TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE Portland, Oregon SOIL CONSERVATION SERVICE

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PLANNING IRRIGATION PASTURE SYSTEMS

Planning Irrigation Pasture Systems can be highly profitable or may barely pay for the water applied. Production of beef up to 800 and 1400 pounds per acre is being accomplished, for example. This makes pasture a high income crop under intensive management.

High yields result from management factors that are all-important to success. A recent Idaho pasture publication sets forth a number of formulas that help the technician determine, with the cooperator, whether he, his irrigation system, and his pasture layout are ready for a well balanced pasture program and top management. Portions of this publication are presented here and should be very helpful in planning. Besides information on plant management, fertilization, bloat and pasture care, the use of formulas to arrive at designable pasture sizes and numbers, grazing schedules and irrigation intervals are shown. Several schematic examples of pasture systems are shown. These may be used as is or revised as needed by use of the formulas to arrive at the best combination of grazing periods, regrowth periods and irrigation cycles.

MANAGING IRRIGATED PASTURES FOLLOWING ESTABLISHMENT

1. Pasture Management - Once established, pastures must be properly managed to remain vigorous and productive. A rotational system of use that will meet the growth needs of the plants, promote uniform forage utilization and correlate irrigation frequencies with grazing cycles, is essential to good pasture returns.

   a. Plant Management - Spring growth starts from root-stored food reserves. Most plants continue to use their root food reserves until they have about 6 inches of growth. It is during the following rapid growth period that food reserves are stored in the plant's root system. The rapid growth period slows when the plants head or bud and stop at or about flowering time. The root-stored food reserves decline gradually from seed set until seed maturity. The greatest yield of total digestible nutrients per acre occurs about the time flowering starts and then declines steadily as the plants mature.

   Grazing plants early while they are still using food reserves stored in the roots will weaken them and slow their regrowth rate. Continuous grazing at this stage will deplete root reserves to the extent plants die or are crowded out by less palatable weedy species. Plants allowed to mature beyond the flowering stage become less nutritious and less palatable.

   The optimum time to graze or mow most plants is at the end of the rapid growth period or about the time they start flowering. The first spring grazing each year must be started before this stage is reached or most of the pasture area will have to be mowed for hay to keep the plants from getting too mature. The time to start spring grazing of legume-grass pastures is normally based on the growth stage of the legume; alfalfa 10-14 inches, birdsfoot trefoil 8-12 inches, and most clovers 8-10 inches. Most grasses should have at least 8 inches growth before spring grazing is started. Tall wheatgrass should be allowed to make at least 16 inches of growth before being grazed and Kentucky bluegrass about 6 inches.

   Grasses should not be grazed so close that regrowth is started from root-stored food reserves. With most grasses, leaving an average stubble height of 6 inches at the end of each grazing will allow rapid recovery. Stubble heights of 6 inches are considered minimum for the recommended wheatgrasses and reed canarygrass, while a stubble height of 3-4 inches would be adequate for Kentucky bluegrass and white dutch clover. Stubble heights as recommended above, should be considered as minimum for winter protection. The time of regrowth period required for a plant to again reach optimum grazing readiness following grazing varies by species and variety. Legumes are more sensitive to grazing intervals than are most grasses and the rotation system should be based on their needs. Alfalfa requires a regrowth period of 28-42 days, birdsfoot trefoil 26-30 days, and white dutch clover 21-42 days.

b. Forage Utilization - Patchy grazing that allows some plants to over-mature and others to be overgrazed reduces pasture yields. Patchy grazing is a result of allowing the livestock excess forage so that they can graze selectively. Confining or fencing the livestock into smaller pasture units (reducing the grazing period) will promote uniform forage utilization and higher pasture yields. Pasture units large enough to supply the forage needs of the herd for 3-4 days per grazing cycle will be grazed more uniformly. When the grazing period is shortened to less than 3-4 days per grazing cycle, fewer plants are left ungrazed and pasture yields are increased. Grazing intervals of one day or less per grazing cycle are common and some herds (beef and dairy) are moved as often as two to three times a day. This practice is known as strip or daily ration grazing.

Livestock, when concentrated in small pasture units at the rate of thirty or more head of mature cows or their equivalent per acre, can be moved to leaved the desired amount of stubble. The trick is to move the herd to new pasture just as soon as the desired stubble height is reached. Three or four such moves and the cows get the habit, move to the fence and bellow to be let into the next pasture.

c. Irrigation Frequencies - Maximum production from irrigated pastures requires timely irrigations and the exclusion of livestock when the soils are wet. This avoids soil compaction and plant injury.

Roots of most pasture plants, soil micro-organisms, and available plant foods are concentrated in the upper one or two feet of soil. Seventy percent or more of the water used by grasses and legumes is taken from the upper one to two feet of soil. Keeping the upper two feet of soil at 50-65 per cent of its readily available water-holding capacity will assure maximum plant growth. Soils too dry or too wet slow plant growth by reducing the uptake of elements essential to plant growth. A pasture should be irrigated whenever the soil moisture level is about half-way between wilting point and field capacity. Examining the soil is the best way to determine when to irrigate. Waiting for plants to show stress will result in growth slow-up and loss in forage yields. A final irrigation following the last grazing in the fall is beneficial.

Only enough water to bring soil moisture levels to field capacity should be applied each irrigation. Over irrigation can create temporary water tables that drive out soil air and that can leach plant foods.

Frequency of irrigation depends on the water-holding capacity of the soil, climate, the pasture mixture, and the grazing cycle. Soils vary in their water-holding capacities from less than .5 of an inch per foot of depth of readily available moisture of loamy sands to more than two inches for the finer-textured soils.

Recent research work at Utah State University shows that summer yields of alfalfa-grass pastures growing on deep, medium-textured soils declined when the interval between irrigations exceeded 15 days. Ladino clover requires more frequent irrigation than alfalfa. To persist, it needs to be irrigated every 7 days or less throughout the summer depending on soil textures and depth.

The irrigation interval must be in sequence with the pasture rotation cycle to avoid conflict between irrigation schedules and the movement of the livestock. Feeding the cattle in the drylot or an emergency pasture until the pasture scheduled for grazing can be irrigated and become sufficiently dry to prevent grazing damage requires extra labor and reduces feed reserves. Delaying a needed irrigation until after the pasture is grazed will reduce production and disrupt the irrigation schedule for the farm. Irrigation schedules that require varying the interval between each irrigation to meet grazing schedules are difficult for the farmer to follow or result in a conflict with the grazing schedule.

d. Rotation Grazing System - The number of pastures used in the grazing system will determine the grazing cycle and the minimum irrigation interval, irrespective of soil water-holding capacities. The number of pastures will also regulate how many of them can and should be irrigated at any one time. This in turn directly influences the efficiency of the farm's overall irrigation water delivery sechedule.

(1) Irrigation Intervals and Grazing Schedules - Optimum irrigation frequencies as well as the amount of water to be applied each irrigation has been determined for most soils and is recorded in the Irrigation Guides in each work unit office. This information provides a key for planning of proper irrigation for pastures but it must be correlated with the grazing schedules to be used efectively.

Each irrigation must be scheduled to allow adequate dry-out time before stock are admitted. Dry-out periods of 3-4 days are adequate for most soils but may need to be lengthened for fine-textured soils and could be shortened for sandy soil.

The dry-out period plus the number of days each pasture is to be grazed (grazing period) within the rotation cycle plus one day to irrigate or finish an irrigation should be equal or less than the planned irrigation interval.

FORMULA No. 1: Dryout period + grazing period + 1 = irrigation interval; or, irrigation interval - dryout period - 1 = grazing period. Assuming the soils require an irrigation every ten days (Irrigation Guide) and a three day dryout period (farmer experience), then by substitution; 10 days - 3 days - 1 day = 6 days or less grazing per pasture per grazing cycle. If the pastures are grazed longer than 6 days within each grazing cycle, then the dryout period would have to be shortened or the irrigation interval lengthened. Either adjustment would reduce forage production.

(2) Number of pastures - The number of days each pasture is grazed also determines how many pastures are needed to provide regrowth periods essential to good plant growth.

FORMULA No. 2: Number of pastures - $\frac{\text{Regrowth period (days)}}{\text{Grazing period (days)}} + 1$

Using the above formula, the plant regrowth periods stated under "Pasture Management, Item 1a," and the 6-day grazing period computed by Formula 1 above:

Alfalfa grass - No. of Pastures = $\frac{28 \text{ to } 42}{6} + 1$

No. of Pastures = $\frac{30}{6} + 1$, or $\frac{36}{6} + 1$, $\frac{42}{6} + 1$

No. of Pastures = 6, 7, or 8

Birdsfoot trefoil-grass - No. of pastures = $\frac{26 \text{ to } 30}{6} + 1$

No. of pastures = $\frac{30}{6} + 1 = 6$

White Dutch Clover-Grass - No. of Pastures = $\frac{21 \text{ to } 24}{6} + 1$

No. of Pastures = $\frac{24}{6} + 1 = 5$

White dutch clover normally requires a shorter irrigation interval than the 10 day interval used in Formula 1. If the irrigation interval is shortened, the grazing period must be shortened an equal amount and this in turn would increase the number of pastures required to make the system function.

As shown by the above examples for alfalfa-grass pastures, it is possible to maintain the 6-day grazing period computed under Formula 1 by varying both the number of pastures and the regrowth periods. Fractional grazing periods are not practical so those used within the range recommended for alfalfa-grass are even multiples of the grazing period.

(3) Grazing Cycle - The grazing cycle in days is equal to the number of pastures in the system times the number of days each pasture is grazed.

FORMULA No. 3: Grazing Cycle = grazing period x number of pastures

Substituting data computed by Formula 2 we would have:

<u>Alfalfa-grass</u>	Grazing Cycle =	6 x 6 = 36 days
	or	6 x 7 = 42 days
	or	6 x 8 = 48 days
<u>Birdsfoot trefoil-grass</u>		6 x 6 = 36 days
<u>White Dutch Clover-grass</u>		6 x 5 = 30 days

The grazing cycle is also equal to the regrowth period in days plus the grazing period in days.

(4) <u>Grazing Schedules and Irrigation Schedules</u> - To correlate the planned irrigation schedule with the grazing schedule requires that the irrigation cycle in days equals the grazing cycle in days. The irrigation cycle would be the number of irrigations per grazing cycle times the irrigation interval in days (if the same) or the sum of the irrigation intervals in days (if they vary) within the grazing cycle.

FORMULA No. 4: $\frac{\text{Irrigation Cycle}}{\text{Grazing Cycle}} = 1$

or

FORMULA No. 5: Irrigation interval (days) x number of irrigations = grazing cycle.

By substitution from formulas 1 and 3:

Alfalfa-grass - 10 x number of irrigations = 36 or 42 or 48
The irrigation interval is not an even multiple of the grazing cycle so must be varied. This could be done by adjusting the irrigation interval to 10, 13, 13 days or 12, 12, 12 days, to provide a 36-day grazing cycle; to 10, 10, 11, 11 days to provide a 42-day grazing cycle; and to 10. 10, 10, 9, 9, days to provide a 48-day grazing cycle. Adjustments greater than those indicated for the 36- and 42-day grazing cycles should be questioned.

White clover-grass: 10 x number of irrigations = 30
10 x 3 = 30

The irrigation interval is an even multiple of the grazing cycle so no adjustment is required.

When the irrigation cycle equals the grazing cycle, the irrigation schedule can be correlated with the grazing schedule by timing the irrigation of each pasture to provide the required dryout period and then apply each subsequent irrigation in accordance with the planned schedule. This will require applying water for a shorter period of time in the cooler months of the grazing season than in the warmer months to avoid over-irrigation. To vary the irrigation interval with seasonal needs for water will result in conflicts between irrigation and grazing schedules.

(5) Irrigation Systems - Schematic diagrams showing 31 different rotational grazing systems for alfalfa-grass and 16 systems for white clover-grass are shown. The systems vary from 3 pasture systems to as high as 12 pasture systems. They do not include all of the possible variations in irrigation intervals, grazing periods, or grazing cycles; however, they should prove helpful when assisting the Soil Conservation District cooperators plan their irrigation pasture systems. A close examination of the schematic for a 3-pasture system for either alfalfa-grass or white clover-grass will show it is quite impractical whether the irrigation interval or the grazing period is held constant.

Study of the other charts shows that: (1) each reduction in the irrigation interval requires an increase in the number of pastures and a reduction in the grazing interval; (2) that 2 or more pastures can be watered at a time when there are an even number of pastures, or when the grazing period is a multiple of the irrigation interval. Such systems would be especially applicable where irrigation water is delivered on a rotational basis and/or where pastures comprise a small part of the cropland acreage; (3) that a different pasture is watered each time for odd numbers of pastures unless the grazing period is a multiple of the irrigation interval. Such systems would be especially applicable when sprinkler systems are used and when water delivery is on a demand basis and pastures comprise a good portion of the cropland acreage; and (4) that flexibility in adjusting for irrigation interval, grazing periods, and farm irrigation water delivery systems increase as the numbers of pastures are increased.

(6) Pasture size will vary with the productive capacity of the pasture, the number of animals to be grazed, and the number of pastures in rotation grazing system.

Pastures should be adjusted in size so that each will produce about the same amount of forage to insure uniform grazing periods. Pastures on shallow, eroded or nonfertile soils will need to be larger than those on deep, fertile, soils. Legume-grass pastures are normally more productive than straight grass pastures, and pasture mixtures containing alfalfa as the legume are normally more productive than mixtures containing other legumes.

When SCD cooperators shift from 3 or less pastures and rather poor management to five or more pastures and good management, it is not uncommon increasing the size of the herd or reducing the size of the pastures. The number of pastures should not be reduced to less than 4. Any change in number of pastures will require adjustments in grazing periods and irrigation schedules.

Pastures large enough in size to carry the herd for more than 3 or 4 days are not grazed uniformly. When the planned grazing period exceeds 3 or 4 days per pasture, it can be easily shortened by dividing the pasture into 2 or more units by means of a temporary (electric) fence. The shorter the grazing period, the more uniform the forage will be grazed.

A rule of thumb that can be used to determine pasture size is to remember that an acre of alfalfa-grass pasture at or near hay stage will feed thirty mature beef cows for 3 to 4 days each time it is pastured. The rule of thumb is based on a dry weight forage yield of 1.5 to 2 tons of forage per acre each grazing period. It should be applied to forage production during the summer and not the spring months. To set grazing capacities on the basis of spring forage production will result in a shortage of pasturage in the summer months.

(7) Type of Systems - Four general systems of grazing are in use. By terminology, these include continuous grazing, rotational grazing, strip grazing, and daily ration grazing. Green chop is often considered a grazing system; however, the forage is harvested from the field and hauled to penned livestock as needed, usually twice daily.

Continuous grazing is the practice in most common use, yet it promotes the lowest pasture yields. Livestock are left in the pasture throughout the grazing season. Rotation grazing systems using 2 or 3 pastures are better but do not produce maximum yields.

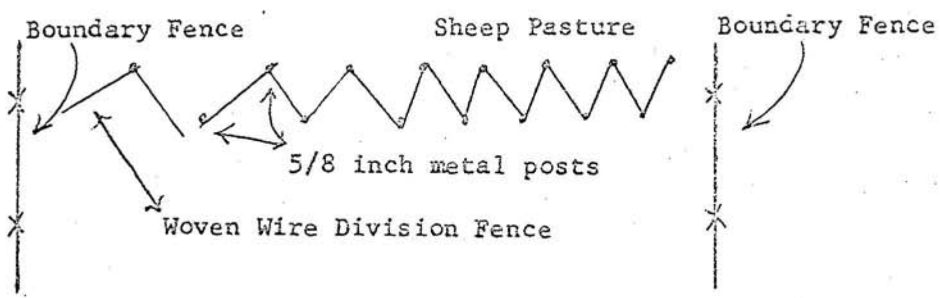
Rotational grazing systems, when designed for high production, provide for grazing four or more pastures in rotation.

Strip grazing systems are improved rotational grazing systems in which each pasture is divided into two or more pasture units to reduce grazing periods and increase forage utilization. When grazing periods are reduced to one day or less, strip grazing becomes daily ration. Both allow the pastures to be managed for maximum production; and when this is done, cooperators state that pasture yields have increased two or more times, the pasture stands persist longer, and they do not need to scatter droppings and mow ungrazed forage. The time required to move the livestock as many as three times per day is reported to take less than 30 minutes.

There are many pros and cons regarding the merits of green chop versus rotational grazing. Under good management, forage yields should be about the same. The major differences would be in costs of fencing and moving cattle as compared to the costs of equipment and time to cut and haul the forage to the animals and to remove the manure from the corrals or feedlots. Equipment breakdown is another matter to consider.

(8) Fencing is essential to a rotational grazing system. Boundary fences of each pasture in the system are usually of a permanent type; however, temporary electric fences seem to function well and are much less expensive. Temporary fences are used to divide individual pastures into two or more units. They normally consist of a single, barbless wire supported by a glass insulator fastened to a 5/8 inch metal rod pushed into the soil. The division fences can be dropped and left in the pasture when not in use.

Pastures grazed by sheep require the use of woven wire fencing. The normal practice is to construct a permanent type fence around the pastures. A few sheepmen are practicing strip grazing using temporary woven wire fences to divide the pastures into grazing units. The temporary fences are supported by fastening each end to the permanent fence along each side of the pasture, then placing 5/8 inch metal rods at even intervals and on opposite sides of the fence as indicated by the following diagram:



e. Fertilizing pastures, is essential to continued high production. For most soils, nitrogen and phosphorus are the two nutrients normally required. The need for other nutrients, such as potassium, sulfur, boron, zinc, and magnesium can be best determined by soil analyses.

(1) Nitrogen - Legumes, when nodulized with the right bacteria, have the ability to utilize nitrogen from the air and fix it in the soil. For this reason, they do not respond favorably to nitrogen fertilizer. Grasses are just the opposite in that they require high levels of soil nitrogen for optimum growth. Grass roots with their high carbon to nitrogen ratio are continually sluffing to reduce the amount available for plant growth. For this reason, grasses do respond to commercial nitrogen and to nitrogen made available by legumes when grown in mixtures.

Nitrogen stimulates the growth and retards the growth of legumes. When legume-grass mixtures show too high a percentage of legume, the grass fraction can be increased by application of nitrogen. Grasses make their best growth in the cooler months of the grazing season. Forage shortages are most apparent in the warmer months of the grazing season. Applying nitrogen to pastures following each grazing will stimulate the growth of the grasses during the warm summer months and help keep forage production at a more uniform level throughout the grazing period. The amount of nitrogen to apply will depend to a large degree on the competition of the pasture and the use of manure. If the pastures contain more than 40 percent legume by weight and receive applications of 10 or more tons of manure per acre per year, it is questionable that the use of commercial nitrogen will be economically beneficial. Without the use of manure one or two split applications of 30 pounds per acre applied during the warmest months will help maintain forage composition and increase forage production. Should the farmer wish less legume or if the pastures are dominantly grass, applications of 80 to 120 pounds per acre per year applied in two or more applications of 30-40 pounds each following the first grazing each year will give good returns for money invested.

(2) Phosphorus needs can be best determined by soil analyses. Soil phosphate levels of 46 pounds P_2O_5 per acre are considered minimum while levels of 70 pounds per acre are considered optimum.

Legumes are heavy users of phosphorus as are the animals that graze them. Only a small portion of the phosphorus used by plants is returned to the soil through the manure of grazing animals. For this reason, soil phosphate levels can be maintained only through application of phosphate fertilizers. Phosphate does not leach through the soil so can be applied in a single application, either alone, in mixture with nitrogen, or with manure. Forage responses from fall applied phosphate can usually be measured in the spring growth the following year.

How much phosphate fertilizer to apply can be best determined by soil analyses. As a rule of thumb, an intial application of 100-140 pounds P_2O_5 per acre for legume-grass pastures followed by yearly applications of 60 - 80 lbs P_2O_5 per acre will provide economic returns. The rates could be reduced by 30 to 40 percent for straight grass pastures. When the legumes in legume-grass pastures start to demonate the grass or make up more of the forage mixture than desired reduce the amount of phosphate applied each year or increase the amomnt of nitrogen applied.

Responses from the use of phosphorus are not always visible as they show up in forage quality, leafiness, frost tolerance, and in other ways. Cows will selectively graze phosphated strips of pastures even when soil phosphate levels of the unfertilized strips approach the 70 pounds P_2O_5 per acre optimum and a forage yield difference would be hard to measure.

Recent research indicates that forage containing less than 0.22 percent phosphorus cannot be fully digested by a ruminant. Feeding tests show that it requires about twice as much alfalfa-grass hay testing 0.15 percent phosphorous to produce a pound of beef than alfalfa-grass hay testing 0.21 percent phosphorus. Forage phosphate levels are normally below the 0.22 percent minimum when analyses show the soil has less than 46 pounds available P_2O_5 per acre. Most soils used for the production of forage crops contain less than the 46 pounds P_2O_5 per acre considered minimum.

(3) Manure can be considered the all-purpose pasture fertilizer. Legume-grass pastures will require additional phosphate to maintain forage quality and productivity; however, most other essential elements are normally supplied with the manure. Yearly applications of 15-20 tons per acre applied in fall and spring are considered optimum. Heavier applications, particularly of liquid manure, have been severely damaging to legumes.

(4) Soil amendments are especially important for the establishment of pastures on problem soils. These needs are discussed in the pasture establishment section of this handbook. Pastures established on acid soils would probably benefit from annual applications of lime; however, the amount to apply should be determined by soil analyses.

f. Bloat is a constant hazard with legume-grass pastures; however, through the use of good management practices, animal losses can be very minor. Techniques that can reduce bloat losses include:

(1) Condition livestock on green feed before turning them on alfalfa-grass pastures. Green feed can be provided by straight grass pastures, grazing of ditchbanks or rangelands. Legume-grass pastures using bloat-free legumes, such as birdsfoot trefoil, or Cicar milkvetch can be used as the first pastures to be grazed in the spring. They could then be used as a part of the regular pasture system; however, they should be the first pasture or pastures laid by in the fall.

(2) Allow alfalfa-grass or clover-grass pasture to reach a height of 12-14 inches before grazing them. Confine the herd to small units to prevent selective grazing. Mowing strips in the pasture 2 or 3 days before the cows are admitted will also help.

(3) Watch the herd closely for the first 3 or 4 days. Sell animals that show a strong tendency to bloat.

(4) Provide plenty of salt and water, and if available, provide a daily tonic of beet pulp and grain at the ratio of 3 parts to 1 part. A new salt containing molasses and polexalene (bloat guard) is now on the market. Fed free choice to livestock it is reported to give excellent control at an average cost of 6 cents per head per day.

(5) Do not graze alfalfa-grass or clover-grass pastures close in the fall, leave a minimum grass stubble height of 4 inches and preferably, 6 inches. If close grazed, the grass will be grazed out first leaving the alfalfa or the clover.

8. Pasture Care

(1) Clipping - When pasture grazing periods are longer than 4 days, the cows graze selectively leaving clumps of ungrazed forage. These, if allowed to mature, become more unpalatable as they loose their food value. Mowing will aid in promoting uniform grazing and this can be done most economically at hay cutting time. When grazing periods are less than 3 days, patchy grazing seldom occurs.

(2) Scattering droppings - Livestock droppings when not broken up and scattered can materially reduce forage production. This can be avoided by dragging a gang of old equipment tires, a spring tooth, or similar equipment over the pastures 2 or 3 times each year. Equipment that tears or breaks legume crowns should not be used. Intensively managed pastures in which livestock are moved at least once a day seldon need to have the droppings scattered.

(3) Weed control is seldom a problem in good stands of vigorous growing grasses and legumes. Most weeds can be controlled by timely mowings in conjunction with a pasture management program that will promote vigorous growth of the pasture plants. Noxious weeds, particularly nonpalatable species such as Canada thistle, Russian knapweed, and white top should be controlled by grubbing or spraying to prevent their spread.

h. Pasture seasons can be lengthened by the use of rotational grazing systems. Continuously grazed pastures do not have a reserve of forage at the time the plants go dormant in the fall. The opposite is true when a rotation grazing system is used. If the pasture system consists of 6 pastures, each grazed 7 days with a 35-day regrowth period, 5 of the pastures would still have grazable forage at season's end. Considering each pasture in turn, the one with the most forage would have the equivalent of 35 days of regrowth, the next 28 days, the next 21 days, the next 14 days, and the last 7 days for an average of 21 days of regrowth. The amount of regrowth remaining would vary with the number of pastures and the grazing schedule, but in every instance would be more than that available under the common practice of continuous grazing.