4-3/8”

Phanaeus vindex (♀)
Size: 3/8-7/8”

Phanaeus vindex (♂)
Size: 3/8-7/8”

Phanaeus vindex (♂)
Size: 3/8-7/8”

Canthon pilularius
Size: 1/2-5/8”

Dichotomius carolinus
Size: 3/4 – 1¼”

Pronunciation guide: There are no common names of these beetles. To make their names easier to understand, a pronunciation guide is provided.

Aphodius distinctus: A-fo-di-us dis-tink-tuss
Aphodius erraticus: A-fo-di-us e-rat-i-kus
Aphodius fimetarius: A-fo-di-us fim-a-tary-us
Aphodius granarius: A-fo-di-us gran-air-e-us
Aphodius pseudolividus: A-fo-di-us sue-doe-liv-i-dus
Canthon pilularius: Kan-thon pie-loo-lary-us
Copris minutus: Koe-pris mi-nu-tus
Dichotomius carolinus: Dik-o-tomee-us carolin-us
Geotrupes blackburnii: Geo-troop-eze black-burny-eye
Onthophagus gazella: On-tho-fa-gus ga-zell-a
Onthophagus hecate: On-tho-fa-gus heck-ate
Onthophagus pennsylvanicus: On-tho-fa-gus pen-sill-van-i-kus
Onthophagus taurus: On-tho-fa-gus tore-us
Phanaeus vindex: Fan-ny-us vin-dex (Rainbow beetle)

Section 15

Earthworms Populations in the Soil

Dan Wallace, USDA-NRCS Georgia
Resource Inventory Coordinator

Section 16

Soil Organic Matter Benefits

Dr. Miguel Cabrera, UGA

Section 17

Soil Compaction and the Lay of the Land

Dr. Dory Franklin, Subash Dahal, and Laura Ney, UGA

Section 18

Nutrient Cycling and Loss in Pasture-Based Systems: Implications for Fertilization

Drs. Dory Franklin and Miguel Cabrera, UGA

Section 19

Soil Health Measures: Interpretation and Practical Application

Drs. Miguel Cabrera and Dory Franklin, UGA

Section 20

Good Grazing = Inc. Soil Moisture, Inc. Soil Health, and Lower Erosion

Team Effort

unlock the secrets in the soil basics & benefits

unlock the SECRETS IN THE SOIL

Healthy, fully functioning soil is balanced to provide an environment that sustains and nourishes plants, soil microbes and beneficial insects.

Managing for soil health is one of the most effective ways for farmers to increase crop productivity and profitability while improving the environment. Positive results are often realized within the first year, and last well into the future.

Soil Health

Soil is made up of air, water, decayed plant residue, organic matter from living and dead organisms, and minerals, such as sand, silt and clay. Increasing soil organic matter typically improves soil health since organic matter affects several critical soil functions. Healthy soils are also porous, which allows air and water to move freely through them. This balance ensures a suitable habitat for the myriad of soil organisms that support growing plants.

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It's not difficult to improve soil health. Here's how: till the soil as little as possible; grow as many different species of plants as possible through rotations and a diverse mixture of cover crops; keep living plants in the soil as long as possible with crops and cover crops; and keep the soil surface covered with residue year round.

Soil Health Benefits

Farmers who manage their land in ways that improve and sustain soil health benefit from optimized inputs, sustainable outputs and increased resiliency. Healthy soils benefit all producers – managers of large, row crop operations to people with small, organic vegetable gardens. Healthy soils provide financial benefits for farmers, ranchers and gardeners, and environmental benefits that affect everyone.

Healthy soils lead to:

- **Increased Production** – Healthy soils typically have more organic matter and soil organisms which improve soil structure, aeration, water retention, drainage and nutrient availability. Organic matter holds more nutrients in the soil until the plants need them.
- **Increased Profits** – Healthy soils may require fewer passes over fields because they are only minimally tilled and they aren't over-reliant upon excessive nutrient inputs to grow crops. Healthy soils can increase farmers' profit margins by reducing labor and expenses for fuel, and optimizing inputs.
- **Natural Resource Protection** – Healthy soils hold more available water. The soil's water-holding capacity reduces runoff that can cause flooding, and increases the availability of water to plants during droughts. Good infiltration and less need for fertilizers and pesticides keep nutrients and sediment from loading into lakes, rivers, and streams. Groundwater is also protected because there is less leaching from healthy soils. Additionally, fewer trips across fields with farm machinery mean fewer emissions and better air quality.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems allow farmers to improve profitability because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions.

Contact your local NRCS office to learn more about Soil Health Management Systems and the technical and financial assistance available to help "Unlock the Secrets in the Soil."

unlock the SECRETS IN THE SOIL

unlock the SECRETS IN THE SOIL

Biodiversity increases the success of most agricultural systems.

Biodiversity helps to prevent disease and pest problems associated with monocultures. Using cover crops and increasing diversity within crop rotations improves soil health and soil function, reduces costs, and increases profitability. Diversity above ground improves diversity below ground, which helps create healthy productive soils.

Cover Crops

Cover crops can be an integral part of a cropping system. Cover crops can be managed to improve soil health, as they help to develop an environment that sustains and nourishes plants, soil microbes and beneficial insects.

Cover crops are typically planted in late summer or fall around harvest and before spring planting of the following year's crops. Examples of cover crops include rye, wheat, oats, clovers and other legumes, turnips, radishes, and triticale. Planting several cover crop species together in a mixture can increase their impact on soil health. Each cover crop provides its own set of benefits, so it's important to choose the right cover crop mixture to meet management goals.

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Cover Crop Benefits

Restoring Soil Health – Cover crops help increase organic matter in the soil and improve overall soil health by adding living roots to the soil during more months of the year. Cover crops can improve water infiltration into the soil. Deep-rooted crops like forage radishes create natural water passages. Legume cover crops serve as natural fertilizers while grasses scavenge nutrients that are often lost after harvest or during winter.

Natural Resource Protection – Along with crop residue above ground, cover crops protect the soil against erosive heavy rains and strong winds. Cover crops trap excess nitrogen, keeping it from leaching into groundwater or running off into surface water – releasing it later to feed growing crops.

Livestock Feed – Cover crops can provide livestock producers with additional grazing or haying opportunities.

Wildlife Habitat – Cover crops provide winter food and cover for birds and other wildlife. During the growing season, they can provide food for pollinators.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems allow farmers to enjoy profits because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions.

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unlock the SECRETS IN THE SOIL

If soil health is your goal, till as little as possible.

Tillage can destroy soil organic matter and structure along with the habitat that soil organisms need. Tillage, especially during warmer months, reduces water infiltration, increases runoff and can make the soil less productive. Tillage disrupts the soil's natural biological cycles, damages the structure of the soil, and makes soil more susceptible to erosion.

Benefits of Reduced-Till/No-Till

Aiding in Plant Growth – Soils managed with reduced/no-till for several years contain more organic matter and moisture for plant use. Healthy soils cycle crop nutrients, support root growth, absorb water and sequester carbon more efficiently.

Reducing Soil Erosion – Soil that is covered year-round with crops, crop residue, grass or cover crops is much less susceptible to erosion from wind and water. For cropping systems, practices like no-till keep soil undisturbed from harvest to planting.

Saving Money – Farmers can save money on fuel and labor by decreasing tillage. Improving nutrient cycling allows farmers to potentially reduce the amount of supplemental nutrients required to maintain yields, further reducing input costs.

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Providing Wildlife Habitat – Crop residue, grass and cover crops provide food and escape for wildlife.

Production Inputs

Soils can be disturbed if inputs are not applied properly, potentially disrupting the delicate relationship between plants and soil organisms. Soil Health Management Systems help minimize that potential disturbance, while maximizing nutrient cycling, which can lead to greater profitability for producers.

Livestock Grazing

Improperly managed grazing can disturb the soil. There are several ways to graze livestock to reduce environmental impacts. For example, implementing a rotational grazing system instead of allowing livestock to continuously graze pasture allows pasture plants to rest and regrow.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it.

Soil Health Management Systems allow farmers to enjoy profits over time because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions. Healthy soils also provide a buffer for precipitation extremes (too wet or too dry).

Contact your local NRCS office to learn more about Soil Health Management Systems and the technical and financial assistance available to help "Unlock the Secrets in the Soil."

SOIL ORGANIC MATTER: THE PASTURE'S TEMPERATURE GAUGE

February 2012 Hay & Forage Grower

Dennis Hancock, Forage Extension Specialist
The University of Georgia

On cold winter mornings, a close eye is kept on the old truck's temperature gauge. Everyone appreciates it when the cab warms up, and getting the fluids up to temperature also helps the engine smooth out and run at peak efficiency. There is an analogous gauge for a pasture's status: the soil organic matter (OM) level. Increasing the OM in your pastures' soil can even out its performance and ensure that it is functioning at peak efficiency.

Scientifically speaking, soil OM is a collective term that refers to the amount of carbon-based material in the soil. In a practical sense, however, soil OM quantifies the living component of the soil (i.e., roots, fungi, bacteria, earthworms, etc.).

Soils in a pasture are a site of much activity, albeit hard to see. Here, an earthworm navigates the root mass of annual ryegrass and arrowleaf clover plants under the remnants of a manure paddy.

Lately, there has been a renewed interest in the effects of management on soil OM levels in pastures, including lots of weblog commentary and discussions in various media outlets. Much of this interest is in the context of on-going drought stress, challenges to pasture productivity in response to climate change, and a resurgence of interest in alternative grazing methods. However, good graziers have known the benefits of increased soil OM for some time. Soils that are high in soil OM act as a sponge to hold more water, reduce soil density (compaction), have a higher cation exchange capacity, are more resistant to soil acidification by N fertilizers, have more stable soil temperatures, host more beneficial microorganisms, and provide a reservoir for the rhizobia that infect legume nodules and biologically fix N.

Scientists have also documented the benefits of pastoral land uses on soil OM. Research has shown that pastures in the Southeast, for example, had greater than 50% more soil OM on average than neighboring croplands. When croplands are converted into pastureland, the soil OM shows an almost immediate marked increase, usually by 0.1 to 0.2 percentage points per year in the first few years. It has also been shown that this rate of soil OM accumulation is sustained for the first 10 - 20 years following conversion. In soils converted from cropland to pasture in the Southeast, soil OM is estimated to increase to approximately 50% of its theoretical maximum within 10 years of conversion and up to ~80% of this maximum by year 25.

My colleagues and I at the University of Georgia have documented some of the highest rates of soil OM increase on record. We observed that soil OM levels increased by approximately 0.35 percentage points for each of the first 3 years when cotton and peanut

cropland was converted to a dairy practicing management-intensive grazing (Table 1). The increase from around 1% OM to over 2% in 3 years time was nearly unbelievable. Subsequently, we have confirmed this rate of change and have recently been examining which part of the forage system contributes the most to this change. We've also been evaluating how much of the OM buildup is due to the roots, plant litter, and animal manure by monitoring the radioisotope signatures of these sources of biomass as they decompose and become incorporated into the soil.

Table 1. Improvement in soil OM over three years (2007-2009) in three paddocks on a pasture-based dairy near Wrens, GA after conversion from cotton/peanut cropland.

Paddock	Initial	Year 1	Year 2	Year 3
	------ Soil Organic Matter, % ------			
Paddock 4	1.08	1.15	1.25	2.20
Paddock 8	1.01	1.17	1.59	2.18
Paddock 14	1.14	1.63	1.86	2.00
Avg.	1.07	1.32	1.57	2.13

Our preliminary results seem to indicate that the roots and root exudates are the major sources of soil OM improvements. These results support the findings of a consortium of American and European scientists in a recent review in the journal *Nature*. Their controversial report challenged the long-held belief that crop residues and biomass on the soil surface are the source of soil OM buildup.

The evidence is mounting for the conclusion that roots and root exudates are responsible for the majority of biologically-active soil OM. Whether large or small, the roots and the fungal mycelia that grow in association with them will thoroughly explore every nook and cranny of the soil, even the microscopic pores and crevices in the soil particle. Added to the root and fungal mass, there are root exudates (e.g., suberin) that lubricate and protect the roots as they slip through the soil and the sugars and protein that the roots exude to feed their fungal dance partners. Though these forms of carbon were once assumed labile and easily decomposed, current research is showing them to be incredibly resilient and stable, often residing in the soil for 30 to 50 years after their creation.

So, what does all this mean, and what does it matter? It shows that improvements in grazing management that focus on encouraging root development rather than accumulating plant litter is the mechanism that will provide the greatest improvements in soil OM. This means a focus on rotational grazing techniques is critical.

The root systems of pasture plants in continuously stocked pastures are short and shallow (Figure 1). These plants are commonly grazed every 2 to 7 days, on average. Rotationally stocked pastures allow pasture plants a recovery period that is long enough to promote a more robust root system to develop.

Soils in a pasture system have a distinct soil OM and soil health advantage over continuously cropped soils, but tremendous improvements over common, continuous grazing methods can still be had. Implementing advanced grazing management can make the pasture more resilient to drought and climatic stresses, as well as provide all the many other benefits of a rationally grazed system.

Figure 1. Bahiagrass plants subjected to simulated grazing by clipping to a 2 inch residual every 2, 7, or 21 days for a period of 3 months. Shoot growth represents 1 week's regrowth.

healthy, productive soils checklist for growers

unlock the SECRETS IN THE SOIL

Managing for soil health is one of the best ways farmers can increase crop productivity while improving the environment.

Results are often realized immediately and last well into the future. Following are four basic principles to improving the health of your soil.

1. Keep the soil covered as much as possible
2. Disturb the soil as little as possible
3. Keep plants growing throughout the year to feed the soil
4. Diversify as much as possible using crop rotation and cover crops

Use the checklist on the back of this page to determine if you're using core Soil Health Management System farming practices. It is important to note that not all practices are applicable to all crops. Some operations will benefit from just one soil health practice while others may require additional practices for maximum benefit. These core practices form the basis of a Soil Health Management System that can help you optimize your inputs, protect against drought, and increase production.

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Soil Health Management Systems Include:

What is it?		What does it do?	How does it help?
Conservation Crop Rotation Growing a diverse number of crops in a planned sequence to increase soil organic matter and biodiversity in the soil.		• Increases nutrient cycling • Manages plant pests (weeds, insects, and diseases) • Reduces sheet, rill and wind erosion • Holds soil moisture • Adds diversity so soil microbes can thrive	• Improves nutrient use efficiency • Decreases use of pesticides • Improves water quality • Conserves water • Improves plant production
Cover Crop An un-harvested crop grown as part of planned rotation to provide conservation benefits to the soil.		• Increases soil organic matter • Prevents soil erosion • Conserves soil moisture • Increases nutrient cycling • Provides nitrogen for plant use • Suppresses weeds • Reduces compaction	• Improves crop production • Improves water quality • Conserves water • Improves nutrient use efficiency • Decreases use of pesticides • Improves water efficiency to crops
No Till A way of growing crops without disturbing the soil through tillage.		• Improves water holding capacity of soil • Increases organic matter • Reduces soil erosion • Reduces energy use • Decreases compaction	• Improves water efficiency • Conserves water • Improves crop production • Improves water quality • Saves renewable resources • Improves air quality • Increases productivity
Mulch Tillage Using tillage methods where the soil surface is disturbed but maintains a high level of crop residue on the surface.		• Reduces soil erosion from wind and rain • Increases soil moisture for plants • Reduces energy use • Increases soil organic matter	• Improves water quality • Conserves water • Saves renewable resources • Improves air quality • Improves crop production
Mulching Applying plant residues or other suitable materials to the soil surface to compensate for loss of residue due to excessive tillage.		• Reduces erosion from wind and rain • Moderates soil temperatures • Increases soil organic matter • Controls weeds • Conserves soil moisture • Reduces dust	• Improves water quality • Improves plant productivity • Increases crop production • Reduces pesticide usage • Conserves water • Improves air quality
Nutrient Management Managing soil nutrients to meet crop needs while minimizing the impact on the environment and the soil.		• Increases plant nutrient uptake • Improves the physical, chemical and biological properties of the soil • Budgets, supplies, and conserves nutrients for plant production • Reduces odors and nitrogen emissions	• Improves water quality • Improves plant production • Improves air quality
Pest Management Managing pests by following an ecological approach that promotes the growth of healthy plants with strong defenses, while increasing stress on pests and enhancing the habitat for beneficial organisms.		• Reduces pesticide risks to water quality • Reduces threat of chemicals entering the air • Decreases pesticide risk to pollinators and other beneficial organisms • Increases soil organic matter	• Improves water quality • Improves air quality • Increases plant pollination • Increases plant productivity

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HEALTHY SOILS ARE: *covered all the time.*

Cover Saves Scarce Water

Extreme temperature changes and high winds characteristic of the semiarid, short-grass prairie of the the Great Plains can have drastic and devastating effects on exposed soil. In the High Plains sub-region of the Great Plains, more than 65 percent of the soil must remain covered to limit evaporation of water. Bare soil heats up quickly in direct sunlight; and the hotter it gets, the faster water evaporates from it.

In this rainfall-limited area (average annual rainfall is 10-20 inches), maintaining soil cover is a key to profitable agricultural production.

The combination of high winds and hot temperatures wastes water if soils aren't covered. However, ground cover (both living and residues) limits the drying effect of wind, shades the soil from hot sun, and traps snow during winter. All of which add up to more water infiltrating into the soil and less evaporating into the air.

unlock the SECRETS IN THE SOIL

IF YOU'RE TRYING TO MAKE YOUR SOIL HEALTHIER, YOU SHOULDN'T SEE IT VERY OFTEN.

In other words, soil should always be covered by growing plants, their residues, or a combination of the two. Keeping the soil covered all the time makes perfect sense when you realize that healthy soils are full of life and that the microorganisms living in the soil have the same needs as other living creatures. They need food and cover to survive.

When you have a vegetative cover on the soil, especially a living cover, you offer those microbes both food and shelter. Some scientists say when you till the soil and remove crop residues, the effects are as devastating to soil microbes as a combination of an earthquake, hurricane, tornado, and forest fire would be to humans. From the perspective of the living creatures within the soil, a tillage tool like a chisel shank has the effect of ripping the ground like an earthquake; removing residue is like a tornado ripping the roof off a house; uncovered soil can be drenched and whisked away by gushing water and wind like that of a hurricane—or scorched in the hot sun like an out-of-control fire.

STOP THE SPLASH, HARVEST THE BENEFITS

When a falling raindrop explodes as it hits bare soil, it dislodges unprotected soil particles, and begins the process of soil erosion. Cover crops and plant residue prevent that violent splash on soil, protecting soil aggregates from being pounded by falling raindrops.

Safe from disintegration by the hammering energy of raindrops, the structure of healthy soils remains intact, which prevents soil crusting. In this protective environment, water infiltrates the soil and becomes available to plant roots.

A mulch of crop residues or living plants on the soil surface also suppresses weeds early in the growing season, giving the primary crop a competitive

HEALTHY SOILS ARE: *covered all the time.*

advantage. This is especially the case if the cover crop is rolled prior to planting the main crop because the entire soil surface is covered and protected.

Cover crops can build moisture reserves far better than row crops can by themselves. Cover crops open pores and small channels in the soil for better water infiltration, and the organic matter they build helps retain both moisture and nutrients.

The cool, moist soil of cover crops also provides favorable habitat for many organisms that decompose residues and recycle nutrients for the next crop. Providing a good habitat for these organisms can increase residue decomposition, and improve nutrient cycling, by up to 25 percent.

LIVING PLANTS GO BEYOND COVER

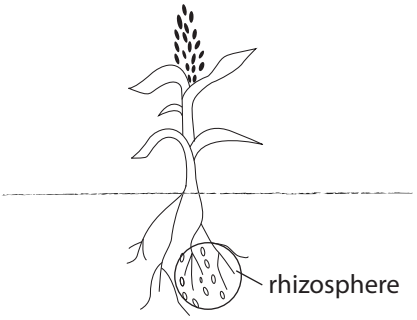
While it's easy to see the importance of giving the soil protection above the ground, it's not always as easy to recognize benefits living covers provide below the surface.

Through their roots, living plants offer soil microbes their easiest, most reliable food source. Because these soil microbes need a consistent food source throughout the year to thrive, cropping plans that include crop rotations with cover crops throughout the growing season (or perennial grasses and legumes) can help sustain them year-round.

WANT TO LEARN MORE?

VISIT WWW.NRCS.USDA.GOV

Living in the Rhizosphere



Every soil organism has something it eats…and something that eats it. Each organism and each bit of plant residue is important to the complex food web under the soil surface. While each source of microbial food is important to a balanced food web in a healthy soil, there is no better food for soil microbes than the sugars exuded by living roots.

Living plants maintain a rhizosphere, an area of concentrated microbial activity close to the root. The rhizosphere is the most active part of the soil biology because it is where the most easy-to-eat food is available for microbes. It's also critical for plant growth and health, because those microbes, in turn, provide essential nutrient cycling for crops.

Because living roots provide the easiest source of food for soil microbes, growing perennial crops or long-season cover crops is the key to feeding the foundational species of the soil food web—so they'll be healthy and ready to perform throughout the primary growing season.

USDA

HEALTHY SOILS ARE: *well-structured.*

Give it the Stake Test!

Does your soil have good structure? Give it the slake test! Ray Archuleta, an agronomist with the USDA Natural Resources Conservation Service with a passion for soil health, has done the test scores of times. Anyone can do it, he says, and he predicts it will open your eyes.

"What happens with poor soil structure is that the pores collapse in water and the soil breaks apart," Archuleta says. "Soil with good structure—the untilled soil—can still be intact for the most part even 24 hours later. The reason for the difference is soil structure. Biological cementing, the work of soil microbes, glues the aggregates of the untilled soils together."

In a similar test, an infiltration or rainfall simulation test, Archuleta puts the two soil samples in wire mesh inserted into empty jars, then simulates rainfall onto them.

"When you put a tilled soil and an un-tilled soil in yarn jars and simulate rainfall onto them, you quickly see the untilled soil allows the water to infiltrate the whole profile. On the other hand, water stays on top of the tilled soil much longer," Archuleta says.

Continued on back

unlock the SECRETS IN THE SOIL

"SOFT AND CRUMBLY." "LIKE COTTAGE CHEESE." "LIKE A SPONGE." "LOOSE AND FULL OF HOLES."

Those and other common descriptions of what healthy soil looks and feels like refer to good soil structure.

Soil structure, the arrangement of the solid parts of the soil and the pore space between them, is critical to how the soil functions. When the solid parts—sand, silt and clay particles—cling together as coarse, granular aggregates, the soil has a good balance of solid parts and pore space.

Highly aggregated soils—those granular, durable, distinct aggregates in the topsoil that leave large pore spaces between them—are soils with good tilth and good structure.

Well-structured soils have both macropores (large soil pores generally greater than 0.08 mm in diameter) and micropores (small soil pores with diameters less than 0.08 mm that are usually found within structural aggregates).

An interconnected network of pores associated with loosely packed, crumbly, highly aggregated soils allows rapid infiltration and easy movement of both water and air through the soil and provides habitat for soil organisms.

Chemical and physical factors play a prominent role in small aggregate formation in clay soils, while biological processes drive development of large aggregates and macropores. Earthworms, for instance, produce both new aggregates and pores. Their binding agents are responsible for the formation of water-stable, macro-aggregates, and their burrowing creates continuous pores linking surface to subsurface soil layers. As they feed, earthworms also speed plant residue decomposition, nutrient cycling, and redistribution of nutrients in the soil profile.

HEALTHY SOILS ARE: *covered all the time.*

Soil organic matter also helps develop stable soil aggregates. Soil microorganisms that are fed with organic matter secrete a gooey protein called glomalin, an effective short-term cementing agent for large aggregates. Organic glues are produced by fungi and bacteria as they decompose plant residues. Water-resistant substances produced by microorganisms, roots, and other organic matter, provide long-term aggregate stability from a few months to a few years.

TILAGE DESTROYS STRUCTURE

Management practices that reduce soil cover, disrupt continuous pore space, compact soil, or reduce soil organic matter, negatively impact soil structure. Since tillage negatively affects all of these properties, it's high on the list of practices damaging to healthy soils.

When tillage loosens the soil, it leaves soil particles exposed to the forces of wind and water. Transported by wind and water, detached soil particles settle into pores, causing surface sealing, compaction and reduced infiltration. When this happens less water is available to plants and runoff and erosion increases.

By contrast, soils that are not tilled and are covered with diverse, high residue crops throughout the year have better soil structure, are highly aggregated, with high levels of organic matter and microorganism activity, high water holding capacity, high infiltration rates, and little compaction.

WANT TO LEARN MORE?

VISIT WWW.NRCS.USDA.GOV

"I think these tests are powerful visual tools to help explain and help people remember how soils function" Archuleta continues. "I used to think if I tilled the soil—fluffed it up—it would allow more water in. But that's just not true. Tilling soil closes pore space and keeps rainfall from infiltrating. You've got to have pore space in your soil from top to bottom."

"The tests tell me in our watersheds we have an infiltration problem, not a runoff problem," he concludes. "What I mean is, if we focus on building healthy soils that result in more infiltration, we'll do what we need to do to eliminate much of the runoff."

How to do the Slake Test

The slake test compares two chunks of topsoil in water to see how well and how long they will hold together. Here are the steps:

1. Collect a chunk of topsoil—a size that would fit in your hand—from an area where you don't till, like a fencerow, or a field you've no-tilled or had in grass for many years.
2. Get a second spade-full or chunk of soil from a field you've tilled consistently. It should be the same soil type as the first sample.
3. Find two glass jars, yarn jars or some kind of clear glass jars large enough to hold the chunks of soil.
4. Put together some type of wire mesh that you can hook at the top of each jar that will allow the soil to be submerged in the water, yet be held within the top half of the jar.
5. Insert the wire meshes into each jar.
6. Fill the jars with water.
7. At the same time, submerge the tilled sample in one jar, and the untilled sample in the other.
8. Watch to see which soil holds together and which one falls apart. The soil with poor structure is the one that will begin to fall apart.

If you want to see "Ray the Soil Guy" demonstrate the test or the infiltration test, checkout our online resources.

Managing pasture and range soil health

www.progressiveforage.com/forage-production/management/managing-pasture-and-range-soil-health

As world population and demand for food rise, keeping soil healthy and productive is of paramount importance.

That's why a growing number of American farmers and ranchers adopt soil health management systems to improve the health and function of their soil, which is not only good for the land but the farm or ranch, too.

Soil health is the capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans.

The soil operates as a vital, living ecosystem that is teeming with billions of bacteria, fungi and other microbes in a symbiotic relationship with plant communities and crops that are the foundation for agriculture.

"By the year 2050, an estimated nine billion people will join us at Earth's dinner table, meaning we'll have to grow as much food in the next 40 years as we have in the past 500 on even fewer acres of land," says USDA's Natural Resources Conservation Service Grazing Lands Specialist Kevin Ogles.

"Improving soil health increases the productivity and function of our soil, which offers increased food security in a growing world."

Soil properties like depth and texture are not easily changed. But dynamic soil properties such as organic matter, structure and water-holding capacity can be changed based on how the site is managed.

Collectively, these soil properties determine how well the soil functions in supporting plants and animals.

NRCS offers conservation practices that help farmers and ranchers improve these soil properties, such as:

- Improving soil health
- Increasing organic matter
- Reducing soil compaction
- Improving storage and cycling of nutrients
- Increasing water infiltration
- Increasing water available to plants

Have you considered the soil health for range and pasture on your farm or ranch? This article covers the science of healthy soils and how they can benefit agricultural operations.

Building blocks of the land: soil aggregates
Soil aggregates are the basis for movement of air, water and plant nutrients through the soil profile.

They are groupings of soil particles bound together by glomalin, or “soil glue,” produced when soil biota break down dead, underground plant materials and old roots.

Small soil aggregates are bound together into larger aggregates, the structural arrangement of which allows water and air to move into the soil profile.

Optimizing live vegetation and litter or plant residue is typically the key to maintaining healthy soil aggregates and aggregate formation.

Conversely, high levels of disturbance tend to degrade the soil structure, which blocks the movement of needed moisture and air and diminishes root penetration.

Increasing organic matter
Soil organic matter is a carbon-rich material that includes plant, animal and microbial residue in various stages of decomposition.

Live soil organisms and plant roots are part of the carbon pool in soil but are not considered soil organic matter until they die and begin to decay.

Roots are the primary source of organic matter. Dead roots and gelatinous materials exuded by plant roots as they grow through the soil are decomposed by soil organisms and converted into organic matter.

Every year, a significant percentage of total root biomass dies and becomes available for incorporation into the soil as organic matter.

One percent of organic matter in the top 6 inches of soil can hold as much as 25,000 gallons of water per acre. Increasing organic matter increases the holding capacity for water, making your land more resilient to extreme weather including periods of drought.

A robust root system is developed when a productive plant community on the surface of the soil assimilates nutrients and processes energy from the sun through photosynthesis.

The roots of forbs and shrubs generally contribute less organic matter to the surface layer of the soil than the roots of grasses, so changes in the composition of plant species have an effect on the organic matter in the soil.

Maintaining a productive plant community on the surface of the soil through judicious grazing management is a

major key to maintaining or building soil organic matter.

Reducing erosion
Wind and water erosion take their toll on the long-term soil health in rangeland and pastureland. Topsoil has the greatest amount of organic matter, biological activity and nutrients in the soil profile and is the most susceptible to the effects of weather.

The loss of topsoil diminishes the productive nature of a landscape by breaking down the soil structure, exposing organic matter to decomposition and loss. Plant communities then often shift to less desirable plants, such as from grass to shrub species.

Sediment removed by erosion can also bury plants and roads, accumulate in streams, rivers and reservoirs and degrade water quality.

Some management strategies to minimize wind and water erosion may include:

1. Maintaining/increasing the cover of plants or litter on the soil through the application of good rangeland and pastureland management practices

2. Reducing soil surface disturbances

3. Minimizing grazing and traffic when the soil is wet and thus preventing reduced infiltration caused by compaction

4. Building water bars that direct flow from roads, trails or vehicle tracks across the slope or into existing drainage ways

Reducing compaction
Soil compaction occurs when moist or wet soil aggregates are pressed together and the pore space between them is reduced.

Wet soils do not have the same weight-holding capacity as a soil with normal moisture content or dry soil.

Compaction changes soil structure, reducing the size and continuity of pores, and increases soil density. Compaction usually does not happen all at once but over time.

Pressure exerted on the soil surface by animals, vehicles and people can cause soil compaction.

Compaction limits water infiltration at the surface causing increased run-off and, in some areas, increased erosion.

When the amount of water that enters the soil is reduced, less water is available for plant growth and less moves deeper in the soil profile for later use. This is especially detrimental in years with low precipitation.

Pastures grown on compacted soils with fewer pore spaces will start growth later in the spring and stop growth earlier in both the hot summer months and cool autumn months.

With limited oxygen, plants not adapted to anaerobic conditions will either not persist or will not produce very well.

Roots help to break up compacted layers by forcing their way between soil particles and are the best route to recovery.

Plants with large taproots are more effective at penetrating and loosening deep compacted layers, while fibrous root systems can break up compacted layers near the surface and eventually work their way down deeper.

Large soil organisms, such as earthworms and anthropods, also move soil particles as they burrow through the soil.

Good strategies for addressing soil compaction include:

1. Minimizing heavy use of pastures when soils are wet

2. Moving hay bales in place during dry or frozen conditions

3. Improving or maintaining plant cover and plant production by incorporating longer rest periods that allow for deeper root growth and penetration, and over time, increased organic matter

4. Leaving more stubble height (grass that remains when moving to the next pasture) in your grazing rotation.

You should generally leave 4 inches for most cool-season forages and 8 inches for warm-season forages, but this will vary some by region and forage species.

Holding water on the land
Infiltration rate is the rate at which soil is able to absorb rainfall or irrigation. Higher infiltration rates allow precipitation to enter the soil profile rapidly, thereby reducing run-off and increasing the opportunity for plants to capitalize on that precipitation.

Infiltration is affected by soil compaction, soil texture, soil structure, soil crusts and above-ground biomass.

Greater productivity can be achieved on pasturelands by managing plant cover and biomass through maintaining optimum plant stubble heights.

By keeping run-off and soil evaporation to a minimum, more water is available for plant growth. The benefits of maintaining proper stubble height of your forage species are rewarded by more available water for plant growth.

“When more available water is stored in the soil profile, grasses and legumes will grow longer during dry weather, more forage will be produced, and the moisture balance is maintained so soil micro-organisms can continue to decompose litter and cycle nutrients,” Ogles says.

The right nutrients
Plant nutrients are used by plants for growth. Uniform nutrient distribution, efficient nutrient cycling and increased soil organic matter can contribute to a reduced need for supplemental fertilizer when soil health on range and pasture is optimized.

Most manure is deposited close to water, shade and feed areas. Strategically locating these areas or managing access to these areas can positively affect manure distribution. Rotational grazing also distributes animal waste on the landscape for optimal nutrient cycling.

Plant diversity
A more diverse plant community can often provide benefits to the landscape and help in maintaining soil health on

range and pasture.

Different species of plants in grasslands have different growth forms, both above-ground and below-ground.

Forbs, grasses or shrubs can be perennial, annual, bunchgrass, sod-former, rhizomatous, cool-season or warm-season. These different growth forms often complement each other, allowing for the diverse plant community to more effectively occupy the site.

A diverse plant community may help break up disease cycles and guard against weed invasion. In addition, livestock can eat more forage when complementary plants are available.

When poisonous plants are present, other forage is available, so there is a higher potential for the poisonous plants to be avoided.

“One of the goals of conservation programs offered by the NRCS is to improve the landowner’s soil health,” says NRCS Rangeland Management Specialist Gene Fults.

“Healthy soil is more resilient to erosion and better able to store water through extended drought periods.

“By restoring the health and function of our soil, we can transform production agriculture and make our farms more productive, profitable, resilient and better prepared to meet the challenges of the 21st century,” Fults adds. ***FG***

Ciji Taylor is a public affairs specialist with the USDA’s Natural Resources Conservation Service.

To get started with NRCS, visit your local USDA Service Center.

PHOTOS
PHOTO 1: Earthworms and other soil-dwelling invertebrates contribute to soil porosity and soil structure development and maintenance.

PHOTO 2: Well-managed forages with proper stocking and rotational grazing exhibit more robust root systems that help sustain pastures through drought.

PHOTO 3: Soil structure is developed and maintained through grazing management that incorporates rest periods during the growing season for plant recovery. *Photos courtesy of Ciji Taylor.*

Appendix

THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

What is Management-intensive Grazing (MiG) and what can it do for my farm?

Dr. Dennis Hancock
Extension Forage Specialist
University of Georgia

Dr. John Andrae
Extension Forage Specialist
Clemson University

Management-intensive grazing (MiG; sometimes called "rotational grazing") is a topic frequently discussed among forage producers. Many testimonials have been made regarding the benefits of MiG. Some claim that simply implementing a MiG system will allow doubling or even tripling stocking rates and total elimination of fertilizer inputs. These claims rarely are truly realized; however, MiG does offer substantial benefits to forage-based livestock producers. Benefits include improved animal productivity, increased plant persistence, conservation of environmental resources, and improved animal temperament. This article will serve as a general overview of MiG and examples are taken in part from Southern Forages 4th Edition and a large three year grazing study conducted by Drs. Carl Hoveland, Mark McCann, and Nick Hill at the University of Georgia.

What is MiG?

MiG is any grazing method that utilizes repeating periods of grazing and rest among two or more paddocks or pastures. "Rotational grazing" is commonly used as a general term and there are many other terms used by producers and scientists for MiG. A few of these include **rotational grazing, managed grazing, intensive grazing, rational grazing, controlled grazing,** and **rotational stocking**. However, MiG is a preferred description because it places emphasis on the "management" aspects of improved grazing systems.

Several methods of MiG grazing are used, including **rotational stocking, buffer grazing, strip grazing, creep grazing, deferred grazing, limit grazing, first-last grazing, mixed species grazing, sequence grazing,** and **frontal grazing**. Each of these methods will have specific situations where they are best applied. For example, limit grazing is an excellent practice for improving utilization of winter annual forages by mature beef cows, rotational stocking is beneficial when stocker cattle graze winter annuals or paddocks containing clovers, and creep grazing can be used to improve calf weaning weights on bermudagrass pastures. Some grazing methods can be combined for further flexibility. **Deferred grazing** allows the stockpiling of forage (e.g., stockpiled tall fescue or bermudagrass), and this stockpiled forage can be efficiently grazed later in the season using either **frontal** or **strip grazing** systems. More information on these terms can be found in a related factsheet entitled "Common Grazing Methods and Some Specific Farm Applications" (http://www.caes.uga.edu/commodities/fieldcrops/forages/questions/023FAQ-grazmethods.pdf).

For simplicity, further discussion in this article will use the more general term "MiG" since it encompasses all of these improved grazing methods. The principles discussed herein can be applied to each of these grazing methods and the impact they generally have on animal requirements, plant needs, and environmental conditions (drought, muddy soils, stream protection etc.).

Why Should I Implement MiG?

Forages are often inefficiently utilized when pastures are continuously stocked. Many times grazing animals will only utilize 30-40% of the forage in a pasture with the rest refused or wasted. There are many reasons for this waste. The grazing herd, like people, is typically lazy and will heavily graze areas close to shade

or water and ignore more distant areas. Animals also prefer young, tender, and leafy portions of forages and refuse stemmy mature material when allowed a choice. When there is an excessive amount of forage present, the grazing animal frequently returns to grazed areas to utilized fresh regrowth and refuse large amounts of previously ungrazed forage because it is too "tough".

Effects on Animal Performance

Many times the benefits of implementing MiG are exaggerated. Claims of doubling or even tripling stocking rate are sometimes made. Don't believe these claims! It is certainly possible to increase stocking rate and decrease hay and fertilizer inputs using MiG. Stocking rate increases of 35-60% have been reported in the scientific literature (Table 1). However, as a general rule, stocking rates should only be increased by 10-25% during the first few years, so as to allow your pastures and forage management skills to improve. In the meantime, any excess forage production can be harvested as hay or mowed and returned to the soil.

Table 1. Increase in gain per acre in rotational compared to continuous grazing.

State	% Increase
Arkansas	44
Georgia	37
Oklahoma	35
Virginia	61

There are situations where MiG is not particularly helpful from an animal performance perspective. Forcing the grazing animal to consume forage to a predetermined height eliminates their ability to select high quality leaves and often reduces individual animal performance (daily gain per head). This is particularly important when animals with high nutrient requirements like stocker cattle or replacement heifers are rotationally grazed on relatively low-quality forages, such as bermudagrass or bahiagrass. Remember that although individual animal performance is reduced, it is possible to increase stocking rate resulting in higher gain per acre. For producers grazing animals with lower nutrient requirements, like mature cows, this can be a great advantage. In a three year study conducted in central Georgia, rotational stocking improved cow-calf stocking rate by about 38% and improved calf production per acre by 37%. Individual cow or calf performance was not affected in this study (Table 2).

Table 2. Effects of rotational stocking on performance of beef cattle grazing bermudagrass and endophyte-free tall fescue in central Georgia.

Item	Continuous	Rotational	Difference*
Cow weight at calving, lbs	1037	1017	NS
Cow weight at weaning, lbs	1090	1071	NS
Stocking rate, cows/acre	0.5	0.69	+38%
Pregnancy rate, %	93	95	NS
Weaning weight, lb	490	486	NS
Calf production, lb/ac	243	334	+37%

* NS = not statistically significant

Effects on Plant Persistence

While increased animal production per acre is often what sells producers on a MiG system, plant performance is also improved. Many plants respond well to short grazing and long rest periods. Rest periods allow plants to produce new leaves which collect energy, transform it into sugars, and store these sugars so that more leaves can be produced following the next grazing cycle. Not only is regrowth potential improved, but root depth and stand life are improved as well.

Practicing controlled grazing also decreases the amount of trampling and pugging (hoof damage) of plants and soils (particularly on wet prepared fields). This can improve productivity and persistence of forages.

Under MiG in the central Georgia study conducted by Hoveland and others, endophyte-free tall fescue productivity and persistence was greatly improved. This resulted in less hay feeding in the rotational stocked system (Table 3). In fact, over the three year grazing study, cattle in the rotationally stocked system required

31% less hay per head. If this hay were priced at $110 per dry ton, an annual average savings of $41.30 per cow would be realized for each of the three years. Reductions in supplement costs and labor for feeding hay would also add to the advantage of MiG.

Table 3. Pounds of winter hay fed per cow as affected by grazing method during three year study. Cows grazed bermudagrass/endophyte-free tall fescue mixture. (From Hoveland. McCann and Hill. 1997).

	1988-1989	1989-1990	1990-1991	3-year Average
Rotational	1310	1480	2240	1680
Continuous	1750	1900	3650	2430
Decrease, %	-25%	-22%	-39%	-31%

MiG systems can also improve legume establishment and persistence. Clover can be broadcast seeded and trampled in by animals grazing small paddocks in late winter. MiG also allows flash grazing of paddocks to prevent small legume seedlings from grass shading. After clovers are established, the improved grazing control allows producers to favor clover regrowth.

Intangible effects

There are many benefits of practicing MiG that are difficult to quantify. Notice that the scope of this article's subtitle "What can it do for my farm?" is much larger than merely animal performance. Two of the most important benefits MiG offers your farm are 1) improved control and 2) improved flexibility.

Control: Cross fencing and water developments in large pastures effectively transfer the grazing decisions from the grazing animal to the farm manager. Before a pasture is cross-fenced, the grazing animals determine 1) where they want to eat, 2) what they want to eat or (more importantly) what they will refuse to eat, 3) how long they will eat, and 4) how often they will return to eat. Once cross-fences are erected the farm manager controls how many animals graze a set amount of acres for a set amount of time. Once available forage has been efficiently utilized, animals are allowed to move to another paddock and cannot return until forage is ready for another grazing.

Flexibility: Producers soon realize that there is no "set" schedule for rotating pastures and that the length of rest and grazing periods will change with weather and forage growth rate. This added flexibility is an often overlooked advantage to practicing MiG. Paddocks can be removed from the rotation for overseeding or complete stand renovation. Individual paddocks can also be skipped during times of rapid growth and stockpiled for later grazing or hay harvest. Low-lying paddocks with drainage problems can be left ungrazed during wet periods to minimize trampling injury and improve stand productivity and longevity.

Summary

Practicing MiG offers many advantages for most producers. Less forage is wasted by animals, which normally allows stocking density to increase. MiG systems also improve the persistence of some forage species and can greatly decrease hay requirements when managed appropriately. Recent fencing and watering equipment developments have made grazing systems easier and cheaper to implement. These advances have "opened the door" for many producers to adopt improved grazing management practices. Other reasons for implementing grazing systems include improved nutrient distribution and environmental stewardship. Animal handling is also usually improved with MiG systems. Frequent movement and exposure to people usually improves animal temperament. This frequent exposure also allows the farm manager to detect diseases or other problems quicker so that they can be treated in a timely manner.

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J. Scott Angle, Dean and Director.

AGRONOMY AND SOILS SERIES

TIMELY INFORMATION
Agriculture & Natural Resources

F 2014-5 Sept. 2014

A Quick Guide to Grazing Methods

Jennifer M. Johnson, Ph.D, Extension Agronomist, Alabama Cooperative Extension System
Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Grazing System – "any integrated combination of animal, plant, and other environmental components and the ***grazing method*** by which the system is managed to meet specific results or goals"

Grazing Method – "a defined procedure or technique of grazing management designed to achieve a specific objective.

There's no "one size fits all" method for all farms, each method is farm/situation specific. Several methods may be used on a farm in different pastures or a different time in a given pasture.

Grazing Management – Goals and Objectives:

When grazing management occurs through the implementation of grazing methods within a grazing system a number of goals and objectives can be achieved successfully.

Goals:

1. Improved Grazing Efficiency
2. Reduce Pasture Waste
3. Conserve Surplus Forage (hay, silage)
4. Increased Animal Performance
5. Improved Forage Quality at time of use

Objectives:

1. To manage the pasture and other feed inputs to efficiently produce animal products.
2. To effectively manage ***forage quantity*** and ***quality*** over the grazing season, regardless of grazing method utilized.
3. To adjusting livestock stocking rates to improve grazing efficiency and animal production per unit of land

Grazing Efficiency is an Effect of Management

Grazing Method	Estimated Typical Efficiency
Continuous Stocking	**30-40%**
Slow Rotation (3-4 paddocks)	**50-60%**
Moderate Rotation (6-8 paddocks)	**60-70%**
Strip Grazing	**70-80%**

Grazing Management Good Rules of Thumb:

- There is no "one size fits all" grazing method
- Each operation has unique circumstances that weigh into grazing management decisions
- Carefully consider the individual goals and needs of your operation
- *All* of the systems require management skills and inputs

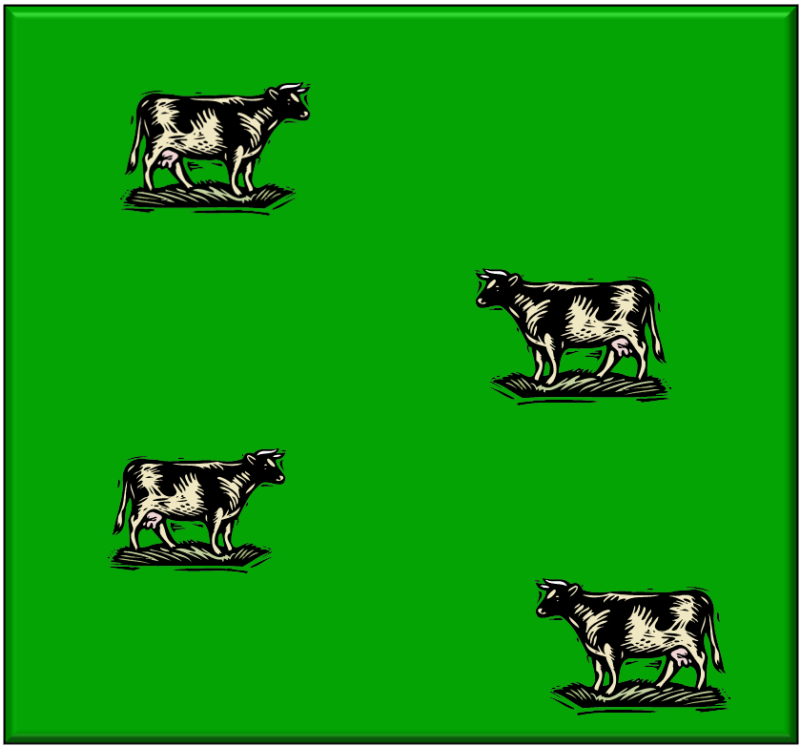
Match the Grazing Method with:

The Plant, The Animal, and the Producer Needs

To Implement a Successful Grazing System!

Prepared by: Jennifer M. Johnson, Ph.D, Extension Agronomist and Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Continuous stocking



Pros and Cons

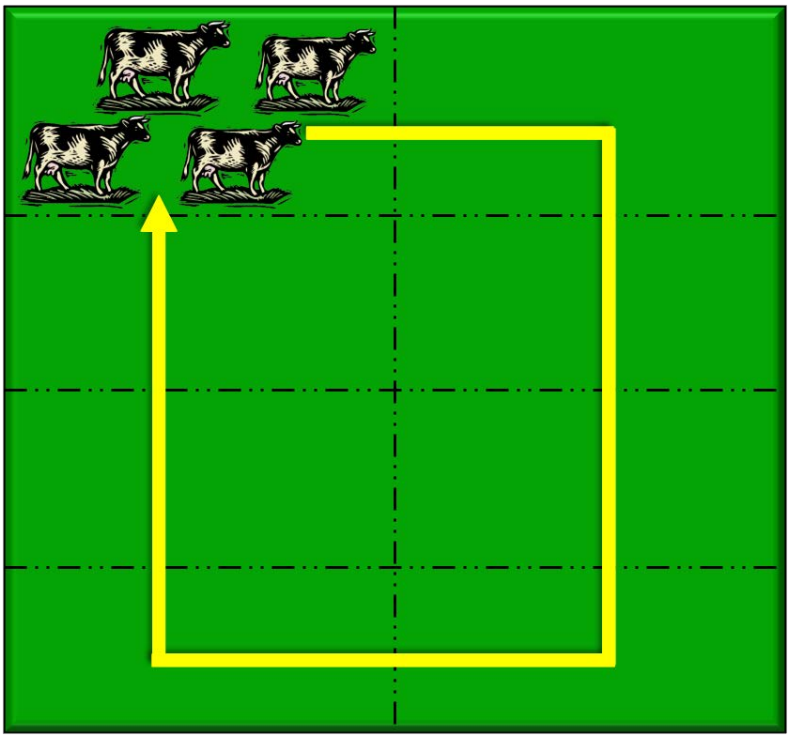
- Simple, most commonly used in Alabama
- Animals stocked on single pasture unit for the duration of grazing season.
- Animals are allowed to selectively graze
- Can result in high animal performance of individual animals, but low overall performance of herd
- May to lead to overstocking, overgrazing, and lower forage production
- Least efficient of all grazing methods

Level of Labor: Low

Good Rule of Thumb: A continuously stocked pasture can be just as productive and efficient as any other method provided that available forage is controlled by adjusting stock numbers as needed.

Prepared by: Jennifer M. Johnson, Ph.D, Extension Agronomist and Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Rotational stocking



Pros and Cons

- A grazing method in which the grazed area is divided into a given number of smaller paddocks.
- Animals will graze plants to a desired height before “rotating” to a new paddock
- Expected outcome: potential increased uniform utilization of forage species compared to continuous stocking
- Rotations can occur anytime but are typically between 1 and 15 days during active forage growth
- There are no specifications for the number of paddocks required – alternating between 2 paddocks is still rotational stocking.
- Effective rotational stocking involves focusing on forage quality and utilization

Level of Labor: Ranges from low to high depending on the number of paddocks

Good Rule of Thumb: The more paddocks you have, the shorter the grazing period in each particular paddock.

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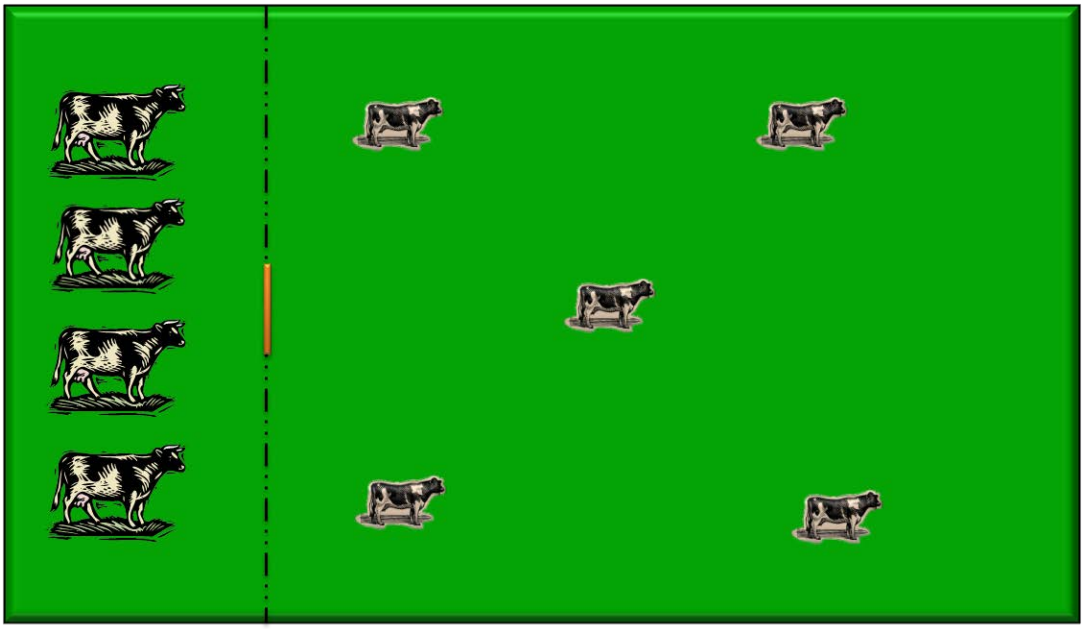
Creep Grazing



Pros and Cons

- Allows young animals with high nutrient requirements access to higher quality forages first
- Access to these paddocks provided either underneath electric fence or through a creep opening
- Dams maintained on traditional base forages
- Excellent potential to improve weaning weights of calves in Alabama

Level of Labor: Low to Medium

Good Rule of Thumb: When using temporary fencing for rotational stocking, place fence height at level to confine dams.

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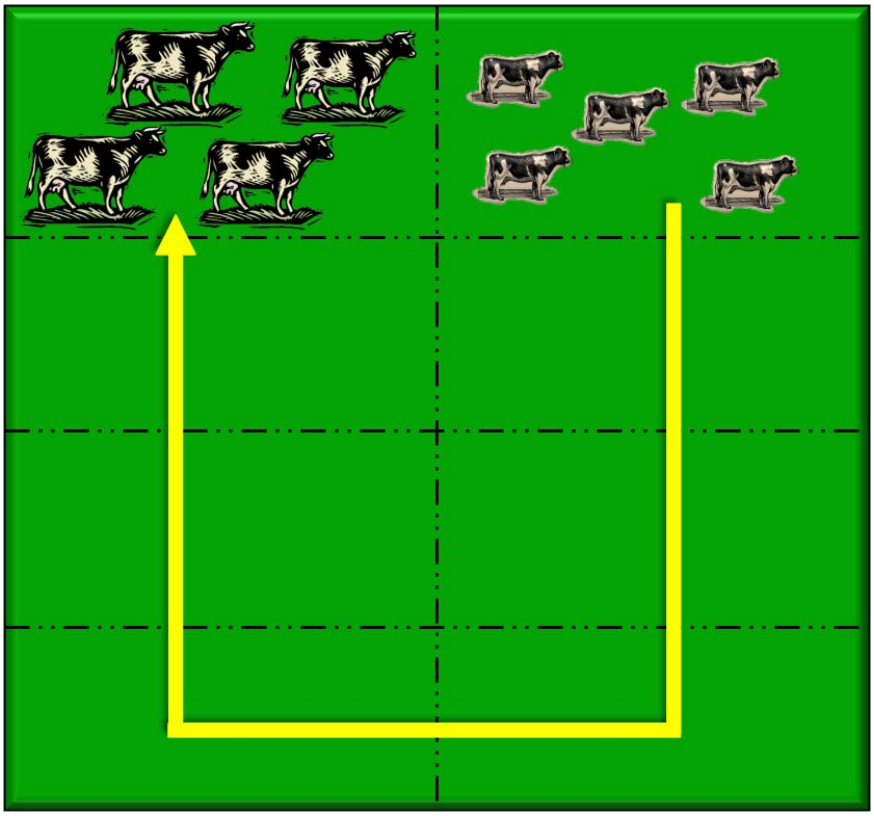
Leader-Follower/ First-Last Grazing



Pros and Cons

- Herd is sorted into nutrient requirement groups.
- The higher nutrient requirement group (leader/first) is rotated through paddocks before the low nutrient group, allowing them to select high quality forage to meet growth or production needs.
- The follower group then grazes the remaining lower quality forage and rotation off paddock allows for rest and regrowth for continued rotation
- Allows animals which need the highest quality feed (i.e. calves, yearlings, lactating dairy cows, etc.) to have first access to a pasture or feed source

Level of Labor: Medium

Good Rule of Thumb: In Stocker and Dairy Operations.

Stocker: Growing calves grazing in-front of cow/calf pairs.

Dairy: Usually two or three groups (Lactating cows lead, calves and dry cows follow).

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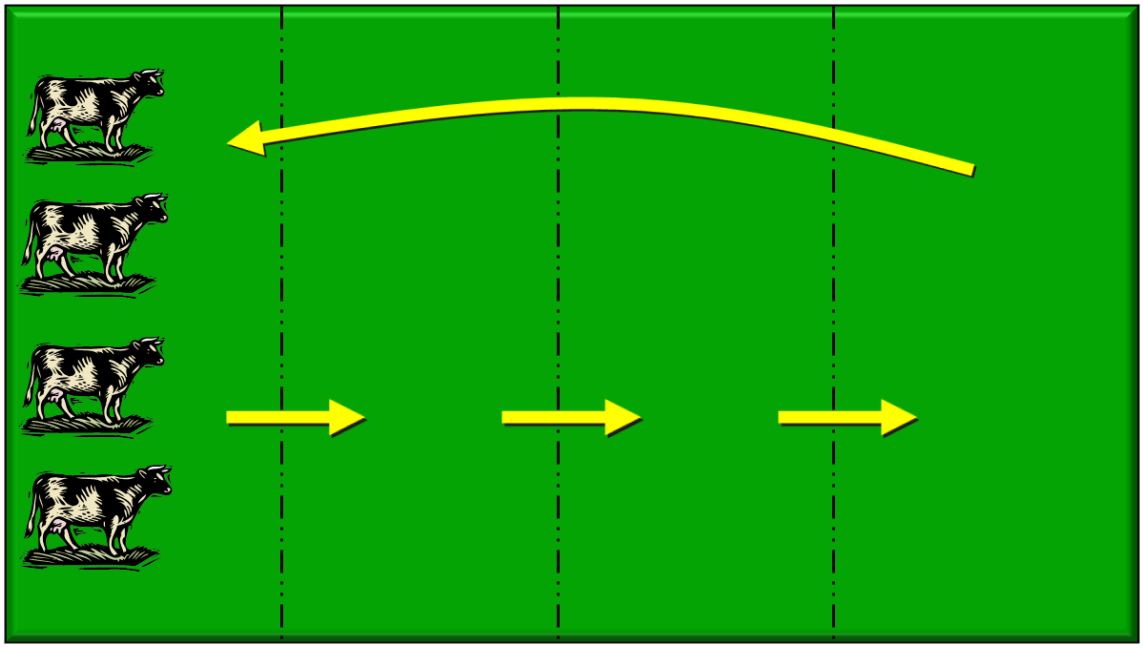
Strip Stocking (Strip Grazing)



Pros and Cons

- Self-descriptive form of rotational stocking
- Animals are held in small areas (strips) by a temporary electric fence and normally graze a one or two day forage supply
- Once this area is grazed, the front fence is moved allowing them access to another small area of forage
- Back-wire may or may not be used in this situation to limit access to previously grazed area and allow for regrowth?
- Most efficient grazing method for forage utilization
- With low quality forage average daily gains may be lower due to less selective grazing

Common Forages Used: Annual Grasses

Level of Labor required: Medium to High

Good Rule of Thumb: Once animals are adapted to the system, they may linger at the fence as forage is grazed down…a sign to tell you it's time to move them!

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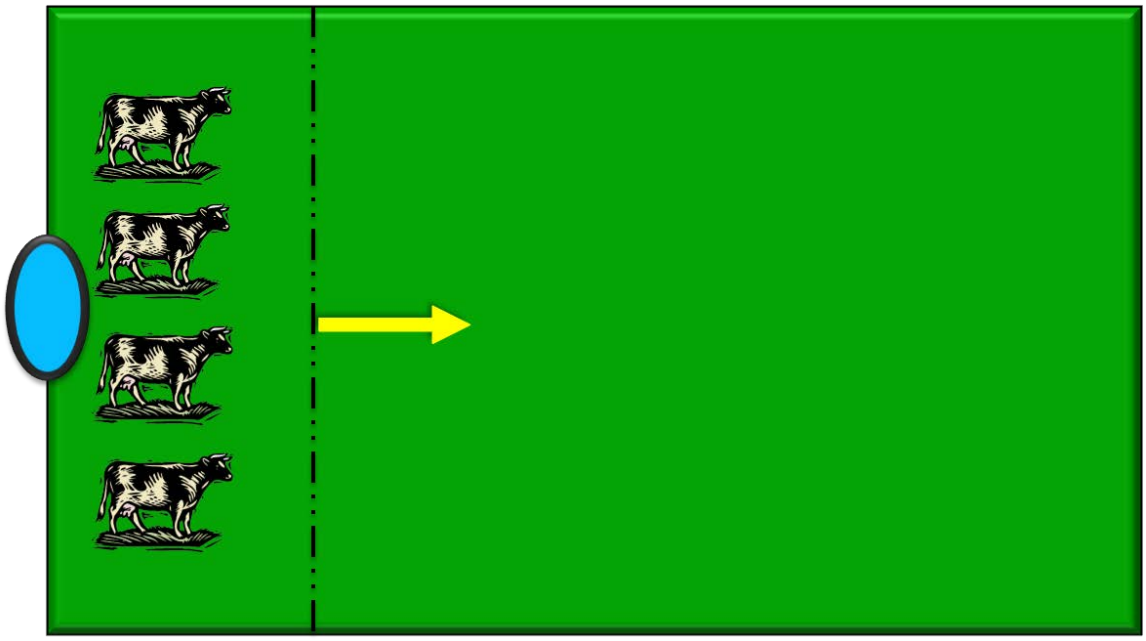
Forward/Frontal Grazing



Pros and Cons

- Most commonly used when stockpiling forage or grazing crop residues
    - Stockpiling: Deferred use of a forage until a later time when available forage is often limited (i.e. Late Fall/Winter)
- Much like "Strip" grazing, except forage is often in a dormant stage therefore no need to limit access to previously grazed area
- Allow access to area closest to available water first, and then move fence away from water as forage is grazed down to a given level
- Typically only allow access to enough forage to sustain the herd for 2 to 3 days

Common Forages Used: Tall Fescue, Bermudagrass

Level of Labor required: Medium

Good Rule of Thumb: Remember to focus on forage quality – accumulated forage that is overly mature is NOT stockpiling – Stockpiling typically occurs 4 to 6 weeks before first anticipated killing frost which induces dormancy of many perennial species.

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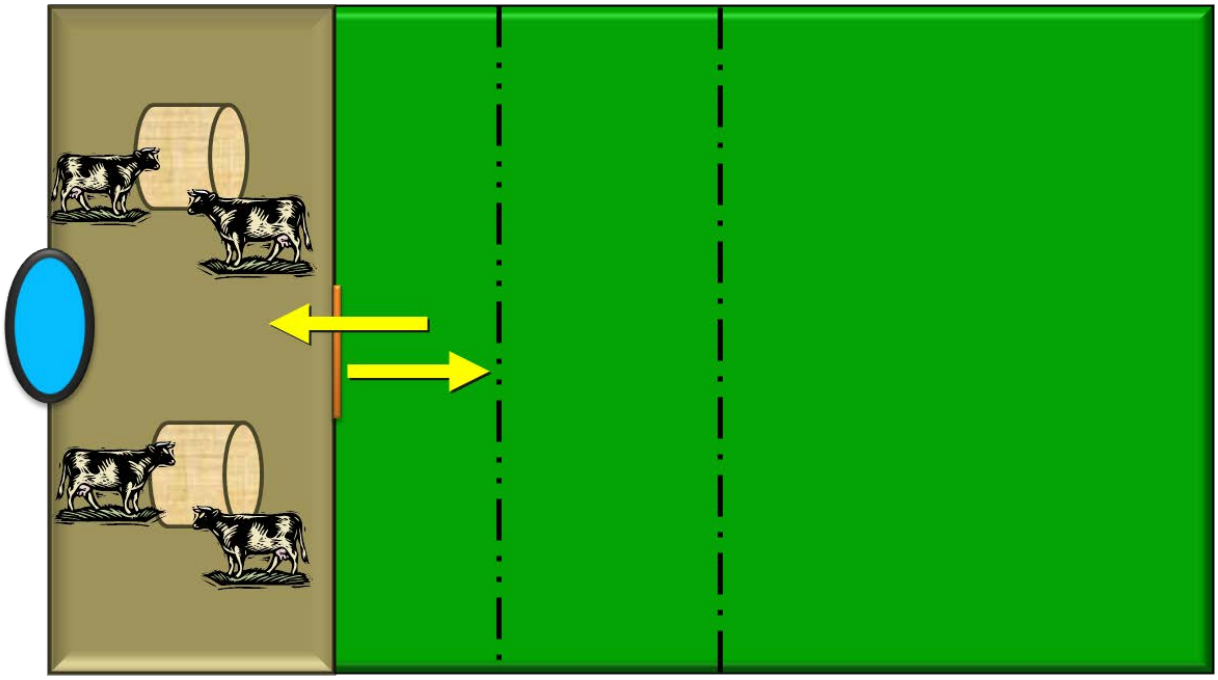
Limit Grazing



Pros and Cons

- Animals are allowed limited time in a typically higher quality forage paddock, and then removed and returned to a lower quality forage area (pasture and/or hay)
- Typically practiced when animals are grazing a base paddock containing low quality forages (dormant species/low quality hay)
- Animals are allowed periodic access to a high quality (usually higher cost) pasture.
    - Representative of winter or summer annual forages
    - May have greater associated annual costs of establishment and typically higher levels of forage quality than perennial forage options
- This method is extremely effective when animals 'limit graze' a pasture for a few hours per day OR on an 'alternate day' basis – thus helping the animal to balance nutrient requirements.
- This method sharply increases the efficiency of utilization of high quality forages.

Common Forages Used: Winter Annuals, Summer Annuals

Level of Labor required: High

Good Rule of Thumb: Pull animals out when they begin to loaf or lay down and are no longer actively grazing for higher efficiency.

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AGR-191

UNIVERSITY OF KENTUCKY College of Agriculture

A collaborative publication of Berea College and the University of Kentucky

Using a Grazing Stick for Pasture Management

Ray Smith, University of Kentucky; Mike Panciera, Berea College; and Adam Probst, University of Kentucky

Good management of livestock feeding enterprises requires an understanding of feed inventories and their use. Gathering this information is straightforward in grain-based feeding systems because bushels of stored grain are easily measured, and the amount fed per day is determined by the ration and the number of animals.

In pasture systems, however, keeping a forage inventory is more difficult. Feed may be allocated for more than one day, and feed quantity and quality are influenced by weather, fertility, stand density, and season. Not all of the feed available is consumed, and the plants continue to grow after they are grazed. Variation in feed quality and animal production status (pregnant, dry, lactating, growing, etc.) may also influence feed consumption.

This publication is intended to help producers meet animal forage needs in a rotational grazing system by mastering the use of a grazing stick to estimate pasture yield and pasture allocation.

Grazing sticks are useful for making immediate pasture management decisions, but good records of pasture yield, grazing days, and other data will provide a means to evaluate past efforts. Grazing sticks look like a simple measuring device, but are really a measurement system. They include a ruler for measurement, grazing guidelines, and conversion formulas for making immediate pasture management decisions. Grazing sticks are handy tools that simplify measuring pasture yield, allocating pasture to animals, and tracking productivity changes. These tasks are all critical aspects of good pasture management.

Grazing sticks vary somewhat from state to state. The Kentucky model consists of the following, shown on the stick itself:

- A ruler to measure forage height
- A quick guide to start and stop grazing on a paddock
- A table to convert stand density to dry matter per acre-inch
- Formulas for pasture allocation and management decisions
- General guidelines and planning information

Using the Grazing Stick

Yield Estimation

Keep in mind the estimate is only as good as the sample. If the forage stand and the topography are uniform, a minimum of one sample per acre is recommended. Take more measurements for fields with variable soils, topography, or forage stands.

Figure 1. Ruler used to measure height.

Step 1—Use the ruler to measure forage height (Figure 1). With most forages, plant height taller than 18-24 inches is really better suited to hay than to grazing. This is particularly true with endophyte-infected tall fescue, because toxins increase with stem growth and seed head development. See *Sampling Tall Fescue Endophyte in Pasture or Hay Stands* (PPA-30) for more information on dealing with infected tall fescue.

Height is not a measure, but rather an average, of the tallest plants. Spread your hand and lower it onto the canopy. The average height is measured at the point where you feel very modest resistance from the plant canopy. In Figure 1, the height is 7 inches. Record the height for each sample location in the pasture and then calculate the average height for the pasture.

Step 2—Stand density is the amount of the ground surface covered with standing forage. Your goal is to place the pasture into one of three density categories (less than 75%, 75 to 90%, or more than 90%).

Visually estimate stand density by looking directly down at each location where you have just measured canopy height. Do not include ground residue, only plant material tall enough for the livestock to consume. Stand density measurements using the grazing stick are most accurate when canopy height is approximately 8 inches.

Record the density reading for each location, then calculate the average stand density for the pasture. The density yield table (Table 1) can now be used to estimate forage yield per acre-inch. The table is more accurate with denser stands.

Step 3—Determine the dry matter (DM) yield per acre-inch using the density measured in Step 2. For example, if you are measuring a tall fescue pasture and you estimate that the available forage covers 85% of the ground area, this pasture would be assigned to the middle density category of 75 to 90% cover. According to Table 1, this density rating would be between 150 and 200 lb of DM per acre-inch. Based on your assessment of the stand, assign a yield. The thicker the stand, the closer the yield will be to the upper end of the range. Since 85% is in the upper end of this density category, 200 lb of DM per acre-inch would be a good estimate. If the average stand height is 8 inches and you want to maintain 3 inches of stubble after grazing, available forage equals:

5 inches x 200 lb/acre-inch = 1,000 lb DM/acre.

Step 4a—Calibration (quick estimate): A periodic check of your measurements can help you be consistent in using the grazing stick. Harvest 1 square foot of forage (cut at soil level), weigh it in grams, and multiply it by 20. This calculation will give an estimate of lb per acre assuming the forage is 20% DM. While this method is useful for a quick check, the DM content of forage does vary throughout the year, so the yield estimate will be more accurate if the sample is actually dried.

Step 4b—Calibration (better estimate):

1. Harvest 1 square foot of forage (cut at soil level) and chop the forage into 1- to 2-inch lengths.
2. Weigh the forage (in grams) then place it on a microwave-safe dish. Place the dish in a microwave oven along with a cup of water, which helps reduce the risk of burning the forage.
3. Heat on high for two minutes.
4. Weigh the forage.
5. If the forage is not dry, place it back in the oven and heat it for 30 seconds more.
6. Repeat steps D and E until the weight does not change. If the forage is charred, use the last weight.
7. Multiply the dry weight in grams by 100 for an estimate of dry matter yield in lb per acre.

Table 1. Estimated dry matter yield per acre inch based on density and forage type.

	Density		
	<75%	75-90%	>90%
Forage	**Dry Matter Yield (lb)**		
Tall fescue or orchardgrass	50-150	150-200	200-300
KY Bluegrass	50-100	100-175	175-250
Cool-season grass (clover)	50-125	125-200	200-275
Bermudagrass	100-200	200-300	300-400
Alfalfa	75-150	150-225	225-300
Red clover	75-125	125-175	175-250

Allocate Forage

Your pasture system will determine how you apportion forage for your animals. If you are using temporary electric fencing and allocating acreage to feed your animals for a specific number of days, you will need to calculate the acres needed per day. If you have a slow rotation with modest-sized paddocks, you will have to determine how many days a particular paddock will carry your herd. If you can vary animal numbers to fully utilize your available pasture, you will have to determine how many animals are required. Each situation will require you to estimate yield and to make the appropriate allocation. In addition to forage yield, the formulas for calculating pasture allocation require values for percent utilization (Table 2), animal weights, and animal intake (Table 3).

Table 2. Percent utilization of available forage based on grazing system.

System	Utilization
Continuous	30-40%
Slow rotation (3-4 paddocks)	40-55%
Fast rotation (8+ paddocks)	55-70%

Source: The Kentucky Grazing Stick.

Table 3. Forage intake guidelines.

Livestock Class	Dry Matter Intake as Percent of Body Weight
Dry beef cow	2
Lactating beef cow	3-4
Lactating dairy cow	2.5-5*
Stockers	2.5-3.5
Horses	2.5-3
Sheep & Goats	3.5-4

*May include grain.

Utilization is defined as the percent of the available forage that animals consume. Utilization rates vary with the intensity of the grazing system (Table 2).

Animals will only use 30-40% of the forage on a continuously grazed pasture because they have excess forage and graze selectively. The forage they do not eat may become mature and unpalatable. In addition, much of the available forage becomes waste because it is trampled or fouled with dung or urine.

With pasture rotation, the grazing period is shortened, animals cannot be as selective, and less forage is wasted (Table 2). With a slow rotation (three to four paddocks, animals moved every seven to 10 days), the utilization increases to 40-55%. A faster rotation will increase utilization to 55-70%. It is possible to achieve higher utilization (70-80%) with intensive rotational systems (animals moved once or twice a day).

Livestock species, class, and physiological condition all have profound effects on intake (Table 3). Forage intake may also be influenced by the stage of plant growth. Mature plants are a low-quality feed because they have high fiber content. Fiber digests slowly and limits the amount an animal can consume. See American Farm Bureau publication *Understanding Forage Quality* (pub. no. 1-01) for more detailed information. Lactating dairy cows need a high level of nutrition to maintain high levels of milk production and, as indicated in Table 3, some supplementation with grain may be necessary to provide sufficient intake for these animals.

Pasture Allocation Examples Using Formulas from the Grazing Stick

Calculate: The paddock size needed to feed a set number of animals.

Example 1: 100 dry cows, average weight 1,350 lb.

$$\text{Acres required/paddock} = \frac{\text{(weight) x (intake in \% body weight) x (animal \#) x (days/paddock)}}{\text{(available DM/acre) x (\% utilization)}}$$

Step 1—Animals will be moved every three to five days in an eight-paddock system, so utilization is estimated to be 60% (Table 2).

Step 2—Set intake—because they are dry cows, use 2% (Table 3).

$$\frac{\text{(1,350 lb/cow) x (0.02/day) x (100 cows) x (4 days)}}{\text{(1,000 lb/acre) x (.60)}}$$

= 18 acres

Calculate: The number of animals needed to utilize the available forage.

Example 2: The paddock size is 20 acres and the grazing period is 4 days.

$$\text{\# of animals required to graze a paddock} = \frac{\text{(DM/acre) x (acres) x (\% utilization)}}{\text{(animal weight) x (intake in \% body weight) x (days)}}$$

$$\frac{\text{(1,000 lb/acre) x (20 acres) x (.60)}}{\text{(1,350 lb) x (0.02/day) x (4 days)}}$$

= 111 cows would be needed to graze these pastures down in 4 days.

Calculate: The number of days a paddock will last.

Example 3: A herd of 100 cows on a fast rotation.

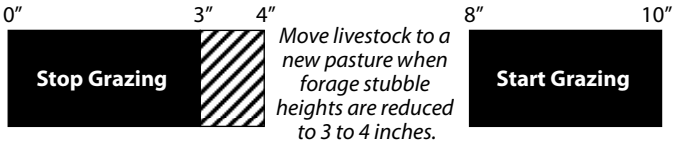
$$\text{Days of grazing per paddock} = \frac{\text{(DM/acre) x (acres) x (\% utilization)}}{\text{(animal weight) x (intake in \% body weight) x (\# animals)}}$$

$$\frac{\text{1,000 lb/acre x 20 acres x .60}}{\text{1,350 lb x 0.02/day x 100 cows}}$$

= 4.4 days

The grazing stick also has a quick guide (Figure 2). If you carry the stick with you whenever you check animals or move fences, you can quickly assess pasture regrowth and readiness for grazing. The suggested starting height for grazing cool-season grasses is 8 to 10 inches, which ensures that forage is in a high-quality vegetative stage. The stop-grazing limit applies to grass or grass-legume pastures. The 3- to 4-inch stubble height ensures that some leaf tissue is available for grass regrowth. Removal of basal leaves will slow grass regrowth and limit yield. If pastures are growing quickly in the spring, you may need to harvest or clip them to keep them productive and in high-quality condition.

Figure 2. Quick grazing guide.



The guidelines for grazing vary according to the plant species (Table 4). For example, grazing is normally delayed until bud stage for alfalfa so that the plants can restore root reserves that were used in regrowth. Consistently grazing forages before the indicated height or stage may thin the stand. Overgrazing so that too little stubble remains after grazing may limit pasture yield because the plants will not have enough leaf tissue for photosynthesis and rapid growth. Rest periods and forage removal must be carefully balanced to keep pastures productive. One of the best ways to achieve this balance is by frequently observing pastures and the amount of pasture regrowth. In spring, pasture growth is often too rapid for optimum grazing, so rotations may need to be accelerated to maintain good pasture quality. In summer, cool-season plants grow more slowly, and the rotations may need to be slowed to allow full recovery from grazing. When planning grazing systems, you can calculate the number of paddocks necessary to provide a desired rest period.

$$\text{Number of paddocks} = \frac{\text{(days of rest)}}{\text{(days of grazing)}} + 1$$

Table 4. Guidelines for Optimum Grazing Height (in inches).

Forage	At Beginning of Grazing	At End of Grazing
Cool-season grasses and legumes other than alfalfa	8-10	3-4
Alfalfa	Bud stage	2-3
Annual warm-season grasses	20-24	8-10
Native warm-season grasses	18-22	8-10
Bermudagrass	6-8	1-2

Good Record Keeping

You'll find the grazing stick a handy tool, but keep in mind that it provides only an estimate of pasture yield. You can improve your grazing system with good records of pasture yield, grazing days, and other data because they allow you to evaluate past efforts. If you keep good records and compare yield estimates with data from actual grazing days, you will be able to more closely calculate the actual yield for your farm and your conditions.

Grain producers determine the number of inputs to use based on the yield they will gain from each one. Because inputs and the resulting yield are easily measured, grain production systems can be quickly refined and improved. Good pasture records are slightly more difficult to collect, but they can also contribute to rapid improvement of pasture systems. One objective of pasture improvement is to increase yield, but changes in pasture management may also target herbage quality, yield distribution, or persistence. Pasture improvement may result in improved gains, increased carrying capacity, or reduced need for supplementation during summer months. Records help a manager place a value on improvements and make decisions on where to spend limited resources to maximize the benefits. These improvements are not necessarily obvious unless producers keep good records and study them.

More specific information about grazing, pasture management, and forage species is available in UK Cooperative Extension publications such as *Rotational Grazing* (ID-143). A list of recommended publications is included at the end of this document.

All your record information should be entered in a timely manner and regularly reviewed. It should include record year, paddock identification, paddock size, monthly rainfall, date and amounts of fertilizer, seed and pesticide inputs, and the most recent soil test data. In addition, each time a paddock is grazed, record the number and average size of animals, dates in and out, pasture height at the beginning and end of grazing, and yield estimate and stand density at the start of grazing.

Using Your Records for Planning

Records must be studied. Some people diligently keep records and file them at the end of the season. It will take some work to compile records into a form that you can use efficiently, but this effort is worthwhile. If you are going to keep records, commit yourself to using them.

Here are a few questions that might be answered by studying your pasture records:

- How much did legumes increase animal grazing days per acre during the summer?
- How much did fertilizer improve animal grazing days per acre?
- Which pastures and forages performed best in a dry year?
- How severe is the summer slump? Do you need to increase production during this period?
- Are your pastures improving or declining? Do you need to increase or decrease stock density to improve your pastures?
- Did your stockpile run out before spring growth began? How many more acres of stockpile do you need to support the herd? Can you fill gaps in forage production by grazing crop residues?
- Did your pasture management improvements result in reduced costs, increased carrying capacity, or better gains?

The following is a selection of the publications on forages and grazing available online at www.uky.edu/Ag/Forage/ForagePublications.htm or from your extension agent.

AGR-59—*Tall Fescue*
AGR-85—*Efficient Pasture Systems*
AGR-108—*Tall Fescue in Kentucky*
AGR-119—*Alternatives for Fungus Infected Tall Fescue*
AGR-162—*Stockpiling for Fall and Winter Pasture*
AGR-175—*Forage Identification and Use Guide*
ID-74—*Planning Fencing Systems for Intensive Grazing Management*
ID-97—*Grazing Alfalfa*
ID-143—*Rotational Grazing*
AE 2005-04—*The Economics of Renovating Pastures with Clover*
AE 2005-05—*The Economics of Using Improved Red Clover Varieties*
AE 2005-06—*The Economics of Pasture Fertilization*
PPA-30—*Sampling for the Tall Fescue Endophyte in Pasture or Hay Stands*
Tall Fescue Endophyte Concepts—Don Ball et al., 2003, Oregon Tall Fescue Commission, Spec. pub. No. 1-03
Understanding Forage Quality—Don Ball et al., 2001, American Farm Bureau pub. No. 1-01

Additional Useful References

Ball, D.M, C.S. Hoveland, and G.D. Lacefield. 2002. Southern Forages. 3rd ed., Potash and Phosphate Institute, Norcross, GA 30092.

Determining Forage Moisture Content Using a Microwave Oven

Revised 5-2010

Grazing Stick Instruction Manual

The ability to accurately estimate forage dry matter availability and animal forage dry matter demand is critical in balancing forage plant persistence and animal performance. A grazing stick is a tool that a grazing manager can use to estimate available standing dry matter. As with any tool, taking time to learn how to properly use it will increase the accuracy of the results.

A very basic first step is to understand that forage yields and animal forage demand are expressed in terms of dry matter or "dry matter basis." This simplifies calculations as moisture content of forage will vary according to season, growth stage and species. For example, a 1,100 lb dry cow has a dry matter requirement of approximately 30 lbs/day. If she is grazing a pasture that has a moisture content of 60%, to meet her dry matter demand of 30 lbs, she will consume a total volume of 50 lbs of forage. When moisture is included, this is termed "as-fed" or "as received."

Proper grazing stick use will help you better manage both forages and grazing animals.

Step 1
Determine Pounds Per Acre Inch
A direct relationship exists between inches of forage canopy height and pounds of standing dry matter (lbs/ac). This relationship varies depending on forage species and stand density (Table 1).

Table 1. Estimated Available Standing Dry Matter Pounds Per Acre Inch (lbs/ac in)

Forage	Average Good	Low-High Range
Bermudagrass	235	80-730
Fescue	160	50-265

A more complete table is found on your grazing stick. When measuring canopy height, take several measurements across the area to insure that canopy height is representative of the entire pasture. Measure to the top of the canopy. If the canopy has fallen over, straighten, but don’t stretch, the canopy to measure (Figure 1).

Figure 1.
Correct use of the grazing stick to measure canopy height.

Example: A bermudagrass canopy height of 10" and an average good value of 235 lbs/ac in would equal a dry matter availability of 2350 lbs/ac.

To reduce the variation in the range of lbs/ac and calibrate both your eye and the grazing stick, clip random, representative forage samples using a frame measuring 12" x 23". Measure canopy height where forage is clipped. Weigh and record sample weights in grams. Save a sub-sample to determine forage moisture content (see formula on back).

Use the following formulas to determine lbs/ac with a 12" x 23" frame:
Grams wet wt X % dry matter = grams dry weight
Grams dry weight X 50 = lbs/acre
lbs/ac ÷ inches canopy height = lbs/ac in

You may continue to calibrate your eye and the grazing stick throughout the growing season or until you become comfortable estimating % dry matter and stand density. At that point, simply measure canopy height and convert lbs/ac in to lbs/ac.

Step 2
Convert Total Pounds Per Acre to Available Pounds Per Acre

- Total lbs/ac X % utilization = lbs/ac of grazeable forage
- Example: 2,350 lbs/ac bermudagrass X 65% utilization = 1527 lbs/ac available for animals to consume

Percent utilization will vary according to plant species, season and management goals. Introduced forages will generally have higher utilization rates than native forages. The rule of thumb is 65 to 70% for bermudagrass and 25 to 30% for native grass.

Step 3
Determine Animal Intake (Forage Demand)

This is determined by estimating what percent of an animal's body weight it will consume in dry matter in one day. The percentage will vary according to class of animal and forage quality (Table 2). An approximate range is 2 to 4%. A value of 2.5% is most often used.

• 1,100 lb cow X 2.5% intake = 28 lbs of dry matter demand per head per day

Table 2. Grazing Formulas

$$\text{Number of Paddocks} = \frac{\text{Days of Rest}}{\text{Days of Grazing}} + 1$$

$$\text{Number of Animals} = \frac{\text{lbs/ac DM X Acres X \% utilization}}{\text{(Animal Wt X \% intake) X days}}$$

$$\text{Reserve Herd Days} = \frac{\text{lbs/ac DM X Acres X \% utilization}}{\text{(Animal Wt X \% intake) X No. Head}}$$

Dry Matter Forage Intake as a % of Body Weight

Dry Cow	2 to 3%
Lactating Cow	3 to 4%
Dairy Cow	3 to 4%
Stocker	2.5 to 3.5%
Horse	2 to 3%
Sheep and Goats	3.5 to 4%

Step 4
Putting it All Together

Grazing stick estimate of bermudagrass yield = 2,360 lbs/ac
2,360 X 65% utilization = 1527 lbs/ac available
1,100 lb cow X 2.5% intake = 28 lbs dry matter demand per day
1,527 lbs available/28 lbs demand = 54 days

Your grazing stick has helped you determine reserve herd days. In this example, one acre of bermudagrass will supply grazing for one cow for 54 days.

Determining Forage Dry Matter Using a Microwave Oven

1. Chop forage in 1" to 2" lengths.
2. Weigh out approximately 100 grams (3.5 ounces).
3. Spread forage thinly on a microwave-safe dish and place into microwave.
4. Heat for 2 minutes and reweigh.
   - If forage is not completely dry, reheat for 30 seconds and reweigh. (Microwaves vary considerably in drying capacity. It is better to dry for short intervals and reweigh until the last two weights are constant than to over-dry and run the risk of burning the forage and damaging the oven.) Continue this process until back-to-back weights are the same or charring occurs.
   - If charring occurs, use the previous weight.
5. Calculate moisture content using the formula:

$$\text{\% moisture content} = \frac{WI - W2}{WI} \text{ X } 100$$

- WI = weight of forage before heating
- W2 = weight of forage after heating
- Dry Matter (DM) is the percentage of forage that is not water
- DM equals 100% minus percent water
  Example: moisture content = 14%
  DM = 100-14 = 86%

October 2017

Pasture Condition Score Sheet Instructions

Pasture Condition Score Sheet

Purposes

- Evaluate current pasture productivity and the stability of its plant community, soil, and water resources.
- Identify what treatment needs, if any, are required to improve a pasture's productivity and protect soil, water, and air quality.

Suggested uses

This score sheet may be used to rate different pastures in a single growing season or the same pasture over a period of years. Rating a pasture yearly can track trends, either improvement or decline, in its condition. Some indicators change slowly in response to stresses caused by management or climate. Also, some indicators may change as each season progresses. An indicator or causative factor may rank high at one time and low another. Uniformity of use, plant residue, percent legume, severity of use, weather, and insect or disease pressure can vary widely on the same pasture depending on when they are scored during the year and the degree of management the pasture receives.

Therefore, it is often wise to score a pasture at different, key times during the year before deciding to make changes in management. Indicate on the form the date the scoring occurred.

Procedure

Step 1 - Rate each pasture one by one that is occupied all at the same time by a herd or flock and separated from other pasture areas by portable or fixed fencing. Paddocks in rotational pastures may be rated separately or as a combined unit. It depends on how alike they are. If any indicator looks markedly different from paddock to paddock, it may pay to rate each one separately.

Step 2 - Score all 10 indicators regardless of your feelings of their relative worth.

Step 3 - Using the attached score sheet and indicator criteria, read the scoring criteria for each of the 10 pasture condition indicators one at a time and rate before moving onto the next. Use the 1 to 5 scale provided. Estimate by eye or measure as precisely as you feel is needed to rate the indicator reliably.

Step 4 - When scoring plant vigor, enter a score based on the general criteria. If the plant vigor score is less than 4, refer to the plant vigor causative factors' criteria on page 2 of the scoresheet to identify the plant stress(es) causing reduced vigor. Rate each causative factor independently. Do not average to adjust the original vigor score.

Step 5 - When scoring erosion, rate sheet and rill erosion every time. Rate other types of erosion only if present.

When present, indicate which one(s) by identifying the erosion type with a unique symbol next to its score. Divide the box as needed to score them separately. Erosion is rated by averaging the individual scores. A need remains to prioritize which erosion problem is controlled first and how.

Step 6—Total the score for each pasture and compare to the following chart. Also, focus on any low scoring individual indicators or causative factors.

Overall Pasture Condition Score	Individual Indicator Score	Management Change Suggested
Greater than 46	5	Few or no changes in management needed.
36 to 45	4	Minor changes in management would enhance resource and productivity concerns.
26 to 35	3	Improvements would significantly benefit resource conservation and productivity.
16 to 25	2	Significant management changes needed to address resource and productivity concerns.
10 to 15	1	Major effort required in time, management and expenses to address resource and productivity concerns.

Step 7 - When an individual indicator's score falls below a 5, determine its worth to your operation. Then, decide whether to correct the cause or causes for the low rating. If you choose to correct, apply the most suitable management options for your area and operation.

NRCS - GEORGIA - PASTURE CONDITION SCORE - PASTURE PLANTS - FUNCTIONAL GROUPS and DESIRABILITY

Desirable Species

Functional Group 1 Cool Season Grasses
Kentucky bluegrass
Orchardgrass
Red Top
Reed Canarygrass
Rescuegrass (also call Prairie grass) "Matua"
Ryegrass, annual and perennial
Smallgrains (barley, oats, rye, triticale, wheat)
Tall Fescue
Timothy

Functional Group 2 Warm Season Grasses
Bahiagrass
Bermudagrass, hybrid or improved seed type
Bluestem, Big
Bluestem, Little
Crabgrass
Dallisgrass
Eastern gamagrass
Indiangrass
Johnsongrass
Millet, Browntop
Millet, Foxtail
Millet, Pearl
Sorghum-sudangrass hybrids
Sudangrass
Switchgrass

Functional Group 3 Legumes
Alfalfa
Clover, Crimson
Clover, Red
Clover, Subterranean
Clover, White (ladino and intermediates)
Hairy vetch
Lespedeza, Kobe
Lespedeza, Korean
Lespedeza, Sericea
Vetch, Common
Vetch, Hairy

Functional Group 4 Forbs
Brassicas (i.e. Rape, Kale, Turnips)
Chicory

Less Desirable Species

Intermediate Grasses
Barnyardgrass
Bermudagrass, common
Carpetgrass
Cheatgrass
Signalgrass, broadleaf

Intermediate Legumes
Black Medic
Clover, Hop
Clover, Rabbitsfoot
Clover, White Dutch
Florida beggarweed
Kudzu

Intermediate Forbs
Chickweed
Dandelion

Undesirable Grasses/Sedges/Rushes
Broomsedge
Foxtail, (giant, green or yellow)
Goosegrass
Little barley
Japanese stiltgrass (*Microstegium vimineum*)
Nimblewill
Nutsedge
Purpletop (*Tridens* flavus)
Rushes, most types
Sweet vernalgrass
Velvetgrass

Undesirable Forbs
Buttercup
Cocklebur
Cypress weed (dogfennel)
Dock
Henbit
Horsenettle
Marestail
Perilla mint
Plaintains
Spiny amaranth
Thistles, all types
White snakeroot

Georgia Pasture Condition Score Sheet

Farm Name: **Date:**

Indicators					Pasture Number / Identification (edit as needed)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCENT DESIRABLE PLANTS % of plant cover by weight that is **desirable** for domestic animals using the forage:																			
1 <20	**2** 20-40	**3** 40-60	**4** 60-80	**5** >80															
Plant Cover - Percent live, leafy canopy cover of desirables and intermediates is:																			
1 <50	**2** 50-70	**3** 70-90	**4** 90-95	**5** 95-100															
PLANT DIVERSITY The diversity of **well-represented forage** species by dry matter weight is:																			
1 1 dominant forage species: from one functional group; not uniformly grazed	**2** 2+ Species; from one functional group; different palatability, distributed in patches	**3** 3 + Species from one functional group; none avoided. Or two species each from different functional groups	**4** 3 + Species, 20% + Dm wt. ea from two functional groups with one being a legume	**5** 4 + Species, 20% Dm wt. ea from three functional groups. At least one legume. Intermixed well.															
PLANT RESIDUE (rate % cover and thatch thickness separately and average the scores) Ground cover of organic residue between plants & thickness of thatch (inch):																			
1 0%; > 1"	**2** 1-10%; 0.5 to 1"	**3** 10-20%; <.5"	**4** 20-30%; none	**5** 30-70%; none															
PLANT VIGOR (level of potential recovery & production post graze) Degree of plant stress which affects recovery: If score <4, score the factors on second page to determine reason for poor vigor. Note plant color for nitrogen deficiencies, insect damage, and drought stress as well.																			
1 No recovery after grazing. Productivity < 30% of potential	**2** Slow-2+week lag. Productivity very low 30-50% of potential	**3** Moderate recovery-1 week lag. Productivity 50-75% potential	**4** Rapid-1-2 day lag. Productivity 75% - 90% potential	**5** Optimum-no lag. Productivity at site potenial															
LEGUME CONTENT Percentage of legume present as total dry weight **(cool season pasture score values above and warm season pasture score values below)**:																			
1 <10% or>60%	**2** 10-19%	**3** 20-29%	**4** 30-39%	**5** 40-60%															
<4%	5-9%	10-19%	20-29%	30-40%															
UNIFORMITY OF GRAZING Estimate the extent of area showing spot or patch grazing in the pasture:																			
1 >50% ungrazed	**2** 25-50% ungrazed	**3** 10-25% ungrazed	**4** Few patches. Minor rejection	**5** No patches only urine and dung patches ungrazed															
SEVERITY OF USE - Intensity and frequency of forage removal is:																			
1 Continuously below minimum height. Or ungrazed brush/weeds invading	**2** Continuously to minimum height	**3** To minimum height. Limited / Slow rotation of livestock	**4** To minimum height. Frequency based on availablity	**5** Grazed above minimum height. Frequency based on availablity															
LIVESTOCK CONCENTRATION AREAS Presence of livestock concentration areas and proximity to **surface** water:																			
1 >10% and/or all drain directly to water	**2** 5-10% most near water no veg. buffer	**3** <5% some near water no veg. buffer	**4** Few areas. All with veg. buffer	**5** None. Or all sited and treated to minimize impact. None near water with veg. buffer															
SOIL COMPACTION - Probe moist soil compared to an ungrazed area beneath fence																			
1 Very Severe	**2** Severe	**3** Moderate	**4** Slight	**5** None															
EROSION Always score Sheet & rill. Score the following when present, gully, streambank, shoreline, wind																			
1 Very Severe	**2** Severe	**3** Moderate	**4** Slight	**5** None Visible															
PASTURE CONDITION SCORE, total for each field																			

Clear Form

FACTORS AFFECTING PLANT VIGOR, Used to identify causes of poor plant vigor (do not average these scores into previous page)					Pasture Number / Identification (edit as needed)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P & K Status of soil Phosphorus and potassium status of the soil is:																			
1 Near Zero or Imbalanced	**2** Severely Limiting	**3** Moderately Limiting	**4** Slightly Limiting	**5** Not Limiting															
N Status in plant tissue Nitrogen status of the plant tissue is:																			
1 Yellow-Brown	**2** Yellow-Pale Green	**3** Pale Green	**4** Pale-Natural Green	**5** Natural Green															
SOIL pH pH status of the soil for the upper 4" rooting zone best fits:																			
1 pH<4.5	**2** pH=4.5-5.0	**3** pH=5.1-5.5	**4** pH=5.6-6.0	**5** pH=6.0-7.3															
SITE ADAPTATION OF DESIRED SPECIES Long term climate and natural soil characteristics play major role in adaptation; rank site for desired species.																			
1 Very Poor	**2** Poor	**3** Good	**4** Very Good	**5** Excellent															
CLIMATIC STRESSES Degree of plant stress due to recent weather effects is:																			
1 Very Severe, dying	**2** Severe, no night recovery	**3** Moderate, mid-day stress	**4** Slight wilt or discolor	**5** None															
INSECTS & DISEASE PRESSURE Level of plant stress due to insect or disease pressure is:																			
1 Severe	**2** Threshold	**3** <Threshold	**4** Slight	**5** None															
Biological Activity Assessment (do not average these scores into previous scores)																			
EARTHWORM & DUNG BEETLE ACTIVITY This category is not an official part of PCS, but will help characterize pastures:																			
1 Poor		**3** Medium		**5** Good															
% Soil Organic Matter Record % soil organic matter values from soil tests if available (Purpose of this category is to set a monitoring baseline for future comparison as management changes):																			

General management changes based on overall score for individual pasture or whole farm.

Overall Pasture Condition Score	Individual Indicator Score	Management Change Suggested
Greater than 46	**5**	Few or no changes in management needed to address resource and productivity concerns.
36 to 45	**4**	Minor changes in management would enhance resource and productivity concerns.
26 to 35	**3**	Improvements would significantly benefit resource conservation and productivity.
16 to 25	**2**	Significant management changes needed to address resource and productivity concerns.
10 to 15	**1**	Major effort required in time, management and expenses to address resource and productivity concerns.

Authors: Dennis Cosgrove, Univ WI. Dan Undersander, Univ WI. James Cropper, NRCS.
July 2012, Modified by James T. Green, Jr., NRCS-NC. December 2015, Modified by Philip Brown NRCS - GA.

Clear Form

Description of GA Pasture Condition Scores

Indicator	Score	Descriptor Range	Detailed Description of the Score
% Desirable Plants	1	<20%	Productive species desirable for animal use < 20 % of stand. Weedy annuals and/or brush species dominate.
	2	20-40%	Productive species desirable for animal use 20-40%stand. Mostly weedy annuals and/or brush species present and expanding.
	3	40-60%	Species desirable for animal use 40-60% stand. Undesireable broadleaf weeds and annual weedy grasses invading. Some brush species.
	4	60-80%	Species desirable for animal use 60-80% stand. Remainder mostly intermediates and a few undesirables present.
	5	>80%	Species desirable for animal use >80% stand. Scattered intermediates.
Plant Cover (Live stems and green leaf cover of all desirable and intermediate species)	1	<50%	Plant canopy cover by live stems and green leaves is < 50%; Very high potential for runoff. Photosynthetic leaf area very low.
	2	50-70%	Plant canopy cover by live stems and green leaves is 50-70%; Relatively high potential for runoff. Low photosynthetic potential.
	3	70-90%	Plant canopy cover by live stems and green leaves is 70-90%; Most forages grazed close; Moderate runoff potential. Moderate photosynthetic potential.
	4	90-95%	Plant canopy cover by live stems and green leaves is 90-95%; Some spot grazing;Very little runoff potential. Good photosynthetic potential.
	5	95-100%	Plant canopy cover by live stems and green leaves is >95-100%; Thick stand; Very slow or no runoff flows under normal rainfall intensities. Excellent photosynthetic potential.
Plant Diversity (By dry matter weight)	1	1 dominant forage species: from one functional group; not uniformly grazed	One dominant forage species making up > 75% of DM by wt. Species **not uniformly grazed.**
	2	2+ Species; from one functional group; different palatability, distributed in patches	Two + forage species making up more than 75% of DM by wt, all from one functional group. **Un-even palatability** resulting in uneven utilization and scattered patches of certain species. Species not mixed but are distributed in patches allowing for widespread avoidance or non-uniform selection by animals.
	3	3 + Species from one functional group; none avoided. Or two species each from different functional groups	3 + forage species (each 20% of DM wt.) from one functional group. **All well utilized**. Or, two forage species each from different functional group; both supply 25-50% of DM by wt.
	4	3 + Species, 20% Dm wt. ea from two functional groups with one being a legume	Three + forage species (each 20+% of DM wt.) from two functional groups with at least **one being a legume.** Well inter-mixed.
	5	4 + Species, 20% Dm wt. ea from three functional groups. At least one legume. Intermixed well	Four + forage species representing three functional groups (each making up 20+% of DM wt.) with at least **one legume.** Intermixed well.
Plant Residue (Ground cover of organic residue between plants & thickness of thatch)	1	0% Cover: > 1" thatch	No ground cover of soil surface between live plants by decaying vegetation, or thatch > 1" thick.
	2	1-10% Cover. 0.5 to 1" thick thatch	1 - 10% ground cover by vegetative organic litter in various stages of decay on soil surface between plants. Thatch 0.5 to 1" thick.
	3	10-20% Cover. < 0.5" thatch	10-20% ground cover by vegetative organic litter in various stages of decay on soil surface between plants. Thatch < 0.5".
	4	20-30% Cover. No thatch	20-30% ground cover by vegetative organic litter in various stages of decay on soil surface between plants. No thatch
	5	30-70% Cover. No thatch	>30% ground cover by vegetative organic litter in various stages of decay on soil surface between plants. No thatch

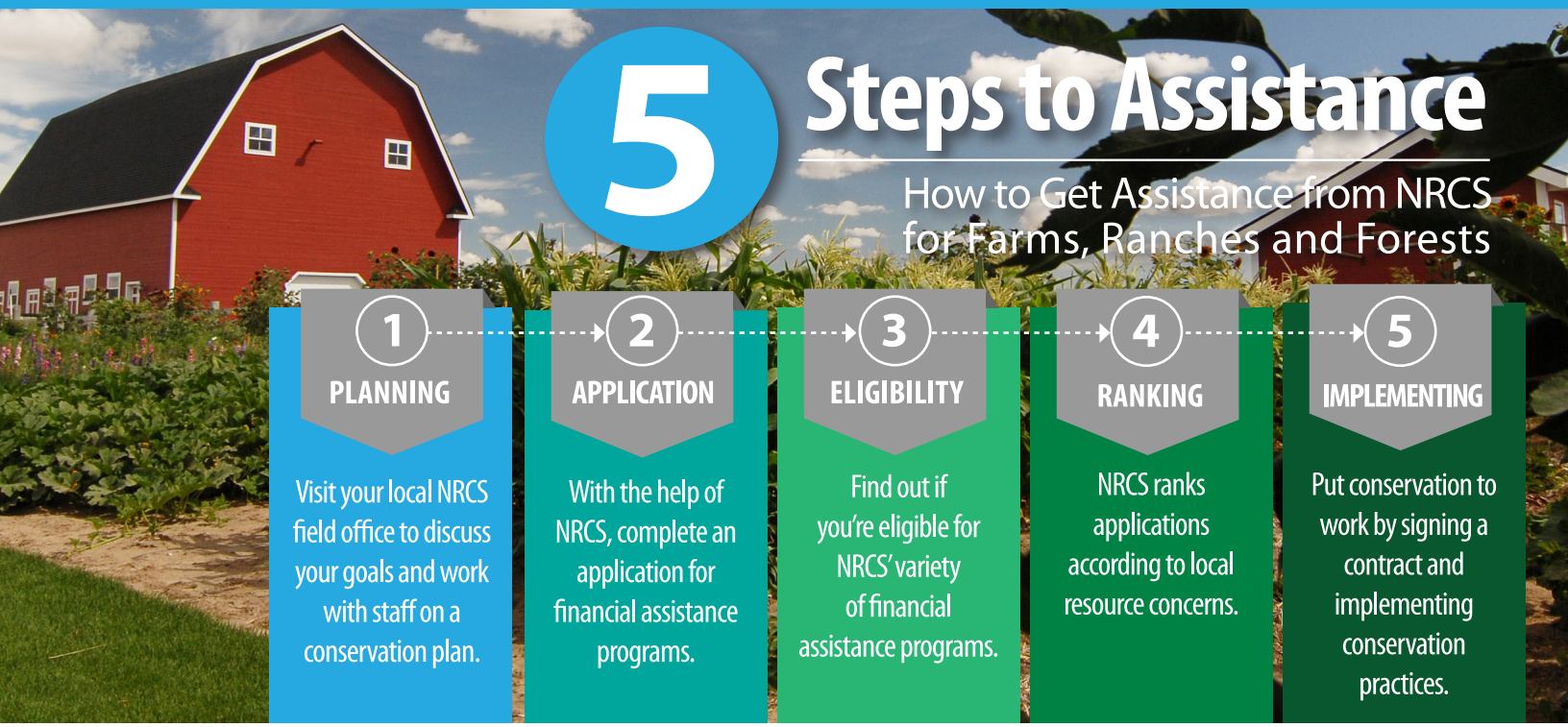
Indicator	Score	Descriptor Range	Detailed Description of the Score
Plant Vigor (Degree of stress which affects plant recovery. If <4, score the causative factors that help determine reason for poor vigor)	1	No recovery after grazing. Productivity < 30% of potential	Recovery following grazing very slow or negligible, even under favorable growing conditions. Plant leaves may be pale yellow or brown. Very few photosynthetically active leaves in canopy. Leaves may appear stressed from fertility, pests, climate or animal or insect damage. Canopy is not very competitive with undesirable species.
	2	Slow-2+week lag. Productivity very low 30-50% of potential	Recovery from grazing may take 2 or more weeks longer than normal under favorable growing conditions. Plant leaves may be yellowish green. Leaves may appear stressed from fertility, pests, climate or animal or insect damage. Productivity may be only 30-50% of site potential.
	3	Moderate recovery-1 week lag. Productivity 50-75% potential	Recovery following grazing may take 1 week longer than normal under favorable growing conditions. Plants may show minor signs of stress due to lack of fertility, climatic stress, competition from undesirable species, pests or animal damage. Plants appear reasonably healthy and photosynthetically active. Very noticeable color contrast between urine/dung patches and surrounding pasture. Productivity may be 50-75% of site potential.
	4	Rapid-1-2 day lag. Productivity 75% - 90% potential	Recovery following grazing may take 1-2 days longer than normal for healthy, vigorous plants growing under favorable conditions. 75-90% of plants appear to be turgid, have favorable color, with very minor stress from pests or fertility. Productivity is >75% of site potential.
	5	Optimum-no lag. Productivity at site potenial	Recovery following grazing is very rapid. Plants appear healthy with the natural green color for the species and weather conditions. Species appear very competitive with invading species and adapted to the site's soil and climate. Productivity would match site potential.
Legume Content (Percentage of legume present as total dry weight. **Note: Cool Season Pasture Scores / Warm Season Pasture Scores**)	1	<10 or >60% / <4%	< 10% by wt. in the mixture or greater than 60%. Warm Season Pasture (WS) <4%
	2	10-19% / 5-9%	10 to 19% by wt. in the mixture of legumes. WS Pasture 5-9%
	3	20-29% / 10-19%	20 -29% by wt in the mixture of legumes. WS Pasture 10-19%
	4	30-39% / 20-29%	30-39% by wt legumes. WS Pasture 20-29%
	5	40-60% / 30-40%	40-60% by wt legumes. WS Pasture 30-40%
Uniformity of Grazing	1	>50% of area ungrazed	"Spot" grazing (ungrazed or slightly grazed areas) is evident on more than 50% of the pasture. Mosaic grazing pattern throughout or identifiable areas have been avoided.
	2	25-50% area ungrazed	"Spot" grazed patches cover 25-50% of the pasture either in a mosaic pattern or obvious portion of pasture not grazed very often.
	3	10-25% area ungrazed	"Spot" grazed patches cover 10-25% of the pasture either in a mosaic pattern or obvious portion is not grazed often.
	4	Few patches. Minor rejection	"Spot" grazed patches cover small percentage of pasture where isolated forage types or areas have been rejected. Most ungrazed areas are surrounding urine and dung spots.
	5	No Patches. Only urnine and dung patches ungrazed	Very few forage species have been rejected. Ungrazed or under-grazed areas are directly related to urine and dung spots.
Severity of Use (intensity and frequency of forage removal)	1	Continuously below minimum height. Or ungrazed brush/weeds invading	All plants continuously grazed as close to the soil as possible and very little leaf area available. Generally less desirable species have survived this management. There is usually significant bare soil exposed. Or no grazing, resulting in thatch or accumulation of dead tissue or non desirable species invasion.
	2	Continuously to minimum height	Plants grazed to 2-3" often, resulting in thin stands and less desirable surviving plants. Pasture may resemble mown lawn look.
	3	To minimum height. Limited / Slow rotation of livestock	Spot Grazing Common. Some areas heavily utilzed; Some areas not utilized. Pasture may have patches with mown lawn look. Limited / Slow rotation of livestock.
	4	To minimum height. Frequency based on availablity	Forages are not grazed below the target height for respective species. Manager rotates livestock into area based on forage availability.
	5	Grazed above minimum height. Frequency based on availablity	Forage species grazed above desired target height for respective species. Manager rotates livestock into area based on forage availability.
Livestock Concentration Areas (% cover of livestock concentration areas and proximity to surface water)	1	>10% and/or all drain directly to water	Livestock concentration areas cover >10% of the pasture; **and/or all** drain directly into water channels.
	2	5-10% and/or most near water no veg. buffer	Livestock concentration areas cover 5-10% of pasture; **and/or most** near water channels and drain into them unbuffered by vegetation.
	3	<5% and/or some near water no veg. buffer	Livestock concentration areas cover <5% of area; **and/or some** near water channels and drain into them unbuffered by vegetation.
	4	Few areas. All with veg. buffer	Some livestock trails and one or two small lounging sites present. Not near water channels. Drainage from these areas is filtered by good vegetative buffer.
	5	None. Or all sited and treated to minimize water quality impact. None near water. All with veg. buffer.	No presence of concentration areas **or** all are sited and treated to minimize water quality impacts. None near water. Drainage from all areas filterd by good vegetative buffer.

Indicator	Score	Descriptor Range	Detailed Description of the Score
Soil Compaction (Probe moist soil with pin flag compared to an ungrazed area (i.e. beneath fence))	1	Very Severe	Excessive traffic. Pushing a pin flag wire into upper 2 inches of soil is very difficult. Infiltration capacity and surface runoff is unsatisfactory.
	2	Severe	Livestock trails common throughout. Off trail hoof prints common. It is difficult to push pin flag wire past the upper 2-4 inches of soil.
	3	Moderate	Scattered signs of livestock trails and hoof prints, mainly confined to paths to water, shade or lounging areas. Resistance to pushing a pin flag wire below 4-8 inches into the soil.
	4	Slight	Scattered signs of livestock trails and hoof prints, mainly confined to paths to water, shade or lounging areas. Almost no resistance to pin flag wire penetration into the upper 6-8 inches of soil.
	5	None	Very few signs of trails or hoof prints on bare soil. No resistance to pin flag wire penetration into soil.
Always score Sheet and Rill Erosion. Score other erosion types when present.			
Sheet and Rill	1	Very Severe	Sheet and rill erosion is active throughout pasture; rills 3-8 inches deep at close intervals and/or grazing terracettes are close-spaced with some slope slippage.
	2	Severe	Most sheet and rill erosion confined to steepest terrain of pasture; well defined rills 0.5-3 inches deep at close intervals and/or grazing terracettes present.
	3	Moderate	Most sheet and rill erosion confined to heavy use areas, especially in lounging areas & near drinking water tanks. Rills 0.5-3 inches deep. Plant / soil debris dams piled at down slope edge.
	4	Slight	No current formation of rills; some evidence of past historic rill formation but are covered with vegetation. Scattered plant / soil debris dams are present.
	5	None Visible	No evidence of current or past formation of sheet flow, rills or "soil scours".
Gully	1	Very Severe	Mass movement of soil, rock, plants, and other debris; occurrence of landslides, debris avalanches, slumps and earth-flow, creep and debris torrents.
	2	Severe	Gully(s) advancing upslope cutting longer channel(s). Revegetating difficult without using constructed structures & livestock exclusion; continuous gully(s) with many finger-like extensions into the slope.
	3	Moderate	Gully(s) present with scattered active erosion, no vegetation at heavy use slopes and/or on bed below overfalls. New eroding channels present and new overfalls appearing along sides and bed of main channel.
	4	Slight	One or more existing stable gullies present, vegetation covers gully bottom and slopes reasonably well; no visual signs of active cutting at gully head or sides. Some soil moved in channel bottom.
	5	None Visible	No gullies; natural drainage ways are stable vegetated channels. Spring or seep fed bare channels are often covered with overhanging vegetation.
Stream bank & Shoreline	1	Very Severe	Stream banks are bare and sloughing. No native vegetation remaining.
	2	Severe	Stream banks are heavily grazed and trampled. Bank sloughing and erosion is quite evident. Little native vegetation remaining.
	3	Moderate	Stream bank vegetation is grazed close but slopes not heavily trampled nor actively eroding. Some native vegetation remaining. Heavy livestock traffic at a few specific points. Remote alternative drinking water facilities may be present usually not sited well to faciltate good livestock distribution.
	4	Slight	Stream bank vegetation is grazed but slopes are stable. Mix of pasture plants, native or naturalized species along water's edge. Muddy livestock stream crossing(s) or pond entrance(s) not used heavily. Alternative drinking water facilities are present and sited to allow for good livestock distribution.
	5	None Visible	Stream bank vegetation is ungrazed or grazed infrequently. Abundant mixture of pasture plants, native or naturalized species along water's edge. Stabilized or constructed livestock stream crossing or watering ramps. Alternative drinking water facilities are used by livestock and sited to allow for good livestock distribution.
Wind	1	Very Severe	Blowouts or dunes present or being formed by wind.
	2	Severe	Soil swept from the established pasture causing plant death by burial or abrasion.
	3	Moderate	Soil swept from adjacent fields or pasture during seedbed preparation and early seedling establishment causing plant death by burial or abrasion.
	4	Slight	Some vegetative debris windrowed. Some dust deposition from offsite source. Minor wind damage to plant leaves.
	5	None Visible	No visible signs of windblown soil or litter. No wind related leaf damage.

Indicator	Score	Descriptor Range	Detailed Description of the Score
The following possible causes for poor plant vigor should be evaluated if Vigor Score < 4.			
P and K Status	1	Near zero or Imbalanced	No soil testing management; Very low P & K, or very high P & K.
	2	Severely limiting	No soil testing management; Low P and K. Confirm with soil testing.
	3	Moderately limiting	No soil testing management; Low P, optimum K; or low P, high K; or optimum P, low K; high P, low K; or high P, high K.
	4	Slightly limiting	Soil testing practiced every 3-6 years; Optimum P, high K; or high P, optimum K.
	5	Not limiting	Soil testing practiced every 2-3 yrs; Optimum P and K.
Tissue N Status	1	Yellow-Brown	Visually, leaves appear yellowish or brownish color relative to natural color for the species. Leaf tips may be brown or withering. N is deficient. However, excessive N may result in dark green appearance and potentially toxic concentrations.
	2	Yellow-Pale Green	Leaves are yellowish to pale green. Tissue testing indicates limited for optimum growth.
	3	Pale Green	Leaf tissue is pale green or slightly yellowish in color for the specific species. Moderately N deficient based on tissue testing.
	4	Pale-Natural Green	Leaf color is slightly pale but generally of the natural green color for the species.
	5	Natural Green	Leaf tissue has natural green color specific for the crop. Optimum N concentration based on tissue testing.
Soil pH	1	pH <4.5	pH < 4.5, or > 9.0 based on Soil Testing.
	2	pH 4.5-5.0	pH=4.5-5.0, or 8.5-9.0 based on Soil Testing.
	3	pH 5.1-5.5	pH=5.1-5.5, or 7.9-8.4 based on Soil Testing.
	4	pH 5.6-6.0	pH=5.6-6.0, or 7.4-7.8 based on Soil Testing.
	5	pH 6.0-7.3	pH=6.0-7.3 based on Soil Testing.
Site Adaptation [Long term climate and natural soil characteristics affect adaptation of desired species.]	1	Very Poor	Properly planted and established desired species are no longer present.
	2	Poor	Properly planted and established desired species are nearly gone. Volunteer unwanted species dominate.
	3	Good	One or more properly planted and established, or recruited desired species are missing. Unwanted species invading.
	4	Very Good	Properly planted and established, or recruited desired species still represented, but not in desired proportions
	5	Excellent	Properly planted and established, or recruited desired species are present in desired proportions
Climatic Stresses [mainly considered as recent "weather" effects]	1	Very Severe, dying	Brown and dying leaf tips due to stress from temperature (cold or hot) or moisture. Frost heaved plants, most with severed roots and dying. Major plant loss due to flooding, submergence or ice sheets. Stress may be from recent or extended weather patterns.
	2	Severe, no night recovery	Wilted plants, very little recovery during night. Or, some frost heaved plants, recovery slow. Some spotty stand loss due to flooding or ice sheets. Stress may be from recent or extended weather patterns.
	3	Moderate, mid-day stress	Wilting during heat of the day but recovery at night. Or, weak plants from winter damage or short-term submergence. Or, freezing damage to foliage. Stress may be from recent or extended weather patterns.
	4	Slight wilt or discolor	Dry conditions, but only slight wilting. Temperatures just outside the favorable range for optimum growth. Or, slight leaf yellowing due to cold, hot or wet conditions. Stress is most likely from recent weather patterns.
	5	None	No evidence of stress due to recent or long-term weather patterns.
Insects/Disease	1	Severe	Insects or diseases have consumed or damaged more than 50% of the leaf surface area.
	2	At Threshold	Insect or disease outbreak at economic threshold; treatment needed immediately.
	3	Near Threshold	Insect or disease outbreak near economic threshold, continue to watch and weigh options for treatment.
	4	Slight	Some insect and/or disease is present, but little impact on forage quality or growth rates.
	5	None	No visible signs of plant damage due to pest or diseases.
Biological Activity Assessment			
Earthworms & Dung Beetles (Not an official PCS Category but useful for soil health evaluation)	1	Poor	No evidence of worms or castings. 0-1 earthworm per per shovelful of soil taken from upper 12 inches. No dung beetle evidence. Manure paddies intact and not decomposing
	3	Medium	Scattered worm castings are found in the pasture. 2-10 earthworms per shovelful of soil taken from upper 12 inches. Some manure paddies have beetle activity.
	5	Good	Worm castings evident throughout. 10 + earthworms per shovelful of soil taken from upper 12 inches.Beetles easily found in manure. Manure paddies disintegrated in a few days.

USDA United States Department of Agriculture

Natural Resources Conservation Service



5 Steps to Assistance

How to Get Assistance from NRCS for Farms, Ranches and Forests

1. **PLANNING** — Visit your local NRCS field office to discuss your goals and work with staff on a conservation plan.
2. **APPLICATION** — With the help of NRCS, complete an application for financial assistance programs.
3. **ELIGIBILITY** — Find out if you're eligible for NRCS' variety of financial assistance programs.
4. **RANKING** — NRCS ranks applications according to local resource concerns.
5. **IMPLEMENTING** — Put conservation to work by signing a contract and implementing conservation practices.

Get Started with NRCS

Do you farm or ranch and want to make improvements to the land that you own or lease?

Natural Resources Conservation Service offers technical and financial assistance to help farmers, ranchers and forest landowners.

1 Planning

To get started with NRCS, we recommend you stop by your local NRCS field office. We'll discuss your vision for your land.

NRCS provides landowners with free technical assistance, or advice, for their land. Common technical assistance includes: resource assessment, practice design and resource monitoring. Your conservation planner will help you determine if financial assistance is right for you.

2 Application

We'll walk you through the application process. To get started on applying for financial assistance, we'll work with you:

- To fill out an AD 1026, which ensures a conservation plan is in place before lands with highly erodible soils are farmed. It also ensures that identified wetland areas are protected.
- To meet other eligibility certifications.

Once complete, we'll work with you on the application, or CPA 1200.

Applications for most programs are accepted on a continuous basis, but they're considered for funding in different ranking periods. Be sure to ask your local NRCS district conservationist about the deadline for the ranking period to ensure you turn in your application in time.

USDA is an equal opportunity provider and employer.

3 Eligibility

As part of the application process, we'll check to see if you are eligible.

To do this, you'll need to bring:

- An official tax ID (Social Security number or an employer ID)
- A property deed or lease agreement to show you have control of the property; and
- A farm tract number.

If you don't have a farm tract number, you can get one from USDA's Farm Service Agency. Typically, the local FSA office is located in the same building as the local NRCS office. You only need a farm tract number if you're interested in financial assistance.

4 Ranking

NRCS will take a look at the applications and rank them according to local resource concerns, the amount of conservation benefits the work will provide and the needs of applicants.

5 Implementing

If you're selected, you can choose whether to sign the contract for the work to be done.

Once you sign the contract, you'll be provided standards and specifications for completing the practice or practices, and then you will have a specified amount of time to implement. Once the work is implemented and inspected, you'll be paid the rate of compensation for the work if it meets NRCS standards and specifications.

To find out more, go to: **www.nrcs.usda.gov/GetStarted**

WHAT'S NEXT?

WHAT SHOULD I EXPECT NOW THAT I AM IN A CONSERVATION PROGRAM?

NRCS requires the participant adhere to the following once they enter into a Conservation Program Contract (CPC):

1. Start at least one practice in the contract within the first 12 months of the contract. **Note: Secure prior approval from NRCS before initiating construction on practices requiring an engineering design.**
2. Complete contract items as scheduled in the CPC. Contract items may be accomplished anytime prior to the year scheduled. (Exception: Conservation Stewardship Program (CSP) contract items do not have funds obligated to them ahead of schedule and therefore cannot be completed in advance.) If a practice will not be completed on schedule, you will need to contact your local NRCS office and work with them to review your contract's schedule. All required treatment must be installed at least 12 months before the end of the contract period.
3. Submit to NRCS an application for payment (Form NRCS-CPA-1245) when practice(s) are completed (CSP, Environmental Quality Incentives Program (EQIP) and Wildlife Habitat Incentives Program (WHIP).
4. Submit receipts for practices completed. This is not required, but encouraged to assist NRCS in maintaining current cost data.
5. Permit free access for NRCS and/or its agents to provide technical assistance and to inspect the work at any reasonable time during the life span of the installed practices.

(Continued)

6. Forfeit all rights to further payments under the contract, refund to NRCS all contract payments received, and pay liquidated damages upon termination of the contract as outlined in the CPC Appendix.
7. Forfeit all rights to further payments under the CPC if the land under contract is transferred.
8. Upon cancellation of the contract, refund to NRCS all payments made under the contract as outlined in the CPC Appendix and as determined by specific program requirements.
9. Maintain the conservation treatment or practice installed on the land *for the life span of each practice*, as identified on the contract documents.
10. Share responsibility for ensuring that your conservation plan and contract documents are accurate and complete. The NRCS has no authority to compensate participants for practices and/or activities that are not in the contract at the time of obligation.
11. Ask questions! If you do not understand specific items or terms of the contract and its associated Appendix, let your local NRCS know. They will be happy to answer questions you may have.

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Other Online Resources:

GovDelivery **www.ga.nrcs.usda.gov**

Twitter: **@USDA_NRCS_GA**

YouTube **www.youtube.com/user/nrcsga**

USDA NRCS Natural Resources Conservation Service

Georgia NRCS

Entity Steps for: Applying for Conservation Programs Natural Resources Conservation Service (NRCS)

Your State NRCS Office is located at:

355 E. Hancock Avenue
Athens, Georgia 30601

Tel: Office: 706-546-2272
Fax: 855-417-8490

www.ga.nrcs.usda.gov

Helping People Help the Land

2013

ENTITY STEPS...

Entity – any partnership, joint venture, corporation (limited liability or other), estate, trust, non-profit association or group, or unit of state or local government that uses an employee identification number (EIN) or social security number (SSN) to apply for conservation program assistance.

1. **Applicant** indicates interest in a conservation program by signing appropriate program application forms.
2. **Applicant** establishes a customer record in the Service Center Information Management System (SCIMS). This will require the applicant set up an appointment with the Farm Service Agency (FSA) to complete record and necessary applicant eligibility information.
3. **Applicant** completes forms* to determine eligibility for USDA programs:
   - AD-1026 Highly Erodible Land and Wetland Conservation Certification
   - CCC-901 Members Information
   - CCC- 902E Farm Operating Plan for Payment Eligibility Review
   - CCC-931 Payment Eligibility Average Adjusted Gross Income (AGI)

These eligibility forms can be accessed on-line for your convenience. Please visit our eForms site at: http://forms.sc.egov.usda.gov/eForms/welcomeAction.do?Home

***The process of establishing applicant eligibility may take several weeks. Some forms may need to be updated annually. You must maintain eligibility status throughout the life of the conservation program contract in order to receive program benefits.**

(Continued)

4. **Applicant** sets up an appointment with local NRCS office to visit the operation and develop a current **conservation plan**. This process can take several visits—both in the office and in the field.
5. **NRCS** develops a program application package based on the approved conservation plan and discussions with the applicant.
6. **NRCS** reviews program applications and selects eligible applications for funding based on ranking criteria and available funding *when funding is available*. Because NRCS programs rely on funds being available, this step may occur weeks or months after your program application package is submitted.
7. **Applicant** provides additional information if NRCS determines their application *may be considered* for funding. This additional information includes:
   - Evidence that the business is in current good standing.
   - Business Documents** outlining
     1. Official business name
     2. The current members of the business
     3. The member(s) of the business who have legal authority to sign on behalf of the business

   ***** See "Typical Types of Business and Acceptable Evidence and Signature Authority" for more information***

   - Document from the IRS that indicates the **name** and **Employee Identification Number (EIN)** for the business. All applicants earning program benefits will receive IRS-1099's based on this information. If you do not have a form available, you may request one from the IRS:
   - Request a **Form LTR 147C** by calling IRS Customer Service @ 800-829-4933 or

     Department of the Treasury
     Internal Revenue Service
     Ogden, Utah 84201

   - Completed SF-1199 Direct Deposit Form. All program payments will be direct deposited using this banking information.

(Continued)

   - Power of Attorney Form (FSA 211 may be used) if the authorized individual wants to allow another individual to sign on their behalf.
8. **Applicant** must document control of the land for the contract period using any of the following:
   - Deed
   - Lease or
   - Other written authorization from the landowner ("NRCS—Farm Bill Conservation Programs Land Eligibility Certification Form" may be used)
   - Land must be considered an *eligible land use* for the program.

Failure to provide the required information may cause your application to be considered "ineligible" for the program year.

If your application is not considered for funding in the year you apply, your application may be considered in future years based on funding and meeting the requirements outlined above.

WHAT'S NEXT?

WHAT SHOULD I EXPECT NOW THAT I AM IN A CONSERVATION PROGRAM?

NRCS requires the participant adhere to the following once they enter into a Conservation Program Contract (CPC):

1. Start at least one practice in the contract within the first 12 months of the contract. **Note: Secure prior approval from NRCS before initiating construction on practices requiring an engineering design.**
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4. Submit receipts for practices completed. This is not required, but encouraged to assist NRCS in maintaining current cost data.
5. Permit free access for NRCS and/or its agents to provide technical assistance and to inspect the work at any reasonable time during the life span of the installed practices.

(Continued)

6. Forfeit all rights to further payments under the contract, refund to NRCS all contract payments received, and pay liquidated damages upon termination of the contract as outlined in the CPC Appendix.
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10. Share responsibility for ensuring that your conservation plan and contract documents are accurate and complete. The NRCS has no authority to compensate participants for practices and/or activities that are not in the contract at the time of obligation.
11. Ask questions! If you do not understand specific items or terms of the contract and its associated Appendix, let your local NRCS know. They will be happy to answer questions you may have.

USDA - Natural Resources Conservation Service

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YouTube **www.youtube.com/user/nrcsga**

USDA NRCS Natural Resources Conservation Service

Georgia NRCS

Individual Steps for: Applying for Conservation Programs Natural Resources Conservation Service (NRCS)

Your State NRCS Office is located at:

355 E. Hancock Avenue
Athens, GA 30601

Tel: Office: 706-546-2272
Fax: 855-417-8490

www.ga.nrcs.usda.gov

Helping People Help the Land

2013

INDIVIDUAL STEPS...

Individual – any individual who controls the enrolled land and uses their personal *social security number (SSN)* to apply for conservation program assistance.

1. **Applicant** indicates interest in a conservation program by signing appropriate program application forms.
2. **Applicant** establishes a customer record in the Service Center Information Management System (SCIMS). This will require the applicant set up an appointment with the Farm Service Agency (FSA) to complete record and necessary applicant eligibility information.
3. **Applicant** completes forms* to determine eligibility for USDA programs:
   - AD-1026 Highly Erodible Land and Wetland Conservation Certification
   - CCC- 902-I Farm Operating Plan for Payment Eligibility Review
   - CCC-931 Payment Eligibility Average Adjusted Gross Income (AGI)

These eligibility forms can be accessed on-line for your convenience. Please visit our eForms site at: http://forms.sc.egov.usda.gov/eForms/welcomeAction.do?Home

***The process of establishing applicant eligibility may take several weeks. Some forms may need to be updated annually. You must maintain eligibility status throughout the life of the conservation program contract in order to receive program benefits.**

4. **Applicant** sets up an appointment with local NRCS office to visit the operation and develop a current **conservation plan**. This process can take several visits—both in the office and in the field.

(Continued)

5. **NRCS** develops a program application package based on the approved conservation plan and discussions with the applicant.
6. **NRCS** reviews program applications and selects eligible applications for funding based on ranking criteria and available funding *when funding is available*. Because NRCS programs rely on funds being available, this step may occur weeks or months after your program application package is submitted.
7. **Applicant** provides additional information if NRCS determines their application *may be considered* for funding. This additional information includes:
   - Completed SF-1199 Direct Deposit Form. All program payments will be direct deposited using this banking information.
   - Power of Attorney Form (FSA 211 may be used) if the authorized individual wants to allow another individual to sign on their behalf.
8. **Applicant** must document control of the land for the contract period using any of the following:
   - Deed
   - Lease or
   - Other written authorization from the landowner ("NRCS—Farm Bill Conservation Programs Land Eligibility Certification Form" may be used)
   - Land must be considered an *eligible land use* for the program.

Water Troughs with Heavy Use Area

(Continued)

Failure to provide the required information may cause your application to be considered "ineligible" for the program year.

If your application is not considered for funding in the year you apply, your application may be considered in future years based on funding and meeting the requirements outlined above.

USDA United States Department of Agriculture

Natural Resources Conservation Service (NRCS)

LOCATE YOUR LOCAL SERVICE CENTER

COUNTY	LOCATION	PHONE
Appling, Bacon, Jeff Davis	Baxley	912-367-6684
Atkinson, Charlton, Pierce, Ware	Blackshear	912-449-6273
Baker, Dougherty, Mitchell	Albany	229-430-8509
Baldwin, Greene, Hancock, Putnam, Taliaferro	Greensboro	706-453-7021
Banks, Jackson, Madison	Commerce	706-335-7145
Barrow, Clarke, Oconee, Walton	Monroe	770-267-1359
Bartow, Cherokee, Gordon, Pickens	Calhoun	706-629-2582
Ben Hill, Irwin, Tift, Turner	Tifton	229-382-4776
Berrien, Clinch, Cook, Echols, Lanier, Lowndes	Nashville	229-686-5557
Bibb, Crawford, Peach, Taylor	Fort Valley	478-827-0016
Bleckley, Dodge, Twiggs	Eastman	478-374-2531
Brantley, Camden, Glynn, Wayne	Brunswick	912-265-8043
Brooks, Thomas	Thomasville	229-228-0459
Bryan, Chatham, Liberty, Long, McIntosh	Richmond Hill	912-459-2350
Bulloch, Candler, Tattnall, Evans	Statesboro	912-871-2605
Burke, Columbia, Jenkins, Richmond	Augusta	706-724-2247
Butts, Clayton, Henry, Fayette, Spalding	McDonough	770-957-5705
Calhoun, Early, Miller	Blakely	229-723-3825
Carroll, Haralson, Heard	Carrollton	770-832-8942
Chattahoochee, Harris, Marion, Muscogee, Talbot	Buena Vista	229-649-3131
Clay, Quitman, Randolph	Cuthbert	229-732-6211
Cobb, Douglas, Fulton, Paulding	Marietta	770-792-0594
Coffee, Telfair	Douglas	912-384-4811
Colquitt, Worth	Moultrie	229-985-5399
Coweta, Meriwether, Troup	Newnan	770-251-4283
Crisp, Dooly, Wilcox	Cordele	229-443-0182
Dade, Catoosa, Murray, Walker, Whitfield	LaFayette	706-638-2207
Dawson, Forsyth, Hall, Lumpkin	Gainesville	770-536-6981
DeKalb, Gwinnett, Rockdale	Lawrenceville	770-963-9288
Decatur, Grady, Seminole	Bainbridge	229-567-3994
Effingham, Screven	Sylvania	912-564-2207
Elbert, Franklin, Hart	Hartwell	706-376-5451
Emanuel, Montgomery, Toombs, Treutlen, Wheeler	Swainsboro	478-237-8037
Fannin, Gilmer, Rabun, Towns, Union	Blairsville	706-745-2794
Floyd, Chattooga, Polk	Rome	706-291-5651
Glascock, Jefferson, McDuffie, Warren	Louisville	478-625-7771
Habersham, Stephens, White	Toccoa	706-779-2134
Houston, Macon, Pulaski	Perry	478-987-2280
Jasper, Jones, Morgan, Newton	Madison	706-342-1315
Johnson, Washington	Sandersville	478-552-6073
Lamar, Monroe, Pike, Upson	Barnesville	770-358-0787
Laurens, Wilkinson	Dublin	478-275-0425
Lee, Terrell	Dawson	229-995-5811
Lincoln, Oglethorpe, Wilkes	Washington	706-678-2630
Schley, Stewart, Sumter, Webster	Americus	229-924-4056

Visit the Georgia NRCS Web site at www.ga.nrcs.usda.gov.

As of July 2016

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United States Department of Agriculture

Natural Resources Conservation Service
Georgia Service Center Administrative Areas (SCA)