Understanding grazing animals and their management

Animal care and behavior influence daily decisions about movement and animal-handling activities in grazing systems. Animals behave first as individuals in their particular grazing selectivity, reproductive cycle, and health, but practicality requires that we manage animals as a herd or flock, which generally improves the efficiency of animal handling. There are inherent group behaviors that should be considered in the design and management of the grazing system. Discussed in this section are some situations where animal needs and habits may influence daily grazing management decisions and animal performance.

Daily grazing behavior

Cattle graze from 8 to 12 hours per day and sheep from 6 to 8 hours. They break this active grazing time into about 5 to 6 separate grazing periods, with time required for ruminating and resting between grazing periods. During summer, grazing the first few hours after daybreak is normally the largest single meal of the day. In this early morning grazing, animals tend to eat a lot and are less selective in their diet. A second large grazing period occurs in late afternoon until about sunset, with minor grazing periods during other parts of the day and even at night. During hot weather, animals tend to graze more at night. In winter, most grazing occurs from midmorning to midafternoon when temperatures are warmest.

Animal behavior can be useful when deciding when to move animals. Because the average nutritive quality of the forage declines the longer a group of animals is in a pasture, the early morning "quantity" grazing is a good time to get the animals to eat more of the lower-quality forage in the paddock. Under ideal conditions, when the nutritional requirements of the herd or flock are relatively low (dry, open, or gestating) moving the group after the morning grazing is a good use of the lower-quality forage on the last day of the graze period. But if the animal group is one that requires a high-quality diet for lactation or gain (dairy cows, stocker steers, or lambs), then turning the group onto the next high-quality paddock before a big grazing (daybreak or midafternoon) will permit a better level of nutrition in the diet. However, convenience and bloat management often dictate when groups are moved. Herds and flocks often behave according to a leadership hierarchy. This is important when moving animals. Each animal group has leaders, followers, and subordinates. Disruption and conflict can arise if subordinates are forced into the leader or follower group as animals are being moved.

Herd effects

Groups of grazing animals appear to prefer to be able to see each other at all times. So when the lead animal begins to move to water or to a remote part of the pasture, all the members of the herd move too. This is a great advantage when rotating to a different paddock in rotational systems, but can be a disadvantage when the group move to a distant water source interferes with grazing and uses energy unproductively for movement, particularly for high-producing animals (lactating dairy cows, stocker steers). Recent research in Missouri shows that if animals are within 700 to 800 feet of the water source, they can generally see each other and are more comfortable going to water individually in coordination with their own grazing and ruminating preferences. Providing water in each paddock or at several locations in large pastures will improve the efficiency of grazing, animal production, and manure nutrient distribution.

In large pastures, grazing animals often prefer to graze near the water source and avoid grazing in distant corners. Some producers place salt and mineral supplements in locations away from the water source to encourage better forage use over the entire pasture.

From: Pasture Mgmt. Guide Iowa State Univ. Ext.

Managing horses on pasture

Horses are forage-consuming animals and must have a daily supply of roughage provided either as pasture or hay. Horses will graze up to 14 to 16 hours per day. A horse's normal pattern is to graze continuously for several hours, rest, and then continue grazing. Even if horses are fed grain and have access to high-quality hay, they will continue to graze. Increased pasture forage availability will decrease grazing time. Horses graze less during very hot or cold weather. Young horses graze less than mature horses. Horses graze more in a group than as isolated individuals.

Horses are selective grazers, which affects the productivity of a pasture. Horses prefer to eat young, immature plants and will graze some areas of a pasture down to the bare ground. In other parts of the pasture, they will allow the plants to grow to maturity, which lessens palatability and nutrient availability. This grazing pattern is often called spot or pattern grazing. Horses will not graze in areas where they defecate.

Productive horse pastures require careful attention to forage supply and animal needs.

To maximize pasture use and nutrient availability, a number of management techniques can be followed. The length of time horses are maintained on pasture should be limited by rotational grazing or limit grazing. Limit grazing is limiting the amount of time a horse has access to a pasture. If adequate quantities of forage are available, a horse at maintenance can meet its dietary nutrient requirements with 4 to 5 hours of grazing.

It is very common to use electric fences to set up a rotational grazing system for horses. A rotational grazing system of 3 or 4 pastures is suitable for horses. Each pasture should be large enough to allow all the forage produced on it to be grazed in 10 to 14 days. In general, plants should be grazed to a height not less than 2 inches tall. If the pasture cannot be grazed to the recommended height, it should be mowed or made into hay. Following the 10- to 14-day grazing period, the pasture should have about a month's rest for forage regrowth before horses are rotated back onto it.

Stocking rate will determine the number of days a pasture can be used. General recommendations for stocking rates per acre are difficult to give because of the variation among forage species and forage density. However, in general, 1 acre of legume and grass pasture with good management and growing conditions can provide enough forage for 1 horse during the grazing season. With good rainfall or irrigation, less acreage may be required. When pasture productivity is poor and in drought periods, 2 to 5 acres of pasture per horse may be required. If the stocking rate is not high enough, more spot grazing will occur and the clipping of mature grasses will be necessary.

Additional management techniques frequently used with horse pastures include breaking up manure piles by dragging a chain link or spike tooth harrow over the pasture, and alternating or mixing cattle and horses because cattle will eat more of the mature grass that horses avoid. Horse pastures should be free of pits, holes, stumps, and other hazards. Chewing on trees is also a common problem with horses. Wrap trees with close-knit, wire fencing.

Introduction

WHY ROTATIONAL GRAZING?

Pastures represent a largely untapped resource for farmers. More than one quarter of the Midwest's agricultural land is in some form of pasture. Yet, 80% of these pastures suffer from poor, uneven fertility coupled with serious weed and erosion problems. Most farmers are reluctant to rely too heavily on pastures due to legitimate concerns that the meager amounts of low quality forage pastures typically yield will not adequately feed their high producing livestock.

The primary reason our pastures produce so badly is poor management. Most pastures are continuously grazed throughout the season. However, **continuous grazing** results in the lowest possible pasture yields since the forage is not allowed to recuperate between grazings.

To produce good livestock feed from pasture, we must manage our pastures differently. This bulletin outlines an alternative: rotational grazing. By using **rotational grazing**, you can make a profit from pastures without continual renovation. This bulletin covers the basics of setting up rotational grazing on your farm.

WHAT IS ROTATIONAL GRAZING?

Under rotational grazing, only one section of pasture is grazed at a time while the remainder of the pasture "rests." To accomplish this, pastures are subdivided into smaller areas (often referred to as **paddocks**) and livestock are moved from one paddock to another. Rotational grazing allows forage to renew energy reserves, to rebuild plant vigor, and to give long-term maximum production.

For rotational grazing to be successful, the timing of rotations must be adjusted to the growth stage of the forage. Unfortunately, rotational grazing has often been reduced to regular animal shifts from paddock to paddock based on rigid time schedules rather than in response to forage growth rate. Rigid schedules reduce the benefit of rotational grazing.

Rotational grazing can be practiced in a variety of intensities. Systems can range from 2 to 30 or more paddocks. **Intensive rotational grazing** involves a higher level of management with greater paddock numbers, shorter grazing periods, and longer rest periods. Generally the more intense the management, the greater the livestock production per acre.

This bulletin covers the basic principles underlying all types of rotational grazing. Intensive rotational grazing will be emphasized because it usually has a number of advantages over both continuous grazing and less intensive rotational systems, including

- more stable production during poor growing conditions (especially drought),
- greater yield potential,
- higher quality forage available,
- decreased weed and erosion problems, and
- more uniform soil fertility levels

There are many names for intensive rotational grazing: Voisin grazing, Hohenheim grazing, intensive grazing management, short duration grazing, Savory systems, strip grazing, controlled grazing, and high-intensity, low-frequency grazing. Although each term implies slight differences in management, they all refer to some sort of intensive rotational grazing system.

WHO IS USING ROTATIONAL GRAZING?

A number of farmers throughout the Midwest practice rotational grazing. These range from a large dairy farmer who rotationally grazes 1,600 head on his 2,100 acre all-grass farm to much smaller dairy, beef, sheep, hog, and even chicken operations. Most livestock have the potential to receive a substantial amount of their feed from pasture.

WHY USE ROTATIONAL GRAZING?

Everyone with livestock and grazing land can benefit from rotational grazing.

Economic Benefits

Most farmers are experimenting with rotational grazing because of the economic savings. Both start-up and maintenance costs are less than for

From: Pastures for Profit. Univ. of Wisconsin- Madison.

green chopping. The only capital cost specific to rotational grazing is fencing. Costs for new fencing range from $450 per mile for mobile electric fencing and fiberglass posts to $900 per mile for high-tensile electric fencing. Use of used materials can cut these costs considerably. Setting up the whole system (using new fencing, fencers, and water systems) costs from $40 to $70 per acre. The higher price range includes the cost of constructing livestock lanes.

If you haven't already invested in confinement feeding systems, this represents a tremendous savings; if you have, maintenance costs are reduced since your confinement system needs to be operated only during the cold months. Once in operation, grazing will reduce equipment, fertilizer, pesticide, and labor costs.

Feed costs, for example, which can account for 65% of total livestock production costs, can be drastically reduced. Studies by the Wisconsin Rural Development Center comparing rotational grazing to confined feeding systems document this. One dairy farmer saved an average of $130 per head in annual feed costs between 1987 and 1990 by using rotational grazing instead of green chopping. In addition, veterinary expenses, fuel, and labor costs were reduced. These savings were gained without any loss of milk production.

Time Savings

Many farmers are reluctant to try rotational grazing because of the time it takes to move livestock. However, on average, the farmer mentioned above found it to be less time consuming (3 hr/acre per year) than green chopping (8 hr/acre per year). Grazing may also decrease your need to make hay which takes an average of 7 hr/acre per season. This farmer spent only 15 minutes moving the fence each day. But to cut, haul, and feed greenchop required an hour per day.

What if you have to move a huge herd? A large-scale stocker farmer prefers to move 250 to 500 head at a time since he has found that it takes no more time to move large groups of cattle than it does to move small groups (such as 50 or less).

Environmental Benefits

Well-managed perennial pastures have several environmental advantages over tilled land: they dramatically decrease soil erosion potential, require minimal pesticides and fertilizers, and decrease the amount of barnyard runoff.

Data from the Soil Conservation Service shows that in 1990, an average of 4.8 tons of soil per acre was lost to erosion on Wisconsin cropland and an average of 2.6 tons of soil per acre was lost on Minnesota cropland. Converting erosion-prone land to pasture is a good way to minimize this loss since perennial pastures have an average soil loss of only 0.8 tons per acre. It also helps in complying with the nationwide "T by 2000" legislation whose goal is that erosion rates on all fields not exceed tolerable limits ("T") by the year 2000. Decreasing erosion rates will preserve the most fertile soil with higher water holding capacity for future crop production. It will also protect our water quality.

High levels of nitrates and pesticides in our ground and surface waters can cause human, livestock, and wildlife health problems. Pasturing has several water quality advantages. It reduces the amount of nitrates and pesticides which leach into our groundwater and contaminate surface waters. It also can reduce barnyard runoff which may destroy fish and wildlife habitat by enriching surface waters with nitrogen and phosphorous which promotes excessive aquatic plant growth (leading to low oxygen levels in the water which suffocates most water life).

Wildlife Advantages

Many native grassland birds, such as upland sandpipers, bobolinks, and meadowlarks, have experienced significant population declines within the past 50 years. Natural inhabitants of the prairie, these birds thrived in the extensive pastures which covered the state in the early 1900s. With the increased conversion of pasture to row crops and frequently-mowed hay fields, their habitat is being disturbed and their populations are now at risk.

Rotational grazing systems have the potential to reverse this decline because the rested paddocks can provide undisturbed nesting habitat. (However, converting existing under-grazed pasture into an intensive rotational system where forage is used more efficiently may be detrimental to wildlife.) Warm-season grass paddocks which aren't grazed until late June provide especially good nesting habitat. Game birds, such as pheasants, wild turkey, and quail also benefit from pastures, as do bluebirds whose favorite nesting sites are fenceposts. The wildlife benefits of rotational grazing will be greatest in those instances where cropland is converted to pasture since grassland, despite being grazed, provides greater nesting opportunity than cropland.

Pesticides can be very damaging to wildlife. Though often short lived in the environment, some insecticides are toxic to birds and mammals (including humans). Not only do they kill the target pest but many kill a wide range of insects, including predatory insects that could help prevent future pest outbreaks. Insecticides in surface waters may kill aquatic invertebrates (food for fish, shorebirds, and waterfowl). Herbicides can also be toxic to animals and may stunt or kill non-target vegetation which may serve as wildlife habitat.

Increased Pasture Productivity

Rotational grazing can help improve long-term pasture quality and fertility by favoring desirable pasture species and allowing for even manure distribution. Rotational grazing also can increase the amount of forage harvested per acre over continuous grazing by 1000 to 2000 lb dry matter per acre.

Aesthetics and Human Health Benefits

One of the greatest advantages to using rotational grazing is that it is a "peaceful way of farming." It is quieter than mechanically harvesting your feed and it gives you the excuse to stretch your legs and take a look at what's happening in your pasture. You might even hear the birds singing or see a deer grazing as you move the fence.

Plant Growth

PLANT GROWTH CURVE

A good understanding of the basics of plant growth is key to establishing and maintaining profitable pastures.

Plants get the energy needed for growth from the sun through photosynthesis which occurs in green leaves. The plant immediately converts this energy to carbohydrates which can either be used right away for growth or stored for future use.

Forage growth is slow when plants are small (early spring growth or after grazing). When plants have few green leaves, they must rely heavily on stored carbohydrates for their energy. As leaves get bigger, photosynthesis increases dramatically, allowing for rapid growth. Prior to flowering, most pasture plants are growing as fast as possible if other factors are not limiting. As plants mature, growth slows since most energy is diverted to flower and seed production when forage heads out (figure 1).

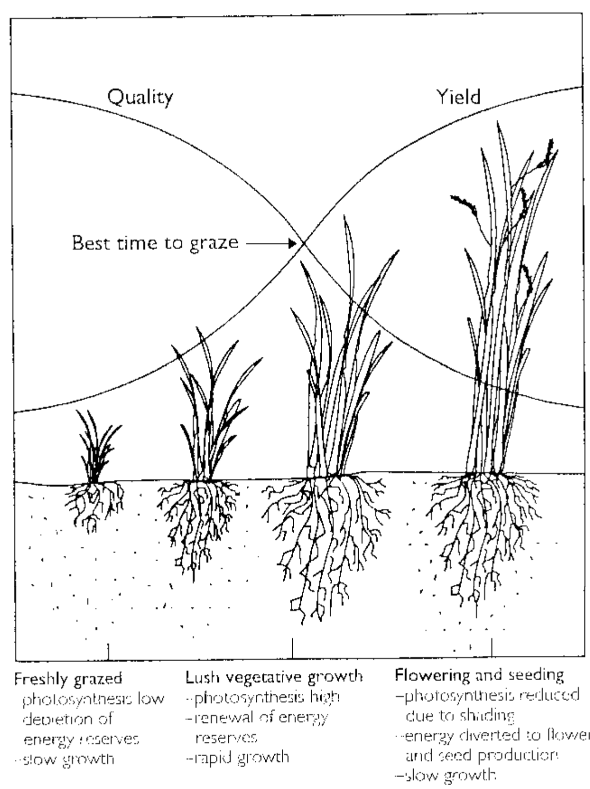


Figure 1. Forage growth curve

Forage quality decreases as plants grow older. This occurs because, as plants get larger and more stemmy, a greater percentage of nutrients and dry matter is tied up in non-digestible forms (such as lignin). Greater amounts of non-digestible fiber result in lower quality forage with decreased amounts of **total digestible nutrients (TDN)**.

A good manager needs to balance pasture quality with pasture yield. As shown in figure 1, *the best time to graze is immediately following the most rapid growth but before flowering and seeding.* At this stage, sufficient carbohydrate reserves have been built up to allow for rapid regrowth; in addition, both yield and quality are high. If grazing occurs before this stage when the forage has not had time to rebuild its carbohydrate reserves, yield will be low, the next regrowth may be slow and reduced, and winter survival may be decreased. One of the cornerstones of a successful grazing system is having rest periods long enough to allow for rapid forage regrowth.

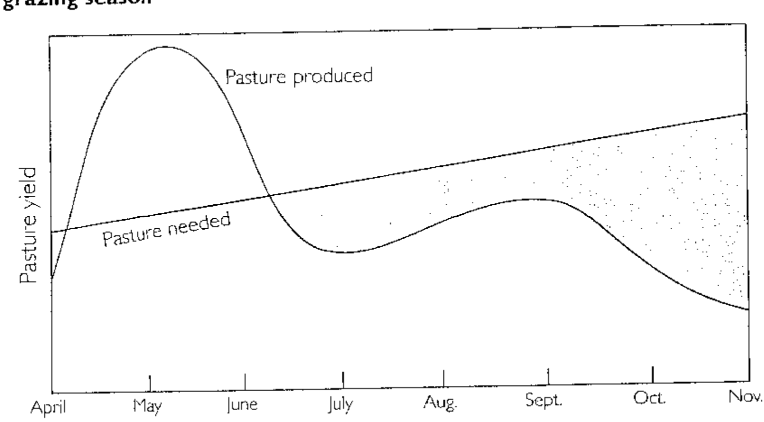
PLANT RESPONSE TO GRAZING

Grazing isn't "bad" for pasture plants. Plants from grasslands all over the world have special ways to cope with grazing. Grazing may actually stimulate pasture growth because old or dead leaves no longer shade young leaves.

Most pasture forages regrow from low-lying or underground stems, crowns, or roots which are not grazed off by livestock. Though their growing points are protected from grazing, few of these forages are well adapted to continuous grazing. Only plants such as Kentucky bluegrass, white clover, and many prostrate weeds whose low-growing leaves escape being completely grazed off, survive well under continuous grazing.

Taller growing forages, on the other hand, usually die out under continuous grazing since most of their leaves can be grazed off. They need rest between grazings in order to persist in a pasture, so are well suited to rotational grazing. If allowed to grow tall, they will shade out shorter forages and weeds. Pastures that are routinely rested may have less bluegrass and a larger percentage of taller growing species, even if tall species have not been recently seeded in the field.

Figure 2. The typical pattern of pasture production during the grazing season



SEASONAL PASTURE GROWTH PATTERNS

In order to make the most out of your pasture, forage production (or availability) should correspond with livestock needs. Livestock need forage all year round, but providing an adequate supply of yearly forage from pasture alone is difficult to do in the upper Midwest. First of all, the growing season is short, ranging from about 185 days in southern Wisconsin to 142 days in northern Minnesota. Secondly, pasture production is uneven during the growing season while livestock feed needs are stable or increasing (figure 2).

One way to lessen this problem is to make hay from some pastures during periods of rapid forage growth. Also, lambing or calving before rapid spring growth will allow the period of highest animal need to match the greatest production of quality forage. Some dairy farmers have switched to seasonal milking to achieve this goal. You can even out pasture production throughout the season and extend the grazing season using the methods described below.

Managing for More Uniform Pasture Growth

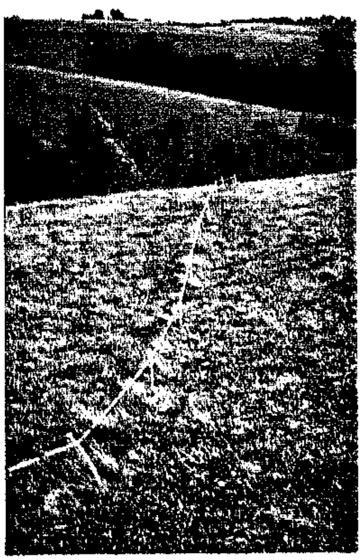
Healthy, unstressed plants will start to grow earlier in the spring, produce higher yields during the summer, and continue growing longer in the fall. Just switching from continuous to rotational grazing can extend the grazing season and boost yields, since rotational grazing, by virtue of its rest periods, is less stressful to the forage. A good fertility program will have similar results.

It is suggested that these worksheets be used for estimating stocking numbers for the first year of a grazing system and that stocking rates be set conservatively until a better understanding of the productive potential of the site can be determined through actual grazing experience. To determine the productivity, keeping accurate records is essential. (See Chapter 4, Monitoring and evaluating the grazing system.)

A constant utilization rate is difficult to implement in practice throughout a growing season. Err on the conservative side when entering utilization percentage in these worksheets. Because most forage in a pasture eventually disappears, producers often overestimate how much is used. The proportion of potential nutrients wasted is often greater than can be seen because of the combination of the reduced quality of mature forage and the actual wasting of dying forage. Grazing managers frequently indicate that they learn a lot about their pasture systems during the first grazing season and can make better adjustments based on their experiences.

Rotational grazing — paddock layout and construction

Once the decision has been made to develop a rotational grazing system and the preliminary calculations are made, you should have some idea of the basic plan — how many paddocks or pastures will be needed and their approximate size. The challenge now is how to best fit the basic plan to the conditions of the specific site. There are few hard rules for paddock layout, but there are some good guidelines. The most important consideration in layout and design is to design with flexibility in mind.



In the start-up year of a rotational grazing system, it is best not to build or install anything that can't be easily moved or shifted.

One guideline often suggested to maximize flexibility in the start-up year of a system is "don't build or install anything that cannot be easily moved or shifted." If the site has no preexisting fences or water sites, this ultraflexible approach may be feasible. But many sites already have some existing permanent fencing, water sites, and handling facilities that may be suitable to include in the layout design. There is always the risk, however, that too much of the existing fencing will be kept in an effort to economize at the sacrifice of a more flexible or efficient layout. Don't be afraid to invest in some temporary fencing and water distribution materials in the early years of a rotational grazing system. Many producers are not really satisfied with their first design and are generally glad they did not install it permanently.

Other possibilities for flexibility that should be considered include laying out a few paddocks initially with the intent of further divisions in the future; installing some main fence lines and lanes with permanent fencing materials but using temporary or semipermanent fencing for all other internal divisions to allow for more efficient hay harvest and fertilization; or using temporary fencing to create variable-sized paddocks as the season and regrowth characteristics dictate, an example being the daily or half-day strip grazing practiced by dairy graziers.

Seasonal dairy operations create constraints upon the grazing system because animals must travel twice daily to and from the milking parlor. Ideally the parlor should be centrally located within the grazing area. However, most farmers aren't going to build new parlors when starting a rotational grazing system or using a dairy operation that extensively uses pasture.

For every site there will likely be several good and workable layouts. Get a good to-scale map of the site, and walk across the site to get a sense of the general lay-of-the-land, paying special attention to ditches, drainage areas, trees, existing livestock trails, and other features of the site that may influence or interfere with movement

From: Pasture Management Guide by Iowa State Univ. Extension

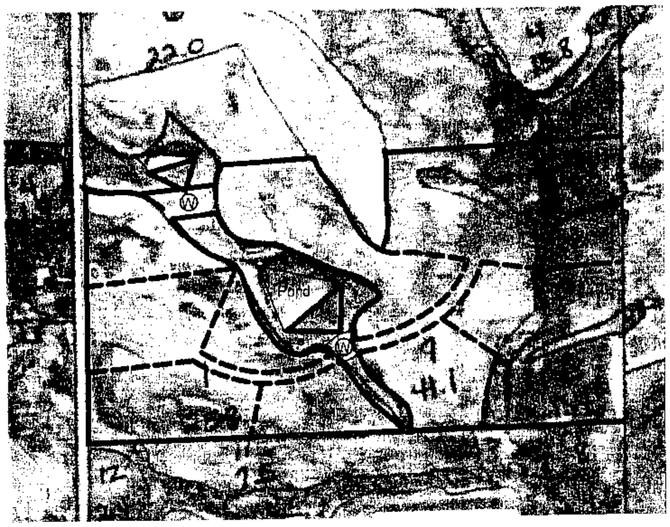
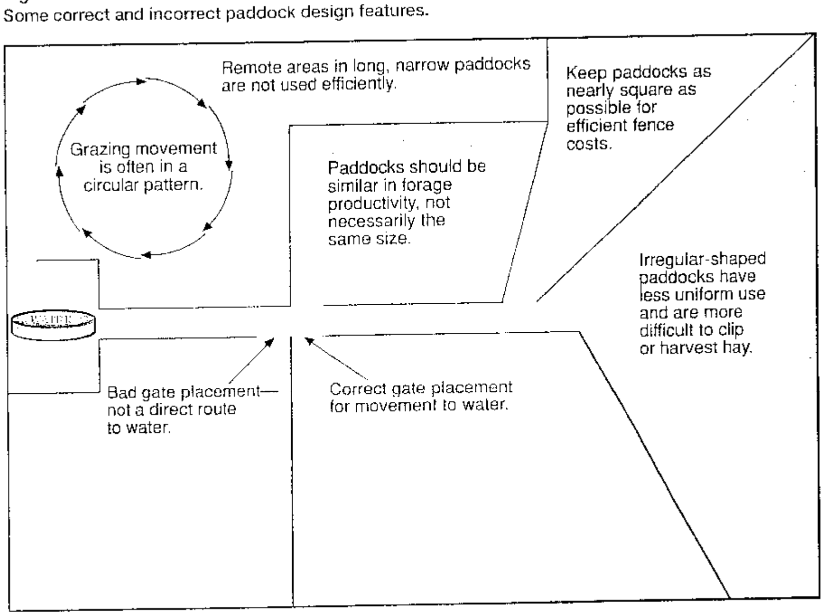


Figure 20
A practical place to begin the pasture layout process is on an aerial map or soil map of the pasture. Many alternate fencing plans can be evaluated before going to the field.

of livestock (Figure 20). Consider paddock and lane arrangements by using the list of guidelines. See Figure 21 for layout guidelines and examples of correct and incorrect design features.

It will not be possible to accommodate all of these guidelines in every design. Draw several alternative layouts on paper and select the two or three that require the least amount of fencing. View these in regard to their potential to add additional water sites in the paddocks. A goal should be to have a water site within 800 feet of all areas of the system; a water point in each paddock is considered to be best.

Figure 21
Some correct and incorrect paddock design features.



Guidelines for paddocks

Paddocks should be as square as possible (no more than 3:1 length: width).

To lessen erosion, avoid aligning paddocks from the top of a hill to the bottom. If possible, make hilltop paddocks, sidehill paddocks, and bottomland paddocks.

If pasture forage types vary across the pasture, attempt to confine the different forage types to separate paddocks.

It is more important that paddocks be as equal as possible in forage productivity than equal in area.

Forage on south-facing slopes grows at a different rate than that on north-facing slopes. If possible, fence slope orientations separately.

Guidelines for lanes

Avoid orienting lanes up and down slopes. If possible, orient lanes on the contour.

Avoid directing lanes through wet or low areas.

Place paddock gates in the corner of the paddock and nearest to the water source.

Make lanes wide enough for free movement of vehicular traffic and easy access to paddocks.

Make paddock gate widths equal to the width of the lane, so the open paddock gate can be used to block animals from unneeded parts of the lane.

Take the two or three best designs to the field and view the areas again with the alternative designs in mind. Use flags or stakes on proposed fence lines. Have grazing advisors from the ISU Extension, NRCS, consultants, or other experienced rotational graziers visit the pasture to provide additional suggestions and comments. Visit other grazing systems for guidance about mistakes made, precautions, and features that others feel are desirable.

Frequent lane use and poor layout design lead to excessive erosion problems.

Once a design is chosen, begin assessing the suitability of existing fence. Use what is still useful, but seriously consider the costs and benefits of new construction. There are many new fencing technologies available, whether permanent, semipermanent, or temporary. All can be adapted to electrification. Begin to acquire fencing and water distribution materials, and begin installing the layout. The list suggests some do's and don'ts for the installation of electric fencing.

The do's and don'ts of electric fencing

Do's

- Use a low impedance energizer that provides 1 joule of power per mile of fence
- Install a surge protector
- Use adequate ground rods (3 feet per 1 joule of output, preferably in a drainage area)
- Install lightning protection
- Use good materials and use them properly
- Make good connections — wire nuts where needed
- Use adequate wire gauge from the energizer to the line fence
- Use a fence tester to check power
- Bury insulated wire under gate openings
- Place gates for natural animal flow
- Use visible gates
- Wire electric gates so they are energized only when closed

Keep lane length and use to a minimum. If possible, fit lanes to the contour of the land.

Don'ts

- Use underpowered energizer
- Electrify barbed wire
- Skimp on material quality
- Turn out untrained animals
- Overbuild or underbuild
- Use cheap insulators
- Crowd the grazing herd

Designing a pasture system — an example

Designing a pasture system puts your proposed paddock rotational plan in place on your site. Figures 22 through 24 are examples of a farm that is switching from continuous grazing to an 8-paddock rotational grazing system. The water sources for this pasture are a good well and a shallow pond, both located at the building site. The buildings are in the lowest part of the site. There is a low, wet area northwest of the buildings, a south-facing slope along the northern property line, and a north-facing slope along the south property line.

Example of transition from continuous into rotational grazing

Figure 22
Existing continuously grazed pasture. Water and handling facilities are at the building site.

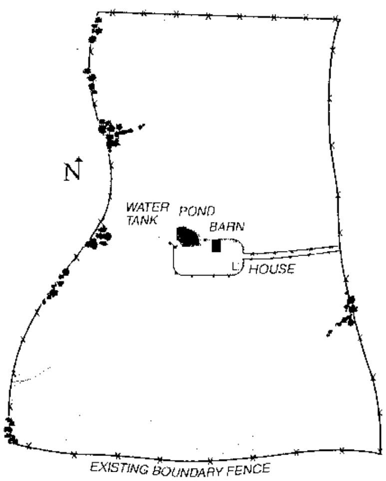


Figure 23
The site divided into 4 pastures. All pastures are accessible to water at the building site. This may be the extent of the changes planned, or a partial installation of a more complex rotational system plan.

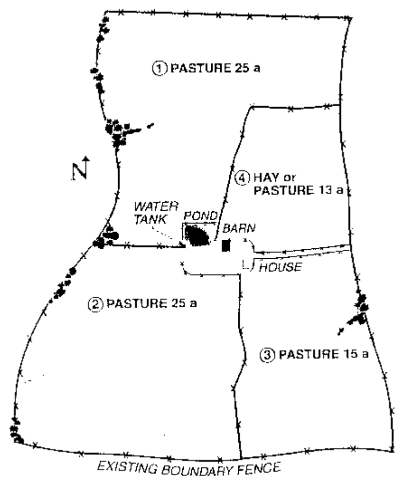
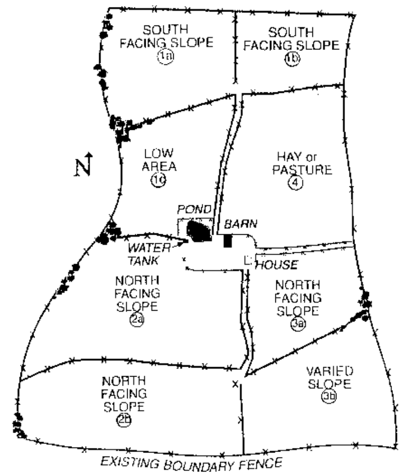


Figure 24
The site divided into 8 paddocks with lanes providing access to other paddocks and to water at the building site. A water delivery system could be installed for this plan to provide water accessibility in each paddock.



The land with buildings and perimeter fence is shown in Figure 22. The 8-paddock system can be implemented gradually over a period of years or all in one year. Figure 23 shows an example of a first-year conversion to a 4-pasture rotation. To maintain water quality, the pond has been fenced off. Well water will be pumped to a waterer in the barnyard. All pastures have a gate at the barnyard. This avoids the need to create lanes and makes livestock handling and rotation possible at a central handling facility. It also allows 1 water source to provide water for all pastures. This arrangement is not necessary for most pasturing systems but essential for milking herds that return to the barn daily. The pasture northeast of the buildings was fenced separately because it is reasonably flat and could be left for hay making in periods of surplus forage. Different slopes were not fenced separately, but with just 4 divisions there are limits to how much fine tuning can be done according to the above considerations. This first-year conversion to a 4-pasture rotation will result in improvement in production over the continuously grazed system of Figure 22. The fencing can be either permanent or temporary and may be the final stage of setting up a 4-pasture system or the first step to establishing the proposed 8-paddock rotational system.

Figure 24 shows the next set of divisions needed to form the 8-paddock grazing system. Further divisions from the previous figure have been made with portable fencing, which can be moved when harvesting hay or spreading fertilizer. In this further fencing refinement, the south-facing slopes were all fenced separately from other areas because they can be grazed earlier than other paddocks in the spring, and the low area northwest of the pond was fenced into a separate paddock because production would be much higher there than in other areas during dry spells. Note that the paddocks are not all the same size. It is more important that the paddocks yield roughly equal amounts of forage than that they have equal areas. (If paddocks are not equal in forage production, you must manage rotations flexibly based on forage that is available.)

Note that in Figure 24 access to water and handling facilities at the building site and access to other paddocks is through lanes. A water delivery system using pressurized water lines could easily be installed in this 8-paddock layout, which would provide water access in each paddock.

Utah Forest Facts

Utah State University Extension

Rural/Conservation Forestry

NR/FF/005

Windbreak Benefits and Design

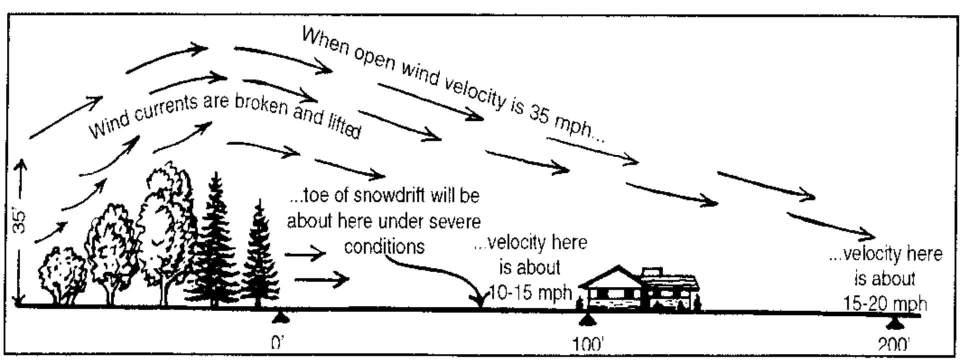
Mike Kuhns, State Extension Forester

This fact sheet gives an overview on the use of tree and shrub windbreaks. It describes the many benefits of windbreaks and goes over important aspects of windbreak design.

Why Windbreaks?

Utahns have a heritage of tree planting going back to when the state was first settled. Early settlers often would bring seeds or cuttings of favorite trees from their former homes to grow in Utah. Many planted windbreaks and hedgerows to protect crops, orchards, livestock, and homesteads.

Unfortunately, this tree planting heritage, and particularly windbreak planting, has faded. Most windbreaks in Utah are old-fashioned, outdated, and sometimes ineffective. Others that were in the way or considered unnecessary have been removed. Windbreaks still belong in modern agriculture though, and should be used more in non-agricultural areas as well.



A dense windbreak provides good wind protection and snow drift control. Adapted from Montana State University Extension Bulletin 366.

Windbreak Benefits

Tree and shrub windbreaks are valuable conservation tools with many functions. Their benefits include:

✓*Reduced soil erosion* — Windbreaks prevent wind erosion for 10 to 20 times their height downwind. They also filter wind-blown soil particles from the air.

✓*Crop protection* — Windbreaks can increase crop yields up to 44%. Wind protection reduces crop water use, increases a plant's ability to make food, and may increase pollination. Quality of fruit and other high value crops can be increased due to reduced sand and soil abrasion.

✓*Energy conservation* — Windbreaks can reduce winter heating costs 20 to 40% by reducing cold air infiltration into buildings. In summer water evaporation from leaves directly cools the air. Windbreaks can be designed to provide energy savings for a small residential lot, a farmstead, or an entire housing development.

✓*Snow control* — Windbreaks can serve as "living snowfences", controlling drifts near roads, buildings, or livestock or distributing snow evenly over large areas like crop fields. Money and energy are saved by reduced need for snow plowing and artificial snowfences.

✓*Livestock protection* — Windbreaks can be used as "outdoor barns," sheltered areas for feeding, calving, and other livestock-related activities.

✓*Wildlife habitat* — In open areas where windbreaks are needed for wind reduction, they may also provide the only woody cover and food necessary for some wildlife species.

✓*Beauty* — Trees provide visual screening and permanence in the landscape that other types of plants can not.

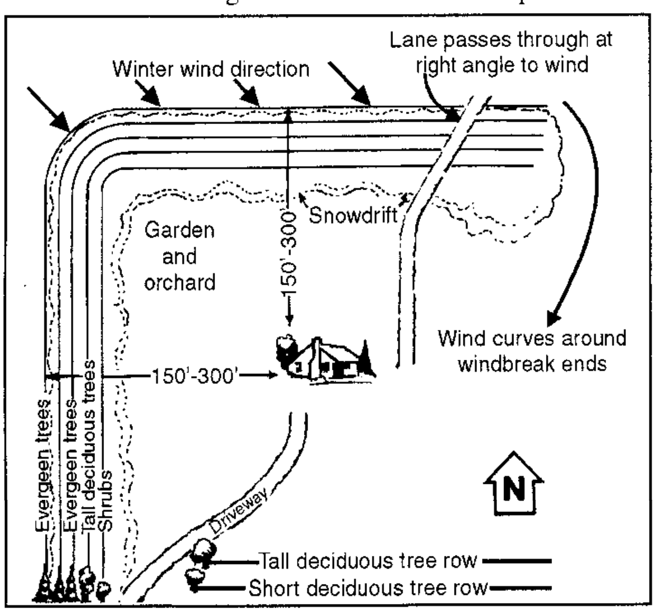
✓*Tree products* — Windbreaks can supply firewood or other products while maintaining conservation functions.

Windbreak Design

Windbreak design depends on your objectives. A basic requirement of any windbreak is a fairly continuous row of trees and/or shrubs placed to provide wind protection or other benefits (we will not cover fences or windbreaks of non-woody plants here, but the principles are similar). The most important factors in windbreak design for wind protection are height, density, orientation, and length.

Height — Windbreaks reduce wind speeds up to 30 times their height (H) downwind. Height increases with age (to a point) and depends on the tree species used. The effective height of a multi-row windbreak is that of the tallest row. Large areas must have a windbreak every 10H to 20H for full protection. For example, 30 foot tall windbreaks should be planted every 300 to 600 feet to effectively protect a large area.

Density — All windbreaks, except solid fences or walls, let some wind through. Dense windbreaks stop more wind by having a greater proportion of solid area to open area, but density is not always good. As wind is deflected up and over a windbreak, low pressure on the downwind side draws the wind back down. This low pressure is stronger in dense windbreaks, drawing the wind down quickly and reducing the protected area size. Letting some wind through reduces the low pressure and results in a larger protected area.



Typical dense farmstead windbreak for north to west winter wind direction. Distances are from house to windbreak's upwind edge. Snowdrift will move downwind and be shallower with less density. Adapted from Kansas State University Extension Bulletin C-645.

Density is affected by the number of tree rows, branch and foliage density (determined by tree species), and tree spacing within rows. Flexible branches and foliage move out of the way as wind speeds increase, making windbreaks less dense. Horizontal or vertical gaps in an otherwise dense windbreak funnel wind and locally increase wind speeds.

Windbreak density is the ratio of the solid portion of the windbreak to its total area and is not easy to measure. A windbreak with zero density has maximum openings and lets wind through unchecked, while a windbreak with 100% density lets no wind through (both situations are impossible). Conceptually, a 50% dense windbreak should let about one-half of the wind through.

Windbreaks with 60 to 80% density give very good protection over a fairly small area like a farmstead, residential lot, or feedlot. A windbreak with 40 to 60% density can protect a large area like a crop field. Windbreak densities below 20% provide little wind reduction.

Snow deposition also is affected by windbreak density. Very dense windbreaks cause a deep but narrow drift to be deposited near the windbreak, usually within 3H to 5H. To spread snow out evenly over a large area, use a windbreak with a density as low as 25 to 35%.

Orientation — Windbreaks should be oriented at right angles to the prevailing wind direction to protect the greatest land area. Remember that prevailing wind directions may vary between summer and winter. Use multiple-leg windbreaks in areas with variable-direction winds to give the most protection. In hilly areas, locate windbreaks just upwind of the hill crest for greatest benefit. Placing a windbreak on the crest will result in a small protected area because of extreme low pressure and turbulence created on the downwind and downhill side.

Length — Longer windbreaks protect more area. Wind tends to curve around the ends of a windbreak because of the low pressure effect mentioned above. Therefore, windbreaks should be long in relation to their height. A length of at least ten times the windbreak height is best.

Species — Trees and shrubs for windbreak planting are selected for hardiness, good form and foliage, fairly fast growth, longevity, low maintenance needs, and pest resistance. Be sure to choose species that are suitable for your planting site and that fit your windbreak design. Good species for windbreaks in Utah include:

Species or Windbreak Type	Within Row Spacing	Between Row Spacing
Shrubs and narrow-crowned deciduous trees	3' to 6'	minimum 12' to 20'; 4' wider than cultivating equipment
Smaller evergreen trees	6' to 12'	same as above
Larger evergreen trees	8' to 14'	same as above
Small deciduous trees	8' to 12'	same as above
Large deciduous trees	8' to 18'	20'
Single-row evergreen or twin-row high-density	6' to 8'	same as within row (for twin-row high-density)

✓Evergreen trees (conifers) — junipers (*Juniperus* species), pines (*Pinus* species), spruces (*Picea* species)

✓Deciduous trees — poplars and cottonwoods (*Populus* species), willows (*Salix* species), honeylocust (*Gleditsia triacanthos*), black locust (*Robinia pseudoacacia*), hackberry (*Celtis occidentalis*), ashes (*Fraxinus* species), elms (*Ulmus* species), mulberries (*Morus* species)

✓Shrubs — false indigo or indigobush (*Amorpha fruticosa*), Siberian peashrub (*Caragana arborescens*), sumacs (*Rhus* species), cotoneasters (*Cotoneaster* species), plum and cherries (*Prunus* species), shrub roses (*Rosa* species), silver buffaloberry (*Shepherdia argentea*), common lilac (*Syringa vulgaris*), golden currant (*Ribes aureum*), and other hardy natives depending on site

Other Design Considerations — Windbreaks can be effective with few rows. Single-row windbreaks can be used where space is limited. These consist of an evergreen row for year-around protection, a single shrub row, or a densely-branched deciduous tree row. Though a deciduous trees loses its leaves in winter, it still can provide good crop protection during the growing season, provides some wind protection, and can control snow in winter. Proper tree spacing and maintenance are very important in single-row windbreaks. Gaps cannot be allowed since there are no trees in adjacent rows to fill them.

Another possibility for an area with limited space is a twin-row high-density windbreak. This design uses two evergreen rows, normally redcedar or juniper, planted close together with a tree in one row filling a gap in the next row. This design fills in and becomes effective very quickly after planting and takes little space.

Using several different tree and shrub species in a windbreak decreases the likelihood of serious disease or insect problems. Wind protection can be improved by combining a row of low, dense shrubs, a row of medium-tall evergreens that retain foliage on their lower branches throughout their life, and a row of tall deciduous or evergreen trees. Species diversity also improves a windbreak's wildlife habitat value.

Windbreaks do not need to be straight to be effective. Curves and angles often are more visually appealing and natural looking. Considerable experience is needed, however, to predict the effects of such designs on windbreak function.

For More Information

For more information on windbreaks contact the USU Extension office in your county, the Utah Division of Forestry, Fire & State Lands (FF&SL; phone 801-538-5555 for the location of your local office), or the Natural Resources Conservation Service (NRCS). FF&SL and the NRCS can help with design and planting, and cost-share assistance may be available.

Tree and shrub seedlings for conservation plantings are available through FF&SL's Lone Peak Conservation Nursery, 271 West Bitterbrush Lane, Draper, UT 84020-9599; phone 801-571-0900; fax 801-571-0460; *www.nr.state.ut.us/slf/lonepeak/home2.htm*. The nursery has seedlings of nearly 90 species of trees, shrubs, and other plants at reasonable prices. Private nurseries also carry appropriate plants. Large transplants usually are not cost effective for windbreaks because of the large numbers of plants needed.

A 50 minute video titled "Green Side Up" is available that covers pre-planting tree care, hand planting, and machine planting. Send a check for $15 to "Green Side Up," Extension Forestry, Utah State University, Logan, UT 84322-5215.

Windbreak Design Examples

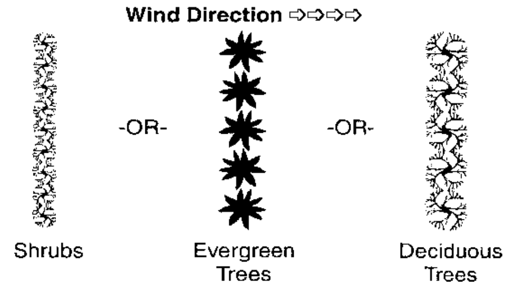
One-Row Windbreak

✓for field or orchard protection, snow "trip" row, or in urban setting with little space; uses little land; limited value to wildlife.

✓densely planted for maximum effect.

✓maintenance and replanting essential to avoid gaps from dead or weak trees.

✓use shrubs, dense evergreens that retain lower limbs and foliage like junipers, spruces, and arborvitaes (for moister sites), or densely branched deciduous trees, preferably with narrow crowns.



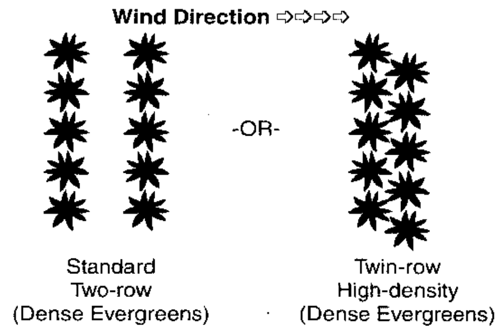
Two-Row Windbreak

✓for field or orchard protection, outdoor barn, or urban setting; some wildlife value.

✓densely planted as with one-row above.

✓twin-row high-density has trees planted alternately, with a space in one row filled by a tree in the other row; rows close together; usually use junipers, spruces, arborvitaes (for moister sites), or Austrian pine

✓standard two-row uses two rows of dense evergreens (juniper, etc.), or one evergreen and one shrub or deciduous tree row; standard between-row spacing.



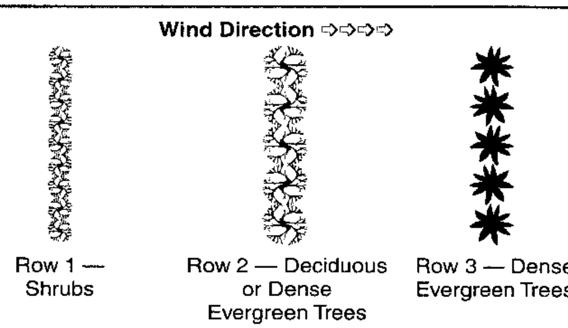
Three-Row Windbreak

✓for field protection where more land is available; farmstead and feedlot protection; wildlife value increased with row of food-bearing shrubs.

✓at least one row of dense evergreens (juniper, etc.), other row(s) consisting of deciduous trees, shrubs, or pines.

✓standard between-row spacing.

✓can alternate similar species within rows.



Four-Row (or more) Windbreak

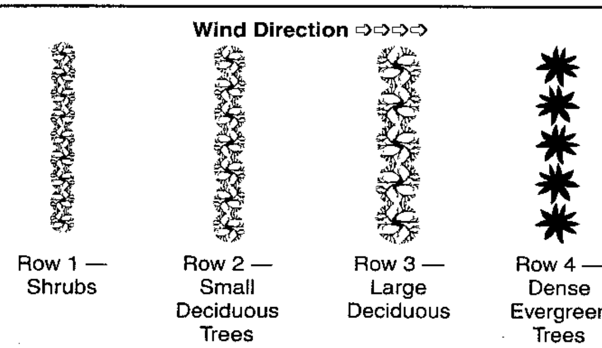
✓for farmstead and feedlot protection; excellent for wildlife.

✓use mix of shrubs, deciduous trees, and at least one row of dense evergreen trees.

✓standard between-row spacing.

✓can alternate similar species within rows.

✓great design flexibility; uses a lot of land.



Acknowledgments

Thanks to G. Scott Zeidler of the Division of Forestry, Fire & State Lands, Scott Burroughs (formerly Stewardship Coordinator with the Division), and Jana Johnston of the Natural Resources Conservation Service for their review of this fact sheet and for their suggestions.

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Robert L. Gilliland, Vice-President and Director, Cooperative Extension Service, Utah State University, Logan, Utah. Published June 1998.

State of Utah

Department of Natural Resources

Division of Forestry, Fire & State Lands

MIKE STYLER
Executive Director

A. JOEL FRANDSEN
State Forester/ Division Director

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Lieutenant Governor

February 18, 2005

Lone Peak Nursery provides quality plants, service and training to help conserve and enhance our environment. We provide more than 90 species of native and adapted trees, shrubs, grasses and wetland plants for use in restoration and conservation projects. The Utah Division of Forestry, Fire and State Lands operates the nursery on a 35 acre farm in Draper, Utah, producing one million seedlings each year.

Seed Selection

Plants are produced from locally adapted seed sources that have genetic traits which help them adapt to our specific geographical locations. These traits are influenced by elevation, precipitation, soil condition and temperature.

Custom Growing

The nursery provides special growing services. You may request a plant species grown from a specific geographic source. Following a two year growing cycle, you may then purchase the plants as needed.

Education & Research

Lone Peak Nursery promotes wetland restoration and enhancement through researching new methods of raising plants. Working in partnership with other agencies we've introduced many new plant species for conservation purposes. Proper plant care is taught using videos and brochures, which illustrate correct planting procedures. These visual aids are available through the Nursery. Group tours for those interested in seedling production and conservation are conducted upon request.

Who May Order

Plants are available to any agency, group or single person. The seedlings are not intended for landscaping purposes. Minimum order of 100 seedlings is required. Orders may be broken down into lots of 25 seedlings per species.

Delivery

Delivery during the spring is provided to several statewide locations. Seedlings may also be shipped Federal Express or may be picked up at the nursery.

Contact

If you have questions concerning the nursery or our plants, please contact:

Nursery Manger: Edie Trimmer at 801.571.0900 or email at edietrimmer@utah.gov

Lone Peak Conservation Nursery, 271 West Bitterbrush, Draper UT 84020
telephone (801) 571-0900 • facsimile (801) 571-0468 • *www.forestry.utah.gov*

Drip Irrigation

by Mike Kuhns, Extension Forestry Specialist

Drip irrigation can be a good way to reduce water use when irrigating trees, but it is not a simple matter to do it right. This article covers some of the important factors to consider when designing and using a drip irrigation system for watering trees.

Design Considerations

- Water must be clean--filtration often is needed.
- Pressure regulation may be needed. Most drip systems operate at 10 to 30 PSI.
- Consider elevation changes. For every foot of elevation change, pressure changes by 0.433 PSI (increases as elevation drops, or decreases as elevation rises). Keep this in mind when designing drip systems for sloped areas.
- The system must be able to wet at least 50% of the root area of each plant (60% or more is better). Root growth will be confined to moist soil. If the drip system wets too small an area, plants will become root-bound, like a large houseplant growing in a small pot.
- A plant's root area for these purposes is considered to be within the drip-line (under the crown), even though woody plant root systems typically extend well beyond the crown edge.
- The drip system must be designed to meet the needs of a mature plant in the hottest time of the year.
- Emitters must be spaced to avoid toxic salt build-up around plants.
- Emitters should be above-ground. This allows visual inspection to see that the system is working. It also prevents root intrusion into emitters.
- Special low pressure backflow preventers should be used when connecting to culinary water systems.

Calculating Water Use by Mature Plants

Water used or needed per plant is expressed as maximum daily potential evapotranspiration, and is calculated as follows:

Gallons per Plant = 0.623 x Plant Area x Plant Factor x Potential ET (evapotranspiration) per Day / Drip System Efficiency

0.623 Conversion Factor

This conversion factor is simply the gallons of water applied when you irrigate one square foot of ground with one inch of water.

Plant Area

Plant Area = Diameter of drip-line or crown diameter squared x 0.7854

Example: A tree has a 10 foot diameter crown, measured from drip-line to drip-line.
Plant Area = 10 x 10 x 0.7854 = 78.54 square feet

For shrubs planted in a grid, multiply plant spacing to get plant area per shrub. For example, if shrubs are planted on a 4' by 4' spacing, 4 x 4 = 16 square feet per shrub.

Plant Factor

This is factor that helps correct for the fact that not all plants use water at the same rate under the same conditions. The following are examples of some research-derived plant factors.

- 1.00 Ground covers, flower beds, evergreens, some perennials, small shrubs (under 4' tall), vines
- 0.85 Apples, cherries, walnuts
- 0.80 Mature shade trees (broadleaved trees)
- 0.75 Pecans, peaches, plums, pears, apricots, almonds
- 0.70 Native plants in semi-arid areas, some ornamental plants, large shrubs (over 4' tall)
- 0.40 Established low-water use native or other low water-use plants

Potential Evapotranspiration

Potential evapotranspiration (PET) for Moab = 0.35-0.40 inches per day; for most of the rest of Utah (slightly cooler and moister climate) PET = 0.25-0.30 inches per day. Your local Extension office may know the PET, even on a week-by-week basis.

Drip System Efficiency

Most drip systems are 85 to 90% efficient; 85 to 90% of the water applied is actually used by the plant. This figure is expressed in decimal form in the calculation (85% = 0.85)

Sample Water Use Calculation

You want to calculate the water needed (maximum daily PET) for a mature, broadleaved shade tree that's not bery drought tolerant with a 10 foot diameter crown (measures 10 feet from drip-line to drip-line). The PET for the area is 0.25 inches per day, and the drip system is 90% efficient.

Gallons per day = 0.623 x 78.54 sq.ft. plant area x 0.80 plant factor x 0.25 PET / 0.90 drip system efficiency = 10.9 gallons per day used by this tree.

Emitter Spacing and Numbers

Soil texture determines how much area is wetted by each emitter:
Sandy texture -- 5 to 21 square feet
Loam texture -- 21 to 65 square feet
Clay texture -- 65 to 161 square feet

To calculate the number of emitters needed for each plant:

Number of Emitters = Area per Plant x % of Area to be Wetted /
Area Wetted per Emitter

For example, you have a 15 foot diameter (crown diameter) tree growing on loam soil. You want to wet 60% of the root area. The plant area is 15' x 15' x 0.7854 = 176.71 square feet. Area wetted per emitter is 21 square feet (loam soil, conservative figure).

Number of Emitters = 176.71 square feet x 0.60 / 21 square feet per emitter = 5 Emitters Needed

These 5 emitters would be distributed evenly under the tree's crown.

Final Considerations

Once you have calculated the amount of water and the number of emitters needed, you will need to decide on an emitter size (flow per unit of time) on a watering schedule (how long you irrigate and how often) that will deliver the needed amount of water. Factors like the infiltration rate of your soil and the timing and duration of your water availability will need to be considered.

Credits: This article is based partly on an article written by Jimmy Tipton of University of Arizona Cooperative Extension.

Updated 10/7/2003