Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

MANAGING IRRIGATED PASTURES

PETERSON • OSTERLI • BERRY

CALIFORNIA AGRICULTURAL
Experiment Station
Extension Service

CIRCULAR 476

Your irrigated pasture—

can help diversify and balance feed production on your farm—also conserve and improve your soil.

The goals of good pasture management are:

To produce efficiently as much meat or milk per acre as possible.
To obtain and continue the highest possible grazing capacity per acre.
To use the feed when its nutritive value is most advantageous.
To maintain an adequate stand and balance of legumes and grasses throughout the pasture season.

These goals can be achieved, with a good yield of quality feed if you:

1. Grade and prepare the land to get efficient irrigation and good drainage of excess water.
2. Use an adapted mixture of legumes and grasses.
3. Apply the right kind and amount of fertilizer.
4. Prevent or control undesirable weedy plants.
5. Manage grazing to utilize fully the feed produced.
6. Manage irrigation to provide continuous supply of water to the plants.

Irrigated pastures have become an important factor in land utilization in California, proving profitable where other cultivated crops have not been permanently successful. Many California farmers include irrigated pasture plantings in the rotation system.

THE AUTHORS:

M. L. Peterson is Professor of Agronomy and Agronomist in the Experiment Station, Davis.
V. P. Osterli is Agriculturist, Agricultural Extension, Davis.
L. J. Berry is Agriculturist, Agricultural Extension, Davis.

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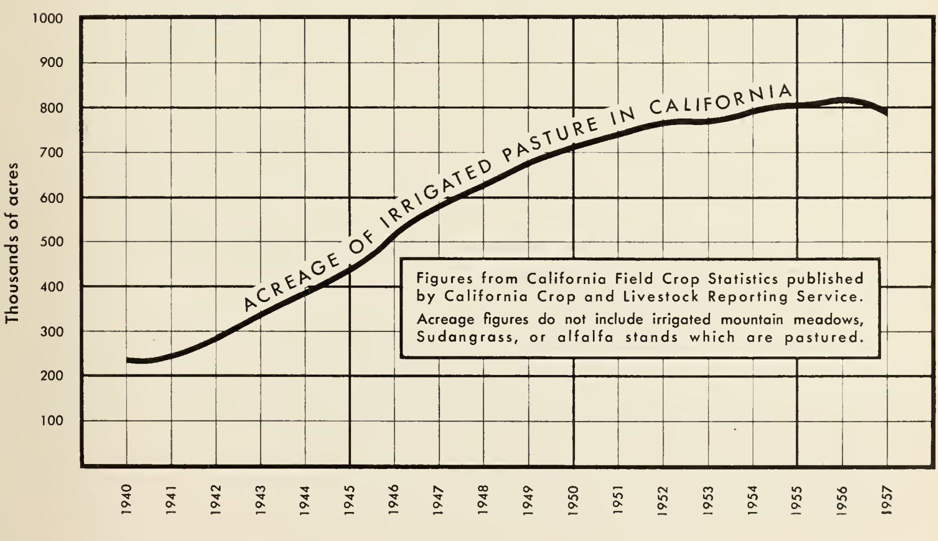
A planting of Ladino clover in 1921, in Yuba County, was the first recorded irrigated pasture in the state. Early development was slow, with only about 5,000 acres planted by 1930; but by 1957, there were nearly 800,000 acres. Much of the acreage shown in the accompanying graph represents new land brought under cultivation.

Except for alfalfa, most plants for irrigated pasture are shallow-rooted. This has resulted in extensive plantings on heavy or shallow soils which are frequently underlain with hardpan or tight subsoil clay layers. However, the more highly productive alluvial soils are also used.

An ample and economical water supply is essential—enough to provide 4 feet or more of water per acre per season.

IRRIGATED PASTURE ACREAGE HAS INCREASED STEADILY



COSTS are highest for grading, but proper land preparation reduces future expense for water and weed control

Overhead (per acre)	Cost	Life expectancy	Depreciation	Interest
		years		
Land	$200.00	..	$	$10.00
Grading	75.00	..	....	3.75
Fences	15.00	20	0.75	0.38
Irrigation preparation (land plane, check, field ditch)	14.00	7	2.00	0.35
Turnout gates	2.50	10	0.25	0.06
Stock water facilities	2.50	20	0.12	0.06
Pasture stand	20.00	7	2.86	0.50
Tillage equipment (based on 80 acres)				
Tractor	25.00	10	2.50	0.60
Mower	4.00	10	0.40	0.10
Pickup or auto	20.00	10	2.00	0.50
Misc. shovels, small tools	2.00	9	0.22	0.05
	$380.00		$11.10	$16.35
Total				$27.45

Annual Cultural Cost (per acre) (not including water)*

Cash and labor costs:		
Irrigate 16 times @ ½ hr. labor		$ 8.00
Fertilize:		
50 lbs. P_2O_5	$5.00	
60 lbs. nitrogen	9.00	
Application, 1/3 hr.	0.50	
Mow 3 times @ ½ hr.		3.00
Ditch work and fence repair		1.00
Misc. labor and truck use		1.00
Taxes, $60.00 @ $5.75		3.45
Total cash and labor		$16.45
Overhead		27.45
Total cost (not including water or fertilizer)		$43.90

* Irrigated pasture will normally require from 2½ to 4½ acre-feet of water per year. Water costs vary widely, ranging from as low as $1.50 to more than $8 per acre-foot.

MANAGING IRRIGATED PASTURES

M. L. PETERSON V. P. OSTERLI L. J. BERRY

Land Preparation

IRRIGATED PASTURES occupy land for longer periods than do most other field crops. For this reason, grading, construction of levees, and proper drainage facilities are very important. The objectives are to keep use of water and of labor for irrigation to a minimum, and to insure high yields for the life of the stand. (For more complete discussion, see University of California Circular 438.)

Land grading to rigid specifications, while expensive, is the most important operation in establishing an irrigated pasture. Proper land preparation will greatly reduce future costs of irrigation and weed control. Cost of preparing land for flood-irrigation of pastures ranges from $30 to $130 per acre. Underground concrete pipelines conserve water and save labor better than do open ditches, but initial costs are greater. The following figures, compiled by the Agricultural Extension Service, show approximate costs for new pasture development on several hundred acres in a Central Valley county:

	COST PER ACRE
Surveying	$ 4.00
Well	9.50
Pipeline	24.50
Grading, including drainage facilities	54.50
Pump	25.50
Total	$118.00

(Ordinarily, complete engineering costs will range from $4 to $6 per acre.)

Irrigation

Manage irrigation to maintain a continuous supply of readily available moisture in the soil at all times to permit optimum plant growth with the least amount of waste in water, soil, and labor. The method of irrigation used will be determined by permeability of the soil, rate of water delivery, surface drainage conditions, water costs, and by what is common practice for the area.

The border method

is the most widely used. With this system, the strips of land between the adjacent levees usually have a grade in the direction of irrigation, ranging from about 0.1 foot to 0.4 foot for each 100 feet of length, and not over 0.15 foot cross slope. In cases of poor internal soil drainage, a slope of 0.3 foot per 100 feet should be used to provide surface drainage.

The length and width of checks depend upon the soil type, head of water available, and the slope in the direction of irrigation. Length may range from a few hundred feet up to a half mile, but should be limited to a distance that will insure fairly uniform depth of water penetration for the entire check. The width may range from 12 to 100 feet. Border checks present the fewest difficulties in establishing fence lines for the rotation grazing system. A levee 3 feet wide at the base and 6 inches high when settled will grow feed.

Contour checks

may prove most economical if the ground surface is relatively flat. This system requires either a large flow of water or a soil with a slow infiltration rate. Levees should have a settled height of 12 to 14 inches, and a base width of about 60 inches to withstand the trampling of stock. The contour system has many disadvantages: cross fencing for control of grazing is difficult; drainage limitations create a tendency to plant scalding; and weeds and mosquitoes are troublesome. As a result, many growers have changed from contour to border checks when possible.

Sprinkler irrigation

has special advantages where the water supply is scarce or expensive, the soil shallow or sandy, or the surface too rough or steep for economical leveling. The decision of whether to sprinkle or flood irrigate should be based upon economic considerations which may differ with each situation. Sprinklers are difficult to manage in areas subject to strong winds.

Wild flooding

is used in rough, mountainous terrain where grading is impractical. This method requires very little grading or ditch preparation. Water is distributed from grade ditches located on ridges or along the sides of hills. The water is released from the ditches at selected points, and moves down the side of the hill to the next distribution ditch. The waste of water resulting from this inefficient application method may be offset by the low initial cost and the minimum labor required. Successful irrigation by wild flooding requires the services of a careful operator when establishing the system.

Water measurement

A knowledge of the amount of water to apply to each field is essential for designing an irrigation layout. The most commonly used units of water measurement are: gallons per minute, cubic feet per second, and the miner's inch.

The formulas at the bottom of the page may be used to compute the approximate depth of water applied to a field.

The following "rules of thumb" are also convenient methods of estimating the irrigation potential of a given flow of water:

One miner's inch (about $11\frac{1}{4}$ gallons per minute) will put 0.6 inch of water on 1 acre or 3 inches on $\frac{1}{5}$ acre in 24 hours; 1 cubic foot per second, or 450 gallons per minute, will put 2 feet of water on 1 acre in 24 hours or will supply a 9-inch depth of water for 80 acres in 30 days; 5 gallons per minute will irrigate 1 acre by sprinkling, while 10 gallons per minute for each acre are desirable when irrigating by flooding.

Larger delivery rates permit more efficient use of labor with surface irrigation. A delivery of 1,000 gallons per minute will adequately irrigate 100 acres, even at peak summer requirements. Most irrigated pastures will require irrigation at about 10- to 14-day intervals. If the irrigation is to be done by sprinkling, a sprinkler system can be designed that

$$\frac{\text{Cubic feet per second} \times \text{hours}}{\text{Acre}} = \text{acre-inches per acre, or average depth in inches}$$

$$\frac{\text{Gallons per minute} \times \text{hours}}{450 \times \text{acres}} = \text{acre-inches per acre, or average depth in inches}$$

$$\frac{\text{Miner's inches} \times \text{hours}}{40 \times \text{acres}} = \text{acre-inches per acre, or average depth in inches}$$

Contour irrigation requires a large flow of water and a soil with a slow infiltration rate. Cross-fencing for control of grazing is more difficult with this system.

Sprinkler irrigation is used where rate of water delivery is too small for surface methods or where the soil is too shallow or sandy, the land surface too rough and steep to make land grading desirable or economical. It is possible to apply water to any pasture by this method, which is practical so long as it proves economical.

will provide the exact amount of water required for correct irrigation within the desired irrigation intervals. Where strip checks or contour checks are used, the volume of water must be sufficient to cover the checks rapidly enough to provide uniform distribution over the entire area.

Water use and frequency of irrigation

The depth of water applied and the frequency of irrigation depend upon the rate at which the crop uses water, the root depth of the crop, and the water-holding capacity of the soil.

The amount of water necessary to penetrate to a depth of 1 foot when the soil is at the wilting point varies with the soil type. As a useful guide, 1 inch of water will wet a clay soil to a depth of 4 to 5 inches; a loam soil, 6 to 10 inches; and a sandy soil, 12 inches or more.

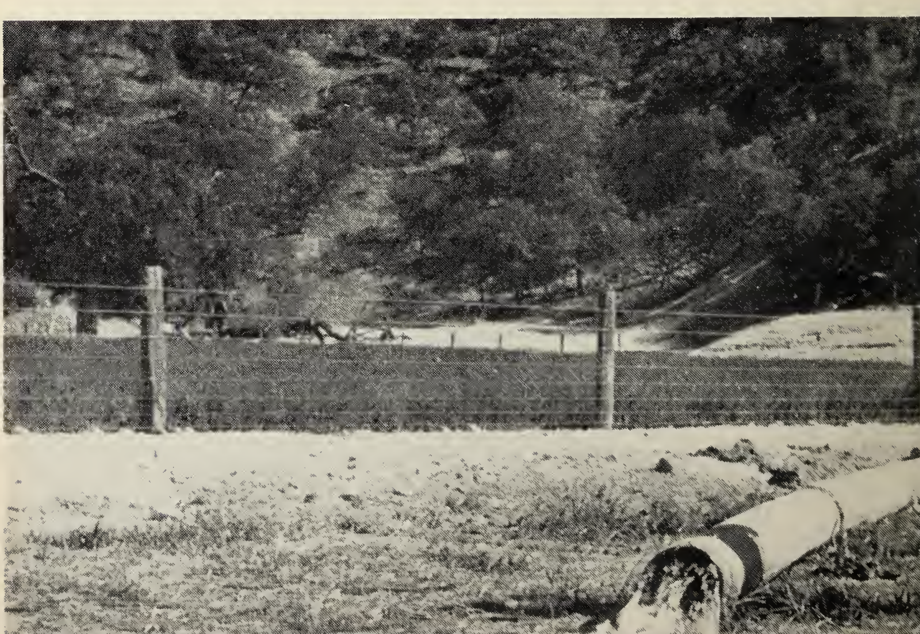
The daily peak water use by an irrigated pasture ranges from 0.25 to 0.35 inch per day, for interior valley conditions; and from 0.10 to 0.25 inch per day under coastal and semicoastal conditions.

Ladino clover, with a daily peak use of 0.30 inch, will use 3 inches of water in 10 days. This amounts to nearly all of the available water in the top 2 feet of a loam soil. Therefore, Ladino clover, with its shallow root system, needs frequent light irrigations. The seasonal requirement will be from 2½ to 4½ acre-feet per acre.

On medium-textured, well-drained soils, plants can remove moisture readily to the following approximate depths:

	FEET
Ladino clover	2
Trefoils	4
Alfalfa	6 or more
Grasses	3 to 4

Depth of rooting is impaired by hard soil layers and poor drainage. Irrigation



This pasture is used in conjunction with dry-land pasture and range feed. The green feed produced under irrigation extends the supply after range pasture dries up.

Improper irrigation and lack of drainage facilities to handle excess surface water reduce pasture yields and provide breeding areas for mosquitoes—a public nuisance and health hazard.

should begin before the available moisture within a major portion of the depth of rooting has been used.

To determine when irrigation is needed, inspect the soil for moisture content with a shovel, tube, or auger. Also watch for signs of wilting in sandy areas which may require more frequent irrigation. An inspection after each irrigation will show whether enough water has been applied to wet the soil throughout the rooting zone of the plants.

Because irrigated pastures require more frequent irrigations than do most other irrigated crops, special care must be taken to prevent waterlogging the soil—a condition that will adversely affect the crop, and encourage undesirable, water-loving weeds. ***Do not irrigate while stock are on the pasture or until the surface of the soil has dried.*** Wet soils are compacted from trampling with the result that root growth is retarded, water fails to penetrate the soil adequately, and growth is greatly reduced.

Leaching

Irrigated pastures are often used in the early stages of alkali reclamation. Because pasture plants require frequent irrigation, excess salts are leached from the soil. In order to leach, adequate subsurface drainage must be provided for removal of water containing the leached salts. In severe cases of alkali, highly salt-tolerant plants such as Bermudagrass or Rhodesgrass are used.

Mosquito control

Mosquitoes become a public nuisance and a hazard to health and comfort under poor irrigation practice. Excess surface water may provide a breeding ground for large numbers of mosquitoes. The types that develop most rapidly need at least three and one-half to four days in water, to reach the adult stage, even under extremely warm interior valley temperatures. It has been found that the lower the field irrigation efficiency, the higher the mosquito population and the lower the yield on irrigated pastures.

Water should not be allowed to stand on an irrigated pasture longer than 24 hours following an irrigation.

Re-use of water

It is difficult to irrigate without losing some of the water through the drainage system at the ends of the checks. Return-flow systems conserve this water for re-use. In most cases water can be recirculated at a cost per acre-foot substantially lower than the original cost of pumping it from the ground. The lift is small compared with that from the average well. Currently operated installations indicate a cost ranging from $1 to $1.25 per acre-foot for the water recovered through return-flow systems.

Recirculation systems can be installed to operate by: (1) pumping from a low-end collecting basin into a supply ditch; (2) pumping from a drainage canal into the main ditch; or (3) pumping from a low-end collecting basin into the main pipeline system.

A common and efficient practice is that of using return-flow water to irrigate adjacent, lower lying fields.

Return-flow systems do not eliminate the need for careful and efficient water management, but they do result in increased yields, better weed control, reduced mosquito populations, and road protection.

A farmer has the legal right to re-use waste water from his own land, provided he recovers the water before it leaves his property. Recirculated runoff water is usually of satisfactory quality for irrigation purposes except when it contains excessive amounts of salts.

Discharging of drainage water on roads, railroad rights-of-way or neighboring properties is an act of negligence.

Return-flow systems conserve water, and result in better weed control, reduced mosquito populations, and increased pasture yields. They do not, however, eliminate the continued need for careful water management.

Seedbed Preparation and Seeding

A good seedbed is firm enough so that the soil particles are in close contact with the seed. Except where the seeds are to be germinated by irrigating, the seedbed must contain sufficient moisture to germinate the seed when sown and to support growth until irrigation or rainfall begins.

Several preliminary operations are involved in seedbed preparation, including disking, dragging, land planing, and harrowing. For fall seeding, the ground is worked when nearly dry or after weeds have germinated following irrigation or early rains. In spring, the ground normally requires harrowing or disking. Often a preliminary stirring of the soil is made to encourage germination of spring weeds before planting.

Time of sowing

Sowing time varies in different parts of the state, usually depending upon rainfall and temperature conditions. South coastal counties experience little difficulty in establishing a stand at any season of the year. In the interior valleys, sowing may be either in the fall or early spring. Spring sowings are best in the northern counties and in the mountains, where severe winters may kill fall-sown seedlings.

Spring sowings should be made as soon as the temperature is warm enough to germinate the seed. Early sowing makes it easier to maintain favorable moisture conditions until the seedlings are well established. Weed control may be easier with spring plantings because they can be clipped at the proper time.

Fall sowings must be early enough for seedlings to make good growth before cold weather sets in and before vigorous winter-growing weeds smother them. Well-established fall-sown pastures will achieve full production the first season. In the Sacramento Valley, fall sowings should be before October 15. In the southern San Joaquin Valley, sowings as late as November 15 have been successful.

Seed

Seed costs represent only a small part of the investment in a pasture. Only seed of high germination and purity should be used. Low-cost seed is not always the most economical. The use of certified seed is advisable to assure the grower that he is getting the desired varieties, high purity, and freedom from noxious weeds.

Good pasture mixtures are offered by many seed firms. The individual species can also be purchased separately and mixed to provide the desired combination of grasses and legumes.

Seed inoculation

For normal, vigorous growth, legumes must have root nodules, formed by rhizobia, the bacteria that fix nitrogen from the air for use by the plants. Legume seed may be inoculated with these bacteria before planting, at a cost of only a few cents per acre.

Commercial cultures of the bacteria, including directions for application, may be purchased from seed dealers. Different legumes or groups of legumes require different kinds of bacteria.

Sowing

Methods of sowing include drilling, broadcasting, or the use of a ringroller with a sowing attachment. Sowing is also done by airplane. Since the legume seeds tend to settle to the bottom of the mixture, the grasses and legumes are generally sown separately. Any method that will give an even distribution of species sown no deeper than ½ inch is satisfactory.

Ringrolling or cultipacking should follow the seeding operation. Nurse crops are not recommended except where unusual conditions prevail, such as severe winds that move light soils.

Fertilizing at time of planting

Applications of about 250 pounds of single superphosphate per acre may greatly stimulate seedling growth of legumes on soils which are known to be acutely deficient. Many phosphorus-deficient soils are also low in organic matter and nitrogen. At such locations the use of about 200 pounds of ammonium phosphate sulphate per acre is recommended on weed-free fields. On weedy fields, ammonium phosphate containing a low ratio of nitrogen to phosphorus, such as 11-48-0, 13-39-0, 21-53-0, should be used. These materials should be applied at rates sufficient to give about 50 pounds of phosphorus per acre expressed as P_2O_5.

The fertilizer materials may be broadcast ahead of sowing or applied through a fertilizer spreader or a fertilizer attachment on a grain drill provided the seed and fertilizer are applied separately. Banding of fertilizer below the seed has proved very successful.

On soils of moderate to high phosphorus supply, the application of fertilizer materials at planting time may not be necessary or should be delayed until the need has been established.

Pasture Plants

Legumes

Ladino clover, a perennial, is a large form of white clover introduced from Italy. It spreads by means of creeping stems (stolons) which root at the nodes. The plants are usually shallow rooted, with most of their roots in the surface 6 to 12 inches of soil, but they may extend to a depth of 24 inches or more. Ladino is therefore ideally suited for use on shallow, hardpan soils. Its growing season is as long as that of other usable legumes. Ladino is winter-dormant in most parts of the state, and has a slight production sag during midsummer which can be partially overcome by phosphorus fertilization. The characteristics which make it the most valuable legume in irrigated pastures are high quality and rapid recovery after grazing. In many older pastures, Ladino shows a yellow streaking or discoloration in the leaves. This is caused by a virus disease that is transmitted by leafhoppers, and for which there is no known control. This virus is most apparent in late winter and early spring. A severe infection decreases production.

Narrowleaf (prostrate) trefoil is a long-lived perennial with a relatively deep, but branching, taproot. The stems grow flat along the ground except in very thick stands or in mixtures where competition for sunlight causes them to grow more upright. Growth begins when average daily temperatures range from 40° to 50° F, with temperatures around 80° believed to be most favorable. Trefoil withstands high summer temperatures up to 120° in the Imperial Valley. This type of trefoil is not suited to areas that have hard, killing freezes since it is subject to winter killing. Narrowleaf trefoil grows under a wider variety of soil conditions than does alfalfa or Ladino clover. It is one of the few legumes in common use that is capable of producing good pasture under conditions of high salt and poor drainage.

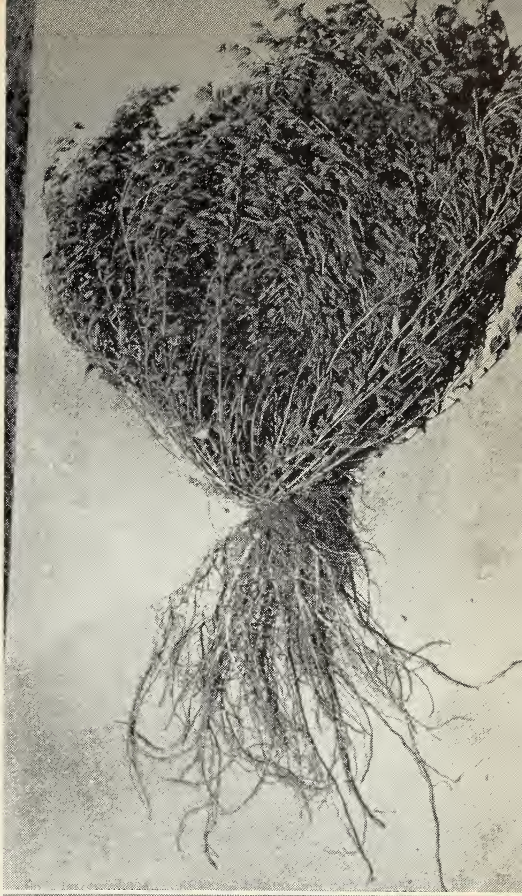
Because trefoil does not cause bloat, it is widely used even where other legumes may be more productive.

Broadleaf (erect) trefoil has a more upright growth than does narrowleaf. The leaves are broader, with individual leaflets usually more than half as wide as long. There are many varieties of broadleaf trefoil, most of which have coarser stems than narrowleaf, but similar flowers and pods. Broadleaf trefoil is almost completely winter dormant, and is more resistant to cold than is narrowleaf. It can therefore be used at higher elevations where winters are cold. Roots of broadleaf trefoil are deeper than those of narrowleaf, and the plants are more drought-resistant. Broadleaf trefoil is much less tolerant of poor drainage or overirrigation than is narrowleaf. Its production is excellent on irrigated pastures in the Sierra Nevada foothills, where water is limited and soils are coarse-textured. Broadleaf trefoil does not present a bloat hazard.

Both types of trefoil are poor competitors with either Ladino clover or grass. Where moisture and fertility conditions are favorable for the vigorous growth of clover and grass the trefoil may be crowded out of the mixture.

Alfalfa, when grown on adapted soils, will yield more than any other pasture plant or mixture. Normally the same variety recommended for hay production should also be used for pasture. Alfalfa for pasture should be grown in pure stands. Its use could be greatly extended, especially for dairy pasture, by carefully controlled grazing practices in combination with dry feeding of grain or Sudan hay to control bloat.

Alsike clover is a perennial used chiefly in the northern counties at the higher elevations. It is able to withstand wet, cold, heavy soils better than do many other legumes. It is not suitable



Narrowleaf trefoil (right, top) grows better under a wider variety of soil conditions than does alfalfa or Ladino clover. It is the only legume in common use capable of producing good pasture under conditions of high salt and poor drainage. Broadleaf trefoil (right, bottom) has a strong tendency toward winter dormancy, and can therefore be used at higher elevations where winters are cold. It is grown successfully in irrigated pastures in the Sierra Nevada foothills. Trefoils do not present a bloat problem.

Characteristic leaf shapes of broadleaf trefoil (left) and narrowleaf trefoil (right).

for areas in which high summer temperatures prevail.

Strawberry clover is a perennial, somewhat resembling Ladino clover in growth habits. It is more alkali- and drought-tolerant than Ladino clover, but is more susceptible to *Sclerotinia*, a fungus disease favored by cool, wet conditions. It is now being used to a limited extent only. A variety called Salina has given superior yield in comparison with common strawberry clover. It has remained productive over a nine-year period in sheep pastures at the Experiment Station at Davis. It is highly tolerant of poorly-drained conditions, but produces most abundantly on fertile, well-drained soils.

Red clover, usually a biennial, sometimes acts as a short-lived perennial. It does best on well-drained soils. The large, leafy, fleshy stems grow upright from a central crown. It has a heavy, but rather short, semi-tap root. Although red clover is subject to mildew, this does not appear to discourage cattle from eating it. However, it is not extensively used, and has few advantages over other pasture legumes.

Grasses

Annual or domestic ryegrass is particularly valuable for its ability to produce an early, heavy spring growth. It is more stemmy and less leafy than is perennial ryegrass, but much more palatable. It contains a mixture of many types of plants ranging from strictly annuals to short-lived perennials.

Perennial (English) ryegrass is similar to annual ryegrass, but does not grow so rapidly. A finer-stemmed plant with many basal leaves, it grows late into the summer and resumes growth with the approach of cool fall temperatures. Rust is a problem at certain times.

Orchardgrass is a perennial, bunch-type grass characterized by its blue-green color, flattened stems, and tufty manner of growth. It is very palatable in the early stages of growth, but becomes coarse and tough as it matures. Occasional mowings and thicker seedings will discourage its tendency to form large clumps or bunches. It starts growth later in the spring and goes dormant earlier in the fall than does perennial ryegrass. Orchardgrass produces somewhat better during the warm seasons than does ryegrass.

Tall fescue is a deep-rooted, strongly tufted perennial with a long growing season and high forage yields. It produces well in the winter on heavy, fertile soils, and its heavy sod makes it desirable for winter grazing. Tall fescue has declined in popularity as an irrigated pasture grass because of its extreme aggressiveness and coarseness.

Dallisgrass, a perennial, has a deep, strong root system, and grows in clumps which tend to die out in the center and enlarge around the edge as the plant ages. It starts growth rather late in the spring, and becomes dormant in the fall. It is strictly a warm-season grower, producing very heavily during the summer months. It will not survive the winter in the colder portions of the state. Some irrigation districts oppose the use of this grass because its light, oily seeds float on water, and the plants become established along ditchbanks.

Plants used occasionally

Bur clover, a winter annual, is entirely dependent upon seed for reproduction. It is used to a limited extent in the southern part of the state.

Yellow sweet clover is a summer-growing biennial used in the early stages of reclamation on alkali soils.

Rhodesgrass, a leafy, summer-growing, fine-stemmed perennial, spreads by running branches which root and produce a tuft at every joint. It is used in the southern San Joaquin Valley and the southern counties. It is more alkali-tolerant than are any of the other regularly used irrigated pasture grasses.

Coastal Bermuda is a highly productive hybrid developed in Georgia. It has larger stolons and rhizomes, and longer leaves and internodes than common Bermuda. Coastal Bermuda produces very few seed heads, and those that are produced rarely contain viable seed. It is propagated by stolons.

Irrigated Pasture Mixtures

Grasses and legumes are usually grown in mixtures for irrigated pasture, except for alfalfa, which is normally grown in pure stands for grazing. Birdsfoot trefoil also is frequently grown alone for pasture when used on salty or poorly drained soils.

Grasses have certain advantages over legumes:

1. They give better bloat control. Among the legumes, only birdsfoot trefoil effectively controls bloat.
2. They insure higher dry-matter intake. (Legumes are normally higher in moisture than are grasses.)
3. Many of them provide earlier spring grazing and later fall grazing than do most legumes.
4. They develop a thick turf which discourages weeds and reduces damage from trampling.

The legumes, likewise, have definite advantages over the grasses:

1. They are higher in protein and mineral content.
2. They maintain or improve nitrogen fertility by symbiotic nitrogen fixation.
3. They provide higher summer production than do most grasses.

Legume and grass mixtures combine certain advantages of each group. However, mixtures should be kept relatively simple, and in some cases, pure seedings may be better. Complex mixtures containing many species are seldom so productive or easily managed as are the better species in simple mixtures.

Proponents of complex mixtures call attention to the fact that each species has a slightly different growth rate and production peak. It is assumed that, as each reaches its rapid growth period, it will join the other species in providing continuous pasturage for the entire growing period. What actually happens is that competition among species nearly eliminates the less aggressive ones, and the more aggressive plants dominate the mixture. Thus, instead of continuous pasture, production is confined to the growth period of the dominant species. Simpler mixtures permit individual management for each species. A series of several such mixtures, sown in separate fields, could provide a pasture program to fit the particular needs of the livestock operator.

Field trials with various species and mixtures were conducted at the Experimental Farm at Davis. Table 1 shows the results. Alfalfa alone produced a greater yield of dry matter and protein than did any other species or mixture. There was no advantage to including a grass with alfalfa since none was able to compete in sufficient quantity to con-

Table 1—Dry-matter and Protein Yields of Various Pasture Species and Mixtures
(Second year after seeding)

Factor	Dry matter at 12% moisture	Average protein	Protein yield
	tons per acre	per cent	lbs. per acre
Species:			
Alfalfa	8.8	25.0	4,402
Ladino clover	5.7	23.0	2,636
Narrowleaf trefoil	5.6	24.2	2,704
Orchardgrass	1.2	13.3	322
Perennial ryegrass	1.2	11.4	262
Mixture:			
Alfalfa–orchardgrass	7.2	22.6	3,246
Alfalfa–ryegrass	6.6	22.5	2,976
Ladino–orchardgrass	6.5	20.0	2,610
Trefoil–orchardgrass	6.5	22.6	2,932
Ladino–ryegrass	6.5	20.9	2,734
Trefoil–ryegrass	6.4	22.2	2,850

trol bloat. Grasses alone, without fertilization, were very unproductive and poor in quality.

In another experiment, a mixture of orchardgrass, perennial ryegrass, and tall fescue, fertilized with 1,000 pounds of ammonium sulfate per acre, was less productive than were these same grasses growing with Ladino clover without fertilization. At the Imperial Valley Field Station, beef steers gained nearly twice as many pounds per acre on alfalfa as did a similar group of steers on tall fescue that received a total of 120 pounds of nitrogen per acre in three applications.

Certain rules should be followed in preparing a pasture mixture for a particular area or purpose:

1. Select the legumes first, on the basis of adaptation to soil, climate, and type of livestock. The level of production is based largely upon the legume content.

2. Choose the grass or grasses that are compatible with the legumes selected. Avoid putting an aggressive legume with a slow-growing grass and vice versa.

3. Manage the pasture (irrigation, fertilization, and grazing) on the basis of the requirements of the legume in most cases. Exceptions to this rule may be advisable in areas where legumes normally outgrow the grasses.

Recommended mixtures

The suggested mixtures, in pounds of seed per acre, are based in part upon experimental evidence and in part upon the authors' observations and judgment. The mixtures may be modified to fit special situations.

Hardpan soils, shallow topsoil

Dairy and beef cattle:

Ladino clover	3
Orchardgrass	10
Total	13

Or

Ladino clover	3
Common ryegrass	2
Perennial ryegrass	3
Orchardgrass	6
Total	14

Sheep and hogs:

Ladino clover	4

Heavy soils, poorly drained

Dairy and beef cattle:

Ladino clover	2
Narrowleaf trefoil	3
Orchardgrass	10
Total	15

Or

Ladino clover	2
Narrowleaf trefoil	3
Common ryegrass	2
Perennial ryegrass	3
Orchardgrass	6
Total	16

Sheep and hogs:

Ladino clover	2
Narrowleaf trefoil	4
Total	6

Deep soils, medium to light textured

All classes of livestock:

Alfalfa	20

Saline (salty) soils, poorly drained

Narrowleaf trefoil	5
Alfalfa	2
Sweet clover	2
Tall fescue (Goars)	3
Common ryegrass	2
Perennial ryegrass	3
Total	17

Horses prefer rather coarse, stemmy grasses for most of their grazing ration. From 10 to 20 per cent legumes meets these requirements, although such a low percentage will hardly maintain maximum forage yields unless heavy applications of nitrogen fertilizers are made.

Goats do best on the type of pasture recommended for cattle and sheep.

Palatability

Palatability of a forage plant is indicated by the readiness with which it is selected and eaten by livestock. Differences in palatability can be a factor of considerable importance if the forage offered is not eaten in sufficient amounts for satisfactory animal gains. Small differences in palatability may not directly affect animal gains, but may have important effects upon the botanical composition of the pastures. The more palatable species are grazed more closely so that the plants are weakened, while the less palatable ones thrive and thicken in the absence of grazing.

Various factors affect palatability:

1) Food preferences

tend to be similar among animals of the same class and breed, but there is also good evidence to indicate that particular animals have individual tastes. Age and degree of appetite influence preference. Animals that are hungry when turned in to graze become more selective in their choice of forage as their hunger is satisfied. Young animals are usually more selective than are older ones; fat animals, more selective than thin ones. Sheep are more selective than cattle.

2) Stage of growth

influences palatability. Young plants are generally succulent. As plants (especially grasses) mature, palatability decreases.

3) Weather

often determines choice of forage. For example, in spring, when the weather is cool and rains are frequent, sheep have been observed seeking coarser and dryer grasses rather than succulent legumes. As the season becomes warmer and dryer, the animals shift to the legumes and leave the grasses. Sunlight is also a factor. Grasses growing in the shade of trees or of taller plants are less readily eaten than are those in full sunlight.

4) Soil conditions,

such as drainage, degree of alkalinity or acidity (pH value), and available minerals, have an indirect effect on palatability. A relationship has been suggested between these conditions and the sugar content of grasses. Soils fertilized with phosphorus may be preferable to nonfertilized ones because this element is involved in sugar formation in plants. Exceptionally high nitrogen content in soil may result in less palatable plants (such as may occur around urine spots in pastures) as a result of a nitrogen/phosphorus imbalance which reduces the sugar content. Poor drainage and low pH may also decrease palatability.

Under systems of controlled grazing, in which each part of the pasture is grazed down quickly and uniformly, small differences in palatability may be unimportant. With less intensive control of grazing, however, even small differences in palatability could convert a good pasture into one largely dominated by the less palatable species. Furthermore, if the more palatable species is the legume in the mixture, pasture yields may be drastically decreased because of nitrogen starvation.

Pasture Management

The most important steps in pasture management are: irrigation, fertilization, regulated grazing, and weed control. All of these factors are essential to the maximum production of the pasture, and any one of them can limit production if not done correctly and in the right relation to the other practices.

Irrigation

The only aim of irrigation is to maintain a continuous supply of readily available soil moisture for the plants in the pasture mixture. Since most pasture mixtures contain several plant species which root to different depths, adequate soil moisture must be maintained throughout the entire root zone. If infrequent, heavy irrigations are used, the deeper-rooted plants, such as alfalfa and trefoil, will become dominant at the expense of the shallower-rooted Ladino clover. Since Ladino clover is usually the most important plant in the pasture mixture, the irrigation practice should be designed to maintain adequate clover growth. Ladino clover produces a large number of shallow roots from the joints of the main stems, and the irrigation practice should provide for water application immediately following grazing or clipping and at frequent enough intervals to keep the top 6 inches of soil from becoming completely dry. This will require close coordination between the grazing and irrigation cycles.

One of the most common faults in pasture management is failure to irrigate early enough in the spring. During this period, when rainfall ceases abruptly and temperatures warm rapidly, soil moisture is quickly depleted in the critical area of the root zone. Irrigated pastures that are allowed to suffer for lack of water at this period are extremely difficult to bring back to maximum production. (For a discussion of irrigation methods, see pages 5–10.)

Fertilization

Irrigated pastures, like any crop, require a high level of soil fertility for maximum yields. Although animal manure is a valuable soil nutrient, manures return only about one-third of the total nutrient supply in the forage eaten by the animals. Addition of commercial fertilizers is recommended for establishment and continued high production over a period of years. Elements most commonly deficient are phosphorus and nitrogen, with sulfur and potassium occasionally deficient in limited areas.

Phosphorus deficiency is widespread on calcareous soils and on acid soils with a hardpan or claypan substratum—soils on which much irrigated pasture is grown. Phosphorus deficiencies are less common on deep, neutral, alluvial soils.

Nitrogen is seldom present in sufficient amounts to provide for the needs of grasses. Although legumes in a pasture mixture fix substantial amounts of nitrogen, much of this nitrogen is utilized by the legume itself. When luxuriant legume growth has occurred, the decaying roots plus the manures of animals eating the forage provide organic nitrogen for use by grasses. If a good stand of legumes cannot be maintained either by fertilization or by irrigation management, it will be necessary to apply supplemental nitrogen to obtain a satisfactory growth of grass. Either manure or commercial nitrogen fertilizer may be applied. Manures or other organic nitrogen must be mineralized to ammonium or nitrate before the nitrogen can be used by grasses. After nitrogen is converted to the nitrate form, it leaches quickly in sandy soils or may be lost if soils remain saturated or waterlogged for extended periods. Since irrigated pastures require large amounts of water, it is doubtful that a commercial nitrogen application would be effective for more than 30 to 40 days. The nitrogen from organic sources such as manure top dressing does not leach so readily as does that from mineral sources. Nitrogen does not give maximum stimulus to grasses on a phosphorus-deficient soil unless phosphorus is also added. Similarly, on a sulfur-deficient soil, nitrogen is not effective unless adequate amounts of sulfur are present.

Sulfur deficiencies are not so widespread as phosphorus deficiencies. They are most likely to occur in northern and central California where water of low sulfur content is used on light soils. They rarely occur in southern California or where pumped underground water containing adequate sulphate is applied.

Potassium deficiencies on irrigated pastures are at present of limited extent in California.

Fertilizing the established pasture. Commercial fertilizers may be used to influence both the volume of feed produced and the proportion of grass to legume in the mixture.

Many irrigated pastures require applications of phosphorus to maintain or improve the growth of legumes. On acutely deficient soils, 80 to 120 pounds of P_2O_5 may be required to provide satisfactory growth of legumes. On moderately deficient soils, 40 to 80 pounds of P_2O_5 annually may be sufficient to maintain adequate growth. Where phosphorus is in short supply, the application of this nutrient increases both the amount and proportion of legume in the mixture.

Phosphorus may be supplied by either single or treble superphosphate broadcast preferably during the dormant season before growth starts in the spring. In areas where sulfur deficiencies are also suspected or known to occur, single superphosphate, which contains about 9 per cent sulfur, should be used.

Where adequate phosphorus is present, the application of additional phosphorus will not increase the growth of the legumes nor change the proportion of legumes to grass.

There are several conditions under which the use of nitrogen may be necessary and desirable. Nitrogen applications may often be used to increase the growth of grass in the forage mixture. Where early spring feed is needed, a late winter application of nitrogen will usually provide earlier grass growth and frequently more total feed. If the soil is deficient in phosphorus, it also must be applied in order to make the nitrogen effective. From 40 to 60 pounds of actual nitrogen per acre should be applied. Under average irrigation intervals, this will be effective for no longer than 30 to 40 days. Where legumes predominate and a threat of bloat exists, application of nitrogen may greatly increase the growth of grass present. Continued application of heavy amounts of nitrogen may stimulate so much grass growth that the legume may be crowded out of the pasture mixture. In the hot interior valleys where some legumes do not thrive in the summer heat, vigorous growing grasses, such as Dallisgrass, may be greatly stimulated by the application of the nitrogen alone or with phosphorus if needed. Under such conditions, forage production may be about doubled by application of from 180 to 200 pounds of nitrogen broadcast at rates of 30 to 40 pounds every 30 days. Equally effective results may be obtained at lower application costs by the continuous use of low concentrations of nitrogen solutions in the irrigation water throughout the summer months.

Liquid-manure pits conserve plant food and offer a convenient way to return corral and barn manures to pastures. The material may be pumped into tank wagons and distributed daily or it may be returned to pastures through irrigation systems. Liquid manures contain more nitrogen than phosphorus, and may be expected to stimulate grass to a greater degree than the legumes.

Controlled grazing

Under ordinary farm conditions, the management of grazing can have a greater influence on the condition of the pasture than any other factor under control of the operator. Methods of grazing have a pronounced influence upon botanical composition of a pasture, its leafiness, yield, and chemical composition (including such important constituents as protein and minerals). The importance of grazing management has not been clearly understood nor fully appreciated.

The objectives of good grazing management are to: (1) produce feed of good quality; (2) maintain high production; (3) obtain efficient utilization; (4) avoid soil compaction. Controlled grazing can help accomplish these objectives.

Grazing methods. These may be classified as: (1) extensive or continuous grazing; (2) rotation grazing; and (3) daily ration or strip grazing. With continuous grazing, there is little or no subdividing of pastures. Animals are permitted to graze freely over the entire area, selecting first those species and portions of plants which are most palatable. Selectivity in grazing results in a decrease of the most palatable species and an increase in the unpalatable plants.

The rotation grazing system requires intensive grazing on an intermittent basis throughout the growing season, using heavy concentrations of animals at each grazing period. Under this system, the pasture is subdivided into small units, and the animals are rotated from pasture to pasture as each is grazed down in turn. Systems differ greatly in number of subdivisions, frequency with which animals are moved, and length of

Intensive grazing on irrigated pastures. Cattle have just been turned in. Note abundance of luxuriant foliage. Rotation grazing encourages maximum production of high quality forage.

growing intervals between each grazing. Research and farm experience have shown that, for most conditions, the rotation system should contain six pastures, each grazed five days before the stock is moved on to the next pasture. With this system, a regrowth period of 25 days is possible between grazings. Irrigations should immediately follow grazing. If repeated every 10 days, three irrigations will be possible between each grazing cycle. Selectivity still occurs with rotation grazing, but its importance is determined almost directly by the time required to graze the pasture completely. The longer this takes, the more important selectivity becomes.

With daily ration or strip grazing, the area grazed is restricted to the amount which can be grazed down in one day or in one feeding (see diagram, p. 22). Portable electric fence is used, and the area upon which grazing is permitted is judged by how full the animals are or by the amount which may be left ungrazed. Adjustments in the size of the area to be grazed are made according to the rate of pasture growth or the amount of green feed required in the ration if supplemental feeding is practiced. The problem of selectivity is least serious with this method of management. Waste of feed from trampling and from fouling with droppings is kept at a minimum.

The cover photo shows a heavy concentration of dairy cattle on a rotation system. The area in the foreground was grazed the previous day.

Production of good quality feed can be controlled in part by grazing management. However, many other factors influence quality, such as soil conditions, plant species, climatic conditions, fertilizer practices, and plant maturity.

Stage of growth. This is probably the most important factor influencing chemical composition and feeding value. Early spring grasses and legumes are succulent, high in moisture and protein, but low in fiber. As the season progresses, days become longer, the temperature rises, and the plants approach the reproductive stage. Stems which produce the flowering parts appear and elongate rapidly. These stems have a higher dry-matter, carbohydrate, and crude fiber content than the leaves, and a lower protein percentage. If the plants are permitted to reach an advanced stage of maturity, the high percentage of crude fiber results in a decrease of both palatability and digestibility.

From a strictly chemical point of view, it might appear that the younger

On suitable land, alfalfa will produce the highest forage yield per acre of all pasture species. Daily rationed grazing has permitted greater use of alfalfa pasture, especially for dairy cattle.

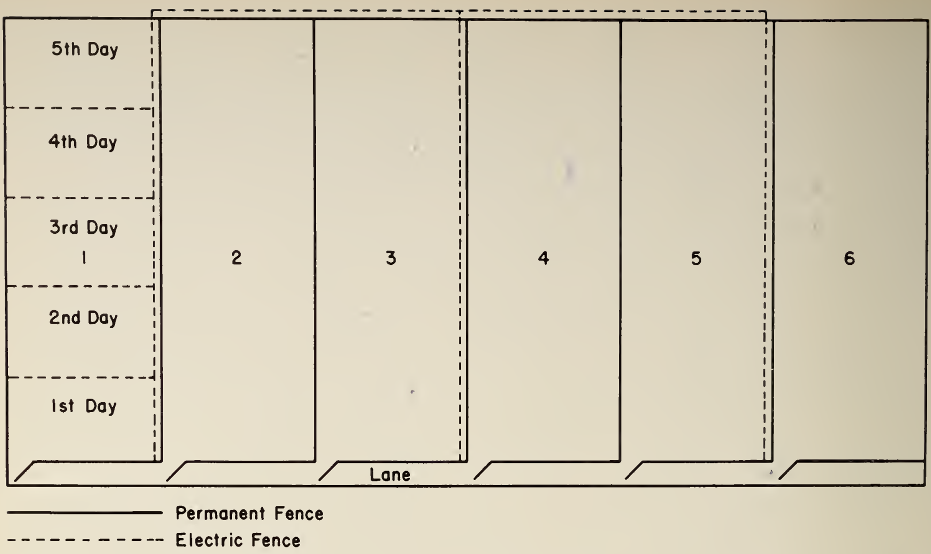


Diagram of a daily rationed grazing layout. The same basic plan can be used for rotation grazing. The chart opposite shows a 30-day grazing-irrigation-regrowth cycle.

the grass, the greater its feeding value. This is not necessarily true. Animals may actually lose weight from severe scouring during the first few weeks on spring grass, as a result of its laxative nature and low dry-matter content. Careful rationing of young grass and use of good roughage will overcome this problem. It seems reasonable to assume that the most satisfactory stage so far as the animal is concerned is somewhere between the extremes of succulent early growth and the very fibrous, mature growth.

Actively growing forages under favorable growth conditions may contain 80 to 85 per cent water. In general, legumes are higher in moisture than are grasses although it must be recognized that both groups may show wide variability in moisture percentage. In studies conducted at Davis, it was found that all pasture mixtures increased in dry matter as the forage became older. One mixture of legumes and grasses averaged 16.5 per cent dry matter when cut at two-week intervals, and 21.4 per cent when cut at five-week intervals. Assuming equal intake of fresh pasture at the two-week and five-week periods, the animals consuming the more mature forage would be ingesting nearly 30 per cent more dry matter. It is not known to what extent animals may compensate for degree of succulence when grazing pasture in which moisture contents differ. However, it is generally believed that animals on very succulent pasture will gain more rapidly if the dry-matter intake is increased by feeding of straw or dry hay on the pasture.

In good irrigated pasture, the quantity of protein is adequate for most purposes. Unfertilized grass pastures seldom contain less than 10 per cent protein, on a dry-weight basis, while grass-legume pastures usually average 20 per cent or more. Rapidly growing pastures with a high percentage of legumes may contain nearly 30 per cent crude protein. The digestibility of crude protein usually amounts to about 60 per cent of the total, but may range from 50 to 85 per cent.

Grazing, Irrigation, and Regrowth Periods for a 30-Day Cycle

Days	Field number					
	1	2	3	4	5	6
1	Graze	Irrigate		Irrigate		Irrigate
2	Graze					Regrowth
3	Graze					
4	Graze					
5	Graze					
6	Irrigate	Graze	Irrigate		Irrigate	
7	Regrowth	Graze				
8		Graze				
9		Graze				
10		Graze				
11		Irrigate	Graze	Irrigate		Irrigate
12		Regrowth	Graze			
13			Graze			
14			Graze			
15			Graze			
16	Irrigate		Irrigate	Graze	Irrigate	
17			Regrowth	Graze		
18				Graze		
19				Graze		
20				Graze		
21		Irrigate		Irrigate	Graze	Irrigate
22				Regrowth	Graze	
23					Graze	
24					Graze	
25					Graze	
26	Irrigate		Irrigate		Irrigate	Graze
27					Regrowth	Graze
28						Graze
29						Graze
30						Graze

Plant-animal relationships. In the foregoing discussion, particular stress has been given to the nutritional value of the forage produced in pastures. However, the needs of the plant as well as the animal must be considered in the development of any sound program of pasture management. There are few fields of research in which such careful consideration must be given plant-animal relationships as in that of grazing management.

In devising any system of controlled grazing, whether rotation or ration, it is important to know the plant responses when the pasture is grazed at varying intervals. Little advantage is gained by grazing at a very early stage if this results in decreased yield, weed infestation, and a ruined pasture. Neither is it wise to favor the plant entirely at the expense of the animal.

The plant responses to various systems of harvesting, grazing, or clipping are determined by the physiology of plant growth. Materials that enter the plant through the roots and leaves are relatively simple, and are inorganic. Water entering the plant through the roots combines with carbon dioxide, which enters the leaves from the air, to form simple carbohydrates—a process requiring light, and known as photosynthesis. Other, more complex substances formed in the plant from these organic and inorganic compounds make up the various structures of the growing plant. All new plant tissue, therefore, is a result of photosynthesis.

The rate at which this process is carried on in the plant is conditioned by many factors, one of which is leaf area. It is known, for example, that an alfalfa plant which has been recently defoliated will grow faster than new photosynthetic materials can be manufactured in the plant. This early growth must, therefore, take place partially at the expense of carbohydrate materials stored in the root. As the leaf area expands, the rate of photosynthesis catches up with, and eventually surpasses, the rate at which carbohydrates are being used for growth alone. Surplus material is again stored in the roots, and the entire process is repeated. It is evident that a frequently defoliated plant would eventually be starved or at least much reduced in growth rate, and that if a large leaf area is allowed to develop before defoliation, growth rate will be increased.

A three-year study conducted at Davis shows the extent to which yields are improved by permitting additional leaf growth to accumulate. The data in table 2 show an average of two different mixtures used in the study. It is evident that protein percentage decreases as yields increase. Obviously, there is a point beyond which increased yields may be more than offset by decreased quality, and the objectives of the livestock enterprise will determine which is to be emphasized.

The data above, together with the practical experience of farmers, show that a growth interval of 25 to 30 days between grazings is very satisfactory. Even shorter intervals should be used if high quality is of primary importance. Intervals longer than 30 days frequently result in much waste from trampling unless strip grazing is being practiced.

The diagram on page 22 shows a very successful system of rotation grazing which can be used where the intervals between irrigations average 10 days.

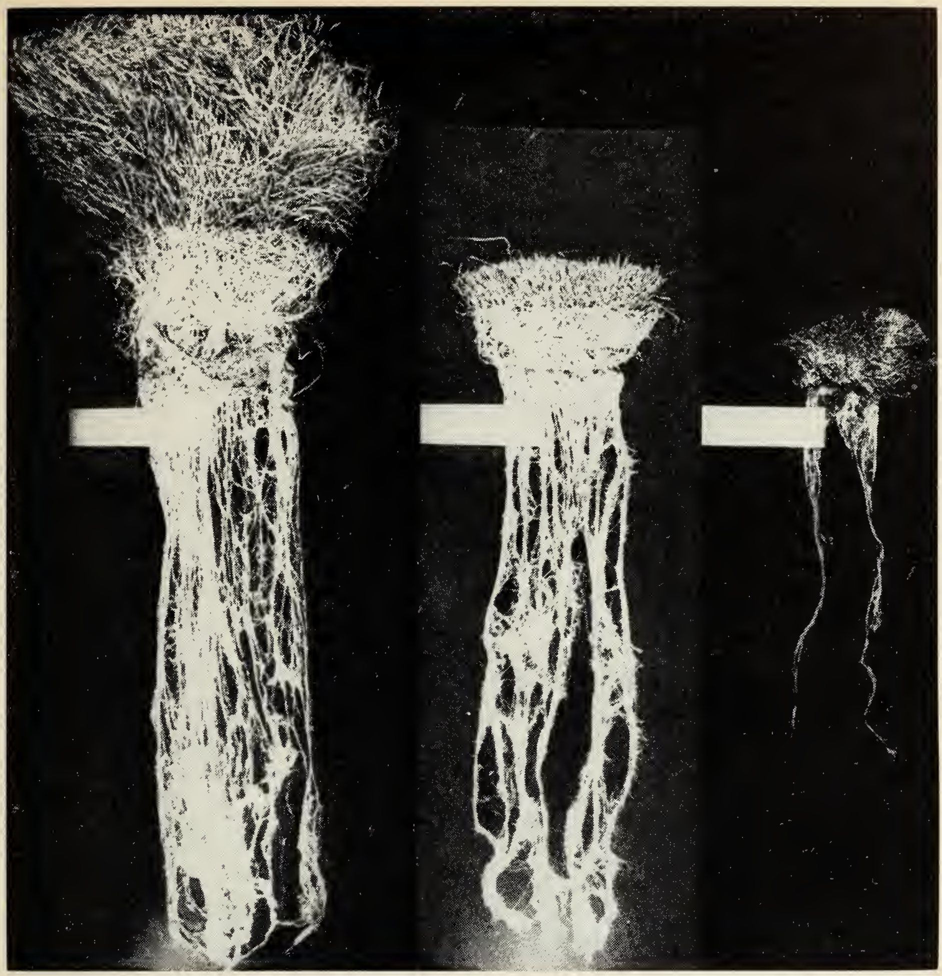
The grazing, irrigation, and regrowth periods for one complete cycle of 30 days are shown in the chart on page 23.

It appears to be quite important that irrigation immediately follow grazing to prevent heat damage to exposed Ladino stolons. Subsequent irrigations during the regrowth periods can be adjusted a

Table 2—Effect of Cutting Frequency Upon Yields and Protein Percentage of Two Irrigated Pasture Mixtures

(Yields and protein figured at 12 per cent moisture)

Harvest frequency	Ladino-grass mixture		Trefoil-grass mixture	
	Yield	Protein	Yield	Protein
	tons per acre	per cent	tons per acre	per cent
Two weeks	5.59	23.8	3.64	21.6
Three weeks	6.65	20.5	4.57	18.8
Four weeks	7.33	19.1	5.23	16.5
Five weeks	8.00	17.2	6.92	16.4



Effect of frequency of clipping or grazing. Left: three months' growth without clipping; center: clipped to 3 inches every three months; right: clipped to 1 inch every week for three months (note greatly retarded growth). Good pasture management permits normal and necessary root development.

day or two either way to accommodate labor and water supply. However, it is very important to allow four or five days for the field to dry before grazing since trampling of moist land damages the roots, compacts the soil, and reduces the rate of water infiltration. Thousands of acres of irrigated pasture in California are not producing to full capacity, and require more frequent irrigation than originally needed, simply because of compaction. To obtain adequate water penetration, some operators are forced to hold the water on the land for extended periods of time. This in turn causes the drowning or scalding of some pasture species. Aside from weeds, soil compaction is perhaps the next most serious problem facing the pasture operator. Once the soil has become compacted, corrective treatments cannot be effectively applied without plowing the stand.

Land needing irrigation at more or less than 10-day intervals will require a different number of pastures or different number of days on each. For example, on land where irrigation is at 8-day intervals, 24 or 32 days may be required to complete the entire grazing cycle. In every case, the need for timely irrigation is of greater importance than the regrowth period, and should be the dominant factor in planning the grazing program. During early spring and late fall when less water is used, the grazing cycle as well as the irrigation cycle must be lengthened. Supplemental feeding must compensate for lower production during these periods.

The carrying capacity of pastures grazed in rotation will have to be worked out on the basis of experience. Under average conditions and with little supplementation, an acre should supply adequate forage for 50 to 60 mature cattle for a day. Therefore, a field to be grazed for five days should carry 10 to 12 cattle per acre.

Not all of the feed produced in a pasture is actually consumed by the grazing animal. Much of it is wasted as a result of trampling, manure droppings, or leaf fall. Recent studies at the University of California showed that 70 per cent of the forage above a 2-inch height was utilized by dairy cattle strip grazing a Ladino clover-orchardgrass mixture. Utilization was 74.3 per cent by rotation grazing. A similar comparison with beef cattle grazing alfalfa pasture showed utilization of 71 and 76.2 per cent for rotation and strip grazing, respectively.

In both of the above-mentioned studies, the rotation system called for animals on each pasture for five days before being rotated to another field. It is believed that the amount of waste would be larger if the grazing period were longer than five days. Animals can be forced to utilize a larger percentage of the forage but in doing so, daily gains or milk production may be reduced. Some of the loss may be recovered by cleaning up the fields with dry cows or other stock in which maintenance rather than gains or milk production is desired.

Overgrazing, lack of drainage facilities, and low fertility contribute to excessive weediness. Turning livestock on to pastures that are too wet results in poor water penetration because of compaction.

Weed control

Land grading. Proper and careful land grading is the first step for control of weeds in an irrigated pasture. Water standing in low spots will drown out the pasture plants and provide ideal conditions for many of the water-loving weedy species, such as curly dock, buckhorn and sedge. High spots which receive insufficient irrigation likewise tend to encourage other types of weeds, such as yellow star thistle, which do well under dry conditions.

Mowing. Mowing annual weeds before they mature is one of the cheapest and best methods of preventing their increase and spread. However, mowing will not kill perennial weed types, such as dock and sedge. Even in mature fields that are being pastured, occasional mowing is beneficial in reducing weeds and promoting even cropping and full utilization of forage.

Chemical control. This is most effective when used to supplement good management and cultural methods. 2,4-D can be used on established Ladino and/or trefoil-grass pasture. It is effective in the control of dock, buckhorn, plantain, chicory, sedges, star thistle, wild lettuce, and other broad-leaved weeds. Weeds on supply ditches can also be controlled by chemicals.

In using 2,4-D, local regulations must always be followed. These points are also important when spraying Ladino or trefoil pastures with 2,4-D:

1. The best time to spray is in April after the legumes have started growing well. Do not spray dormant legumes (November to January).

2. The amine form of 2,4-D appears to be safer to use than does the ester form.

3. Use from ½ to ¾ pound of actual 2,4-D acid equivalent per acre. If buckhorn is the principal weed to be controlled, use ¾ pound of actual 2,4-D per acre. For best control of buckhorn, the field should be grazed or mowed back before spraying to expose the low growing plants, but this may increase the damage to the legumes. Dock and chicory appear to be readily killed by 2,4-D in normal, unmowed or ungrazed stands. The sedges and dock are difficult to kill and may require treatment for several years before they are checked.

4. Ground-spray equipment gives very good results, provided 20 to 50 gallons of water are used per acre. Less water can be used with airplane application.

5. All 2,4-D-sprayed fields should be kept well irrigated following spraying.

6. Do not graze 2,4-D-sprayed stands during the recovery period—about 30 days for Ladino clover and longer for the trefoils.

Chemical weed control is effective only where land is properly graded, drainage is adequate, and good irrigation and general management practices are followed. The greatest source of failure with any weed control practice either cultural or chemical is improper timing of the application. Once a pasture is infested with weeds, periodic spraying and mowing may be required throughout the life of the pasture.

The weed population of a pasture is also affected by grazing practices, soil fertility, and crop rotation. Pasture plants that are grazed too frequently or too closely will not compete with aggressive weedy species. Adequate soil fertility permits the desired species to grow better and thus compete favorably with weeds.

Poisonous weeds occasionally cause stock losses, but are rarely a problem where pastures are managed to permit good growth and adequate production of feed.

Crop rotation

A well-balanced program of crop rotation can include land devoted to pasture. Irrigated pastures do not remain

Pasture land should be included in the farm crop-rotation program since irrigated pastures do not remain at maximum production indefinitely. Rotation with other crops permits regrading of land, aids weed control, and provides for a more balanced farm feed production.

at maximum production indefinitely. Ordinarily, a pasture remains profitable not longer than five to eight years, and then begins to become weedy and difficult to irrigate.

Satisfactory pasture renovation can best be accomplished through rotation with other crops. Forage production can be continued by using such crops as oats and vetch for winter feed and Sudangrass for summer pasture or for hay. Cultivated annual crops, such as corn, milo, and small grains, help the reduction and control of weeds. (The ease with which corn fits into a rotation system that aids weed control is an important point in its favor.)

Rotation permits regrading and deep tillage, such as chiseling or subsoiling, to help open up the soil for more efficient use of irrigation water and better control of weeds. A change of planting also permits use of newly developed improved varieties or strains, and provides an opportunity to take advantage of the improved soil fertility.

Miscellaneous management practices

Mowing. If the livestock numbers on any given farm are properly balanced with year-round feed supplies, there will probably be an excess of pasture during the spring months of flushest growth. By adjusting the rotation so that each paddock may be mowed at least once, this surplus may be used for hay. It also makes good silage when molasses or other additives are used. As the grazing season progresses, clipping after each rotation grazing will further reduce weeds, result in a uniform pasture growth for the next grazing period, and promote more nearly equal utilization of all pasture plants.

Harrowing. Pasture should be harrowed regularly to spread the droppings of cattle and prevent bunchy growth around manure clumps. Harrowing for this purpose is especially effective after an irrigation. A flexible type harrow does a better job of breaking up and spreading than does the rigid type.

Livestock Management

Supplemental feeding

Irrigated pasture feed attains its maximum efficiency when combined with supplemental feeding planned for a specific type of livestock. Experience indicates that daily gains of good quality cattle are increased by supplemental feeding. The supplement ordinarily consists of a combination of hay and grain. Beef cattle are not normally finished on irrigated pasture. A period of from 30 to 60 days in the feedlot is generally required to finish cattle to top market grade. Young cattle and calves particularly require supplemental feeding in order to make satisfactory gains on irrigated pasture. On the other hand, cattle of lower quality, as well as older animals, may be advantageously marketed directly from irrigated pasture without the benefit of supplemental feeding. Producing dairy cattle are normally fed dry hay and a grain concentrate in addition to the irrigated pasture green feed. This practice does not seem to be justified for low-producing herds.

Lambs appear to make satisfactory gains on good irrigated pasture with no other supplement than dry roughage. Hogs make the most economical gains when self-fed grain while in pasture.

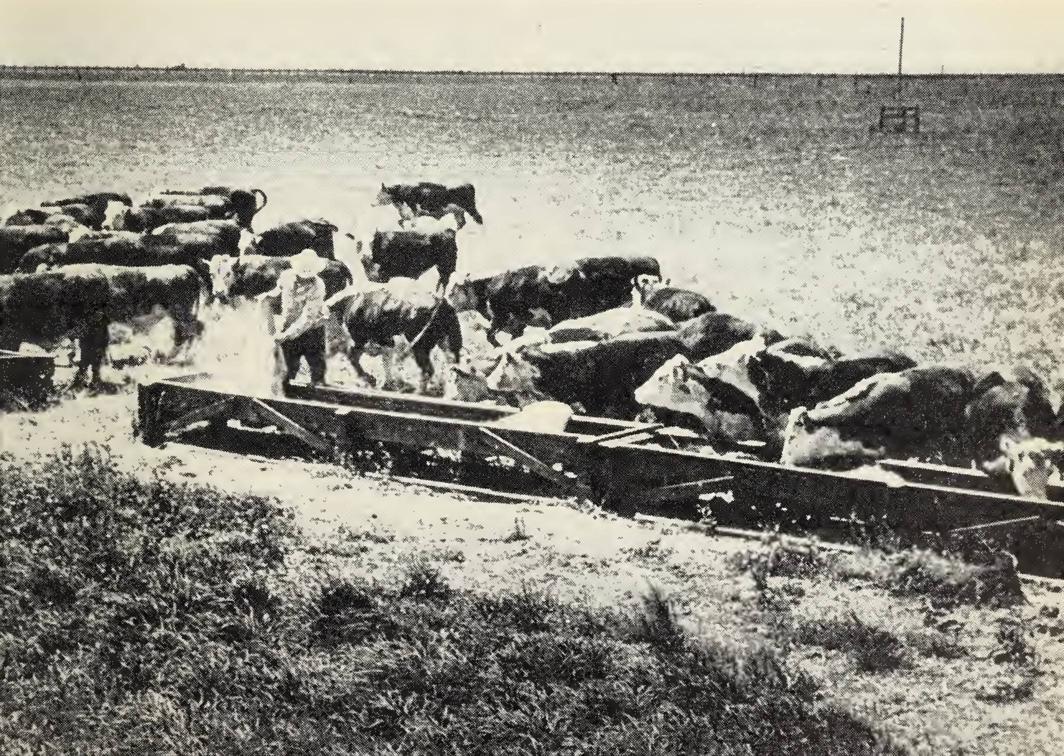
Bloat

Bloat is a hazard when cattle and sheep are grazed on pastures containing a high percentage of clovers and immature alfalfa. Several precautionary measures may be taken to minimize the problem:

1. Mow strips in the pasture the day before cattle are turned in to feed. The dry feed in the strips will reduce the incidence of bloat.

2. Do not turn hungry cattle in on new, luxuriant, or immature growth, especially in spring, without first giving them a fill of dry cereal hay or Sudangrass hay. Feeding straw may be of value under some circumstances. Alfalfa hay is less effective than straw in prevention of bloat. Green Sudangrass pasture and Sudangrass hay are the most effective

Fattening animals will gain from ¼ to ½ pound more per day when given supplemental feed. All other livestock and pasture management practices must also be properly integrated.



feeds known at present for preventing bloat.

3. Rotation grazing has resulted in a noticeable lessening of the bloat problem. With proper control of grazing, many dairymen and stockmen successfully pasture alfalfa throughout the entire growing season. However, rotation grazing is not a reliable method for eliminating the bloat hazard.

4. An adequate supply of nitrogen will produce maximum grass growth and aid in maintaining the desired grass-legume balance.

Molybdenum toxicity

Soils in certain areas of the state contain an excess of molybdenum. Plants growing in these soils, particularly legumes and some grasses, contain an amount that is toxic to cattle.

Areas affected. The areas known to be affected at present include the west side of the San Joaquin Valley and, to a limited extent, eastward along the Kings River. The problem exists also in the Sacramento–San Joaquin Delta and in many of the south coastal counties.

Molybdenum content of plants. The exact amount of molybdenum in plants that is sufficient to be toxic to cattle is not known, but is believed to be somewhere between 10 and 20 parts per million. The range of molybdenum in plants varies widely, depending upon its content in the soil. The following is an analysis of some plants from affected areas:

PLANT	MOLYBDENUM RANGE *parts per million*
Legumes:	
Alfalfa	10 to 30
Birdsfoot trefoil	21 to 116
Ladino clover	7 to 103
Sweet clover	14 to 122
Grasses:	
Ryegrass	2 to 20
Orchardgrass	5 to 9
Sudangrass	2 to 8
Rhodesgrass	12 to 26
Burmudagrass	3 to 11

The molybdenum content of pasture plants appears to decline with the age of the pasture stand.

It is important that the pastures be kept in an active growing condition. Good cultural practices, such as adequate nitrogen fertilization, will permit maximum growth of grass in the pasture.

Animals affected. Young cattle and calves show the effects of molybdenum most noticeably. Some evidence also indicates difficulty with sheep pastured in areas known to be high in molybdenum.

Symptoms. Molybdenum poisoning results in severe scouring and loss in weight to the point of emaciation. The hair coat becomes rough and dry, and changes color. Red Hereford cattle become a dirty yellow, and black animals turn mouse-gray. There is some evidence that cattle on affected pastures develop breeding difficulties.

Symptoms alone are not sufficient for positive diagnosis. Since cattle scour from other causes, a chemical analysis of the forage should be made to determine the molybdenum content. Molybdenum apparently does not cause death, except of those cattle that have had prolonged access to affected forage.

Prevention. Copper sulfate fed to cattle at the rate of 1 gram per head per day has proved effective in preventing most cases of molybdenum poisoning. In a few instances, when it has been necessary to go to 2 grams per day, there has been no ill effect on the cattle. The copper sulfate may be added to the drinking water, or it may be added to the grain mix. For details, see your local Farm Advisor.

Pasture mixtures for affected areas. Since legumes generally contain a higher amount of molybdenum than do most of the grasses, it is recommended that pastures in affected areas be seeded largely to grasses.

Feeding dry roughage on pasture. Providing cattle on irrigated pastures with free access to dry roughage has been helpful in reducing the symptoms of molybdenum poisoning. Such feeding may eliminate all evidence of trouble where pasture plants contain only slight amounts of molybdenum.

Ergot poisoning

Ergot poisoning, although fairly rare in California, can result in severe damage and even stock loss when it does occur. It is a fungus disease which attacks grasses—mainly perennial ryegrass and Dallisgrass—when they are flowering and making seed.

Ergot can be recognized first by the appearance of a sticky exudate or honeydew on the seed heads, followed, in most grasses, by dark-violet to black "spurs" in place of, and noticeably longer than, the normal grass grain. Dallisgrass ergot does not form these dark, spur-like enlargements, but develops light, pinkish bodies which do not differ greatly in appearance from the seeds. The presence of the honeydew should be regarded as a warning.

Stock pasturing on ergotized fields are usually covered about their heads and bodies with the sticky, black exudate.

When driven or forced to move, cattle that have consumed toxic amounts of ergot exhibit a staggering gait, trembling of the muscles, and nervous outbursts during which the animals fall. These symptoms may or may not be followed by paralysis. Cattle lost because of ergot poisoning have, in the majority of cases, either fallen down out of reach of food or have drowned in shallow water.

Rotation grazing and mowing to keep grasses from developing seed heads will practically eliminate the ergot problem.

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THE COVER PHOTO shows how rotation grazing with dairy cattle may be accomplished on irrigated pasture. The area in the immediate foreground was grazed the previous day. Note the heavy concentration of cattle.