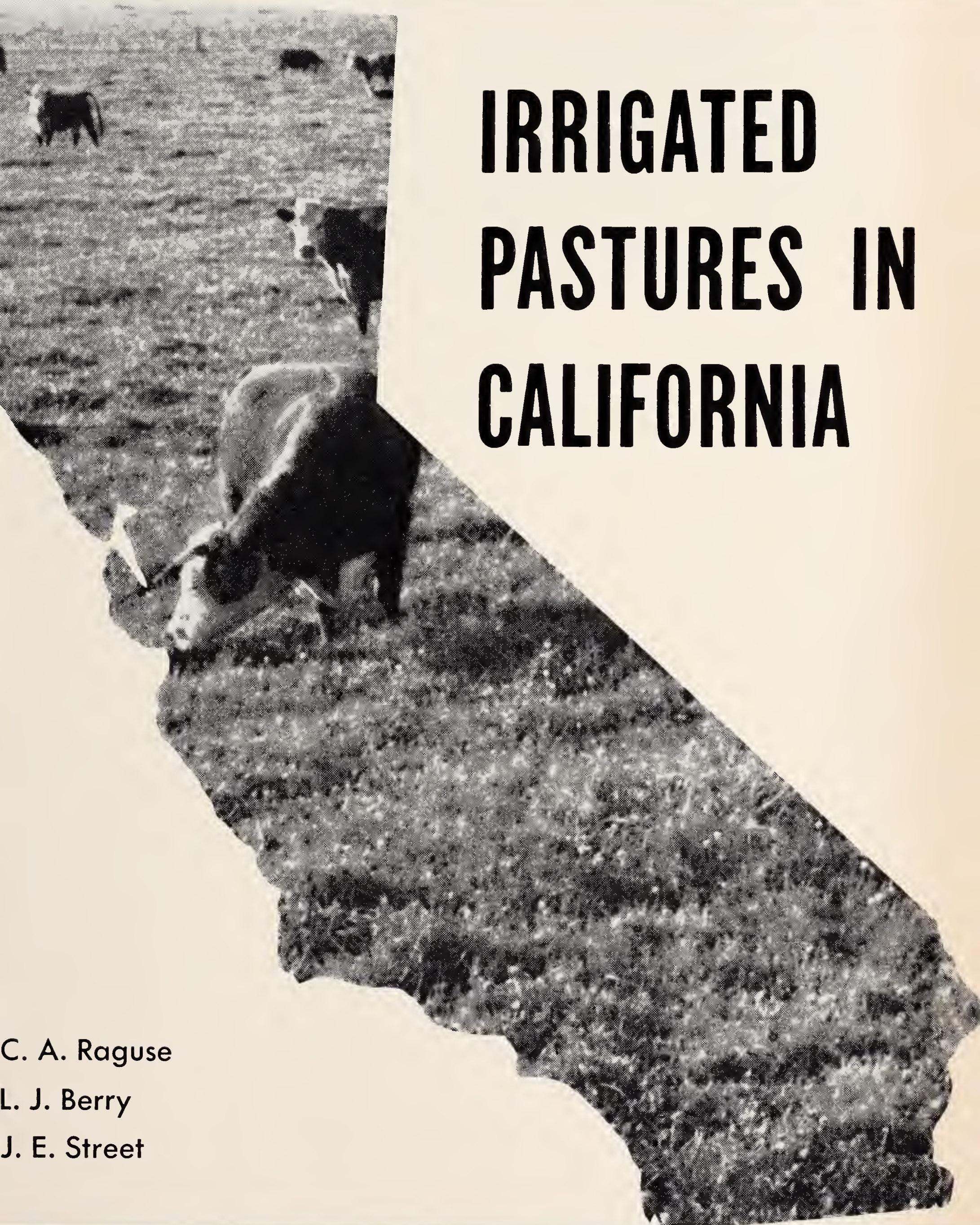
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

IRRIGATED PASTURES IN CALIFORNIA



C. A. Raguse
L. J. Berry
J. E. Street

CALIFORNIA AGRICULTURAL
Experiment Station
Extension Service

CIRCULAR 545

The goals of good pasture management

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:

- Grade and prepare the land to get efficient irrigation and good drainage of excess water.
- Use an adapted and compatible mixture of legumes and grasses.
- Apply the right kind and amount of fertilizer.
- Control weeds.
- Manage grazing and supplemental harvesting to utilize fully the feed produced.
- Manage irrigation properly.

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.

Irrigated pastures tend to be grown on soils not well suited for other more profitable crops. These are usually heavy-textured soils or shallow soils underlain with hardpan or tight subsoil clay layers. Therefore, most plants for irrigated pasture are shallow rooted. At times irrigated pasture is grown on deeper, more productive alluvial soils.

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

This circular replaces Circular 476.

NOVEMBER, 1967

THE AUTHORS:

C. A. Raguse is Lecturer in Agronomy, and Assistant Agronomist in the Experiment Station, Davis; L. J. Berry is Agriculturist, Agricultural Extension Service, Davis; J. E. Street is Agriculturist, Agricultural Extension Service, Davis.

The cover and the picture on the left show well-stocked, well-managed irrigated pastures of the type found in California and described in this circular.

IRRIGATED PASTURE COSTS PER ACRE

Overhead	Initial cost	Life expectancy	Depreciation	Interest
	dollars	*years*	*dollars*	*dollars*
Land, unimproved	$500.00	..	$....	$30.00
Grading, including drainage	90.00	..	....	5.40
Fences	25.00	20	1.25	.75
Irrigation preparation (land plane, check, field ditch)	14.00	7	2.00	.42
Turnout gates	3.00	10	.30	.09
Stock water facilities	3.00	20	.15	.09
Pasture stand	30.00	7	4.29	.90
Tillage equipment (based on 100 acres)				
Tractor	40.00	10	4.00	1.20
Mower	6.00	10	.60	.18
Pickup	25.00	10	2.50	.75
Miscellaneous	2.00	10	.20	.06
	$738.00		$15.29	$39.84
Total overhead cost				$55.13

Cash and labor costs:	*dollars*
Irrigation: 16 times, 8 hours labor	$12.00
Mowing: 3 times, 1 hour labor and equipment	2.50
Ditch work and fence repair: labor, equipment and supplies	2.00
Miscellaneous labor and truck use	1.00
Taxes	6.00
Total cash and labor costs	$23.50
Total overhead costs	55.13
Total cost (not including water or fertilizer)*	$78.63

* 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. Fertilization may require 22 lbs. of P ($5.00), 60 lbs. of N ($9.00) and ⅓ hour application ($0.50).

IRRIGATED PASTURES IN CALIFORNIA

Profitable management of irrigated pasture is neither simple nor easy. Economic considerations alone discourage the growing of irrigated pasture where water and operating costs are high and, especially, where higher-value crops can be grown successfully. These factors must continually be appraised by both new and existing growers. Irrigated pastures are most likely to be grown where soil conditions are unsuitable for higher-value crops, or in conjunction with dryland range operations, and in alkali land reclamation. They will serve as part of a rotation in a more general farming operation.

Sound management is most important. Two popular misconceptions about management are, first, that irrigated pastures are "permanent" pastures, that once established they can be forgotten and, second, that management is simple. The fact is that irrigated pasture is one of the most difficult crops to manage well. It consists of a mixture of perennials, usually including plants from two widely differing families, the legumes and the grasses, whose growth patterns and responses change throughout a season and over the years. The management of animals can markedly influence pasture quality by altering botanical composition and stage of growth which in turn affects animal yields. Small errors in management, such as in irrigation practice, can noticeably influence the quality of a pasture stand.

The operator must weigh carefully the economic factors in irrigated pasture production, compare it with alternative land uses, and be prepared to apply the best possible management.

PASTURE PLANTS

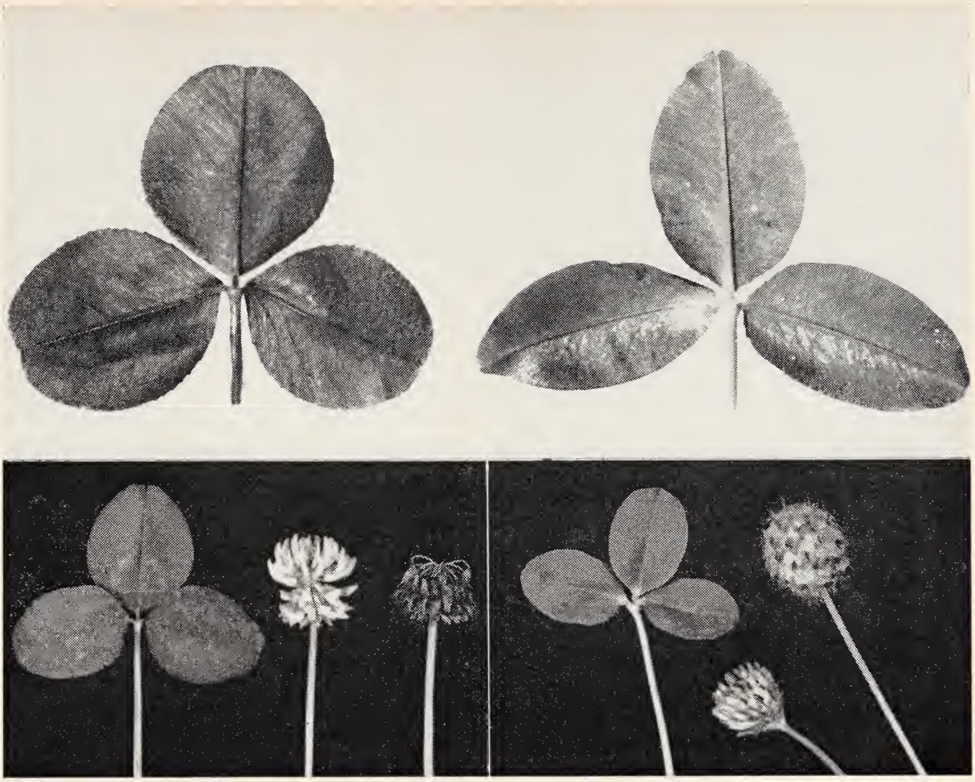
Legumes

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 aster yellows, a virus disease that is transmitted by leafhoppers and for which there is no known control. This disease is most apparent in late winter and early spring. A severe infection decreases production.

Salina strawberry clover . . .

a selection from the Palestine variety of strawberry clover, is a perennial legume similar in appearance and growth habit to Ladino clover. The flower heads are denser than those of Ladino and sometimes resemble small strawberries. Although slower in establishment than Ladino, yields over the 3 to 5 years of a rotation pasture stand compare favorably with Ladino under growing conditions suitable for them both. There also is some-



Top: **Underside of Ladino clover (left) and Salina strawberry clover (right). Note: The entire underside of all three leaflets of Ladino clover is shiny. On the underside of Salina strawberry clover, only half of each side leaflet is shiny; the center leaflet is entirely dull on the back.**
Bottom: **Leaf, flowers, and seedhead of Ladino clover (left) and Salina strawberry clover (right).**

what less bloat problem with Salina than with Ladino. Salina strawberry clover is more tolerant of drought, salinity, and poorly drained conditions and, in a mixture, will become the dominant legume where these factors limit the growth of Ladino. It is susceptible to *Sclerotinia,* a fungus disease occurring under cool, wet conditions. Close grazing or clipping in late fall may reduce the damage by making the environment less favorable for the growth and spread of the fungus. Salina is not as winter hardy as the other types of strawberry clover but has done well under a wide range of growing conditions in the state, and especially in the cooler summers of the coastal area.

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°F in the Imperial Valley. This type of trefoil is not suited to areas that have hard, killing freezes because 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.

Narrowleaf (prostrate) trefoil.

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. Many varieties of broadleaf trefoil exist, most of which have coarser stems than does narrowleaf, but similar flowers and pods. Broadleaf trefoil is almost completely winter dormant, more resistant to cold than narrowleaf, and 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 narowleaf. 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 vigorous growth of clover and grass the trefoil may be crowded out of the mixture.

Broadleaf (erect) trefoil.

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 sudangrass hay to control bloat. Because of its vigorous growth, upright habit, and need for deep, well-drained soils, alfalfa is less well suited to pasture use than are the clovers or trefoil. Where alfalfa can be grown successfully, it must compete with other higher-value crops for land use, and mechanical harvesting in the form of hay, wafers, or greenchop, may be a more efficient means of utilizing its potential productivity than pasturing.

Alsike clover . . .

is a perennial used chiefly in the northern counties at higher elevations. It is able to withstand wet, cold, heavy soils better than do many other legumes, but is not suitable for areas with high summer temperatures.

Red clover . . .

classified as a short-lived perennial, usually responds as a biennial in most hay and pasture stands. It does best on well-drained soils but will tolerate soils too wet, shallow, or acid for successful alfalfa production. The root system is shallower than that of alfalfa and less strongly tap-rooted. Red clover must be irrigated more frequently than alfalfa and should not be subjected to excessively dry or flooded conditions. Yields of red clover often range from 5 to 8 tons of dry matter per acre, when harvested for hay at 25 to 50 per cent bloom. Red clover may be used as an interim crop between successive stands of irrigated pasture. Its thick, vigorous growth, coupled with regular cutting, can greatly aid in weed control and provide a source of highly nutritious hay or greenchop for supplementary feeding.

Grasses

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, and proper grazing management in conjunction with regular clipping will avoid the problem of coarseness at maturity. Orchardgrass starts growth later in the spring than perennial ryegrass and goes dormant earlier in the fall; it produces somewhat better during the warm season than does ryegrass.

Perennial (English) ryegrass . . .

is a fine-stemmed, leafy plant which begins growth earlier in the spring than orchardgrass and continues later into the fall. It is not as palatable as either orchardgrass or annual ryegrass in early and midseason, but tends to become more palatable in late season when the other grasses begin to mature. Its total production is likely to be less than that of orchardgrass.

Annual (domestic) ryegrass . . .

is more robust and stemmy than perennial ryegrass but may be more palatable. It produces an early, heavy spring growth. Annual ryegrass often contains a mixture of plant types and individual plants may range from strictly annuals to short-lived perennials.

Bermudagrass . . .

is a perennial adapted to the southern parts of the state. Once established, it spreads by aboveground stolons and underground rhizomes. Because of its considerable tolerance to saline and alkali conditions, it is valuable in reclamation. Bermudagrass is strictly a hot-weather plant and goes dormant under cool fall

Orchardgrass. Characteristic is the slight bluish color, the flattened stem, and an arrangement of flowers resembling the foot of a chicken.

conditions. Frost will kill the plants or induce complete dormancy. Coastal Bermuda, a hybrid developed in Georgia, is more productive than common Bermuda, but because it produces very little seed, must be propagated by stem cuttings. NK37, a commercial selection that produces seed, is leafier and finer textured than common Bermuda and does not produce the thick sod of Coastal Bermuda.

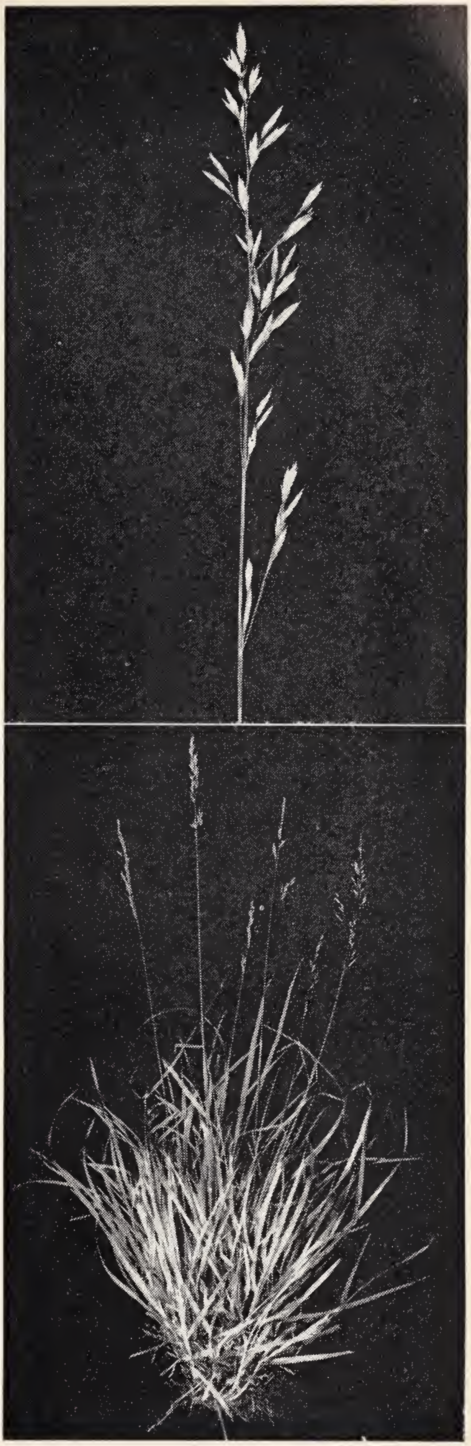
Dallisgrass . . .

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. Starting growth rather late in the spring, and becoming dormant in the fall, it is strictly a warm-season grower, producing heavily during the summer months. Dallisgrass 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 as weeds along ditchbanks.

Tall fescue . . .

a deep-rooted, strongly tufted perennial with a long growing season and high forage yields, 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. Both tall fescue and Dallisgrass are somewhat more controversial than the others listed above. Whether these two species are satisfactory

Annual ryegrass (left), perennial ryegrass and annual ryegrass heads (center), and perennial ryegrass (right). Note: Annual ryegrass normally has awns, perennial ryegrass does not. The undersides of the leaves of both are very shiny.



Tall fescue. It has dark green color, bunchy growth habit, and seeds that are borne in an open panicle.

will depend on individual stockmen's preferences, animal acceptability, and skill in pasture management.

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, and is more alkali tolerant than are any of the other regularly used irrigated pastures grasses.

Other plants . . .

used occasionally include the annual legumes, bur clover and subterranean clover. At higher elevations winter-hardy varieties of orchardgrass and Ladino clover are used as well as smooth bromegrass, timothy, meadow foxtail and reed canarygrass. Yellow-blossom sweet clover, a biennial, is sometimes used in early stages of reclamation on saline-alkali soils. Other grasses found are tall wheatgrass and Goar's fescue, particularly when irrigated pasture is used for alkali reclamation.

IRRIGATED PASTURE MIXTURES

Grasses and legumes are usually grown in mixtures for irrigated pasture, except 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.

Advantages of grasses over legumes:

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

Advantages of legumes over grasses:

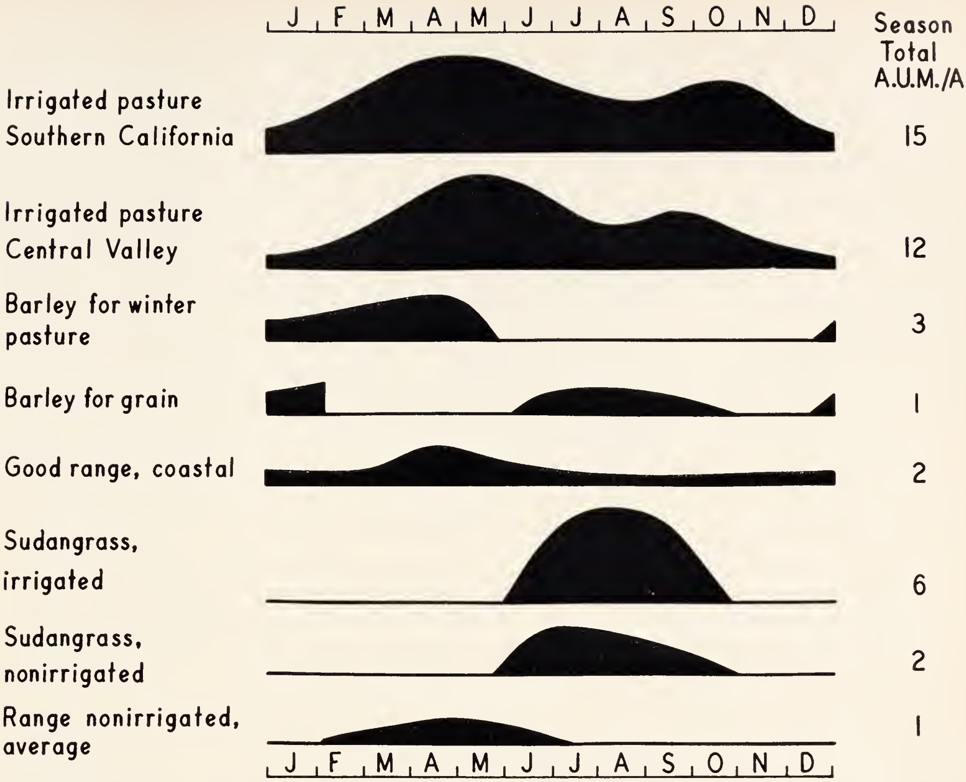
- They are higher in protein and mineral content.
- They maintain or improve nitrogen fertility by symbiotic nitrogen fixation.
- They provide higher summer production than do most grasses.
- Grasses alone, without legumes or nitrogen fertilizer, tend to be unproductive and of poor quality.

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 and thus the mixtures will provide continous 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. The effect is that instead of continuous pasture, production is confined to the growth period of the dominant species. This condition becomes increasingly pronounced in succeeding years of a stand.

Simple 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. The graph on page 11 gives some examples of how different forages can be incorporated into a general pasture program. This method of mixing species can be extended even further by utilizing excess forage from pastures as hay, or by using the reestablishment phase of pasture rotation to



Example of forage available at different seasons from various types of pasture. Total estimated annual productivity is given in animal unit months (A.U.M. equivalent of forage eaten by one 1,000-lb cow in one month).

plant red clover (where it can be grown), cereals, sudangrass, or other annual forages, to be harvested as hay.

In preparing a pasture mixture for a particular area or purpose follow these rules:

- Select a legume-grass mixture on the basis of adaptation to soil, climate, and type of livestock. Where legumes are well adapted, the level of production attainable depends considerably upon the legume content.
- Choose compatible legumes and grasses. Avoid putting an aggressive legume with a slow-growing grass and vice versa. Also avoid putting a highly palatable plant with one which is unpalatable.
- Manage the pasture (irrigation, fertilization, and grazing) on the basis of the requirements of the legume. Exceptions to this rule may be advisable in areas where legumes normally outgrow the grasses and a serious bloat problem may exist; also where legumes are of minor importance in the mixture because of natural soil and climatic conditions.

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

	lbs. of seed/acre
Dairy and beef cattle:	
Ladino clover	3
Salina strawberry clover	1
Annual ryegrass	2
Perennial ryegrass	3
Orchardgrass	6
Total	15
OR	
Ladino clover	3
Salina strawberry clover	1
Orchardgrass	10
Total	14
Sheep and hogs:	
Ladino clover or Salina strawberry clover	4

Heavy soils, poorly drained

Dairy and beef cattle:	
Ladino clover	2
Narrowleaf trefoil	3
Annual ryegrass	2
Perennial ryegrass	3
Orchardgrass	6
Total	16
OR	
Ladino clover	2
Salina strawberry clover	1
Narrowleaf trefoil	2
Orchardgrass	10
Total	15
Sheep and hogs:	
Ladino clover	2
Salina strawberry clover	2
Narrowleaf trefoil	2
Total	6

Deep soils, medium to light textured

All classes of livestock:	
Alfalfa	20

A number of species are suitable for use in reclamation of saline or alkali soils, or where saline-alkali conditions are a continuous problem. Recommendations for these cases range from 5 pounds per acre of NK37 bermudagrass up to 23 pounds per acre of a complex mixture. Local experience should be relied on in the final decision regarding both choice of species and seedling rate. Species most frequently used include narrowleaf birdsfoot trefoil, Salina strawberry clover, tall or Goar's fescue, Rhodesgrass, and bermudagrass. Others sometimes used are tall wheatgrass, Dallisgrass, orchardgrass, sweet clover, and alfalfa.

The makeup of irrigated pasture mixtures for horses varies from standard mixtures recommended for beef and dairy cattle to plantings consisting solely of grass. A grass such as tall fescue can often be used to advantage in a horse pasture to form a dense, tough sod. Nearly all suggested mixtures, however, contain from 10 to 20 per cent legumes.

Suggested mixtures for horse pastures

	lbs. of seed/acre
Perennial ryegrass	2
Annual ryegrass	2
Tall fescue or orchardgrass	8
Birdsfoot trefoil (narrowleaf)	2
Salina strawberry clover	2
Total	16
OR	
Bermudagrass	10
Salina strawberry clover	2
Total	12

If a single species is preferred, either tall fescue 10–12 lbs/acre or bermudagrass 10–12 lbs/acre may be used.

Horses are highly susceptible to internal parasites and most horses on closely grazed irrigated pasture are heavily parasitized. For this reason pasture used by horses

A mixture of half legume and half grass provides attractive, nutritious, and productive pasture. About 50 per cent composition of vigorous legume can fix sufficient nitrogen for near maximum grass production.

should never be grazed below a height of 6 inches. This will require careful grazing and irrigation management and fairly heavy applications of nitrogen fertilizer at frequent intervals throughout the growing season.

Goats do well 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 may be important 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.

Factors affecting palatability

Forage preferences tend to be similar among animals of the same class and breed, but evidence indicates 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.

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

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.

Soil conditions, such as drainage, degree of alkalinity or acidity (pH value), and available minerals, have an indirect effect on palatability. A relationhip 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 plays a part 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. Practical experience bears out these observations, and serves to emphasize the fundamental importance of careful management to the success of a pasture operation. Furthermore, if the more palatable species in the mixture is the legume, pasture yields may be drastically decreased because of nitrogen starvation as the legume, with its nitrogen-fixing capacity, is eliminated from the mixture.

LAND PREPARATION

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 show approximate per-acre costs for new pasture development.

Surveying and mapping	$ 6.00
Grading, including drainage facilities	90.00
Well	20.00
Pipeline and valves	25.00
Pump and motor	40.00
Total	$181.00

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. Do not plant the seed deep to insure contact with moisture because you may get poor emergence.

Preliminary operations in seedbed preparation include disking, dragging, landplaning, and harrowing. For fall seeding, work the ground 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.

With soils that tend to wash, crust, and frost-heave excessively, planting into an organic mulch or stubble is helpful. A successful practice is to landplane, make levees, and float the field for irrigation then sow sudangrass for summer feed. In fall just prior to rains, sow the irrigated pasture mix into the sudangrass stubble without further cultivation except light harrowing, ringrolling, or drilling to cover the pasture seeds.

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.

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. In the Sacramento Valley fall sowings should be made before October 15. In the southern San Joaquin Valley sowings as late as November 15 have been successful. Seedings after these dates should be delayed until temperatures warm up in the early spring. Well established fall-sown pasture will usually support normal grazing by the middle of the first growing season. However, on spring-seeded pastures normal grazing will have to be delayed until the late summer or early fall. In either case it is usually necessary to either graze heavily for three or four days or clip the growth for weed control early in the growing season.

Seed

Seed costs represent only a small part of the investment in a pasture. Use only seed of high germination and purity. Low-cost seed is not always the most economical. The use of certified seed will 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. You can also buy the individual species separately and mix them to 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 should be inoculated with these bacteria before planting. The cost is only a few cents per acre. Seed pelleting is an improved method of seed inoculation. (See University of California Agricultural Extension publication AXT 200 for details of the method.)

Commercial cultures of 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, ground or airplane broadcasting, or the use of a ringroller with a sowing attachment. 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.

Fertilization at time of planting

Applications of about 250 pounds of single superphosphate per acre, worked into the seedbed, may greatly stimulate seedling growth of legumes on soils which are known to be deficient in phosphorus and sulfur. A soil test for phosphorus may be helpful to determine if phosphorus is needed. Many phosphorus-deficient soils are also low in organic matter and nitrogen. At such locations use about 200 pounds of ammonium phosphate sulphate per acre on weed-free fields. On weedy fields, use ammonium phosphate containing a low ratio of nitrogen to phosphorus. Apply these materials at rates sufficient to give about 22 pounds of phosphorus per acre. Remember, added nitrogen gives grass and weeds an advantage over the legume.

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.

On soils of moderate to high phosphorus supply, the application of fertilizers at planting time may not be necessary or should be delayed until the need has been established. (See University of California Bulletin 815.)

Management of new stands

Manage irrigation carefully to prevent drying out of shallow-rooted seedlings. Clipping usually is needed to reduce weed competition, especially during winter, with fall-sown pastures, when weeds adapated to cool-season growth can be severe. If much growth is present, remove it, to prevent smothering of pasture seedlings. Pasturing, especially with sheep, is an alternative to mechanical clipping. Care must be taken, however, to avoid compaction or rut formation by animals or machinery if the soil is wet, because this may result in future difficulties that outweigh the benefits of reduced weed competition, and lessen irrigation efficiency. In certain circumstances, herbicides may be used effectively.

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, slope and drainage conditions, and water costs.

The border method

This system is the most widely used. The strips of land between the adjacent levees usually have a grade in the direction of irrigation, ranging from about 0.1 to 0.4 foot for each 100 feet of length, and not more than 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. Length and width should be so regulated that they can be completely irrigated and drained before mosquitoes have time to develop—which may be only three or four days in hot weather. 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. (For more information see University of California circulars 408 and 438.)

Contour checks

This system may prove most economical if the ground surface is relatively flat. It 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

Sprinklers have special advantages where the water supply is small or expensive, the soil shallow or sandy, or the surface too rough or steep for economic 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 of strong winds. University of California Circular 456 (out of print, but available in some libraries) deals with this subject in detail.

Wild flooding

This method can be used in rough, mountainous terrain where grading is impractical. It 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 water waste 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. (For irrigation on steep land see University of California Circular 509.)

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 11¼ gallons per minute) will put 0.6 inch of water on 1 acre or 3 inches on ⅕ 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. A water supply of 6 gallons per minute for each acre is adequate for sprinkler irrigation; 10 gallons per minute for each acre is 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 7- to 14-day intervals. If you want to irrigate by sprinkling, a sprinkler system can be designed that will provide the exact amount of water required for correct irrigation within the desired irrigation intervals. If you use strip checks or contour checks, you must have sufficient water to cover the checks rapidly enough to provide uniform distribution over the entire area.

How deep and how often to irrigate

How deep and how often to irrigate 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. Start irrigation before the available moisture within a major portion of the depth of rooting has been used.

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

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

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

Irrigated pasture complements dryland range in summer. Green feed from the irrigated land provides protein and succulence to make possible better utilization of energy in the dry grass on adjacent rangeland.

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, take special care to prevent water-logging the soil—a condition that will harm the crop and encourage water-loving weeds. Do not irrigate until the surface of the soil has dried. Do not irrigate while stock are on the pasture. 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, there must be adequate subsurface drainage to remove the water containing the leached salts. In severe cases of alkali, use highly salt-tolerant plants such as bermudagrass, Rhodesgrass, or Salina strawberry clover.

Mosquito control

Mosquitoes become a public nuisance and a hazard to health when water is allowed to stand on irrigated pasture. Some of the types that occur here develop from egg to adult in four days during the hot summer months. *Aedes nigromaculis,* the irrigated pasture mosquito, is most common. It is

Inefficient irrigation and lack of drainage facilities to remove excess water not only reduce pasture yields but also provide breeding areas for mosquitoes—a nuisance and health hazard to the public and to the grazing livestock. (Photo courtesty of Delta Mosquito Abatement District.)

a serious pest to man and animal but is not known to transmit any disease. Second in importance among pasture mosquitoes is *Culex tarsalis* which transmits encephalitis, also known as "sleeping sickness" or "brain fever" to humans and horses. During the past 16 years, 826 cases were reported in California in humans, and 698 cases in horses. Irrigated pasture mosquitoes breed in great numbers and may cause extreme discomfort to field laborers and prevent livestock from grazing.

Efficient and careful irrigation and drainage practices must be followed to prevent the formation of mosquito-producing areas. An adequate drainage or return-flow system must be provided to quickly dispose of tailwater at the lower ends of the checks. Frequent inspections are necessary to see that weeds or livestock trampling do not clog the drainage channels. Avoid the use of excessively long, wide checks with little fall. Water moves slowly through them and mosquito larvae hatched in the upper end of these checks may develop and emerge as adults before the water reaches the lower end after the head has been shut off. 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 stand on irrigated pasture longer than 24 hours. Grazing pasture before the surface has dried will cause soil compaction, poor water penetration, and deep hoofprints which hold water and serve to increase the number of mosquito producing areas. Use land and forage management practices that increase pasture production and reduce mosquito development:

- Prepare land properly for irrigation and drainage before a crop is planted.
- Apply only sufficient water to wet the soil to the depth of plant rooting.
- Irrigate only as often as needed to maintain adequate soil moisture.
- Do not graze pastures until irrigation water has completely run off the field, and the surface is dry enough to prevent deep hoofprints.
- Divide large pastures into smaller fields for herd rotation and more efficient irrigation management.
- Clip pastures occasionally to reduce weed and less palatable plant growth, thereby permitting more rapid water movement.

Aims of irrigation

The only aim of irrigation is to maintain a continuous supply of readily available soil moisture for the plants in the pasture mixture. Because most pasture mixtures contain several plant species which root to different depths, adequate soil moisture should be maintained throughout the entire root zone. If infrequent, heavy irrigations are used, the deeper-rooted plants will become dominant at the expense of the shallow-rooted plants. Because shallow-rooted Ladino clover is often 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. Water, therefore, should be applied immediately after grazing or clipping and often enough to keep the top 6 inches of soil from becoming completely dry. This will require close coordination between the grazing and irrigation cycles.

Two faults in pasture management are rather widespread. One 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.

The second and most common fault is failing to keep livestock off a recently irrigated pasture sufficiently long to allow surface drying. Treading under wet conditions is destructive of turf, makes already tight soils even more impenetrable, and the hoof imprints serve to collect and hold water, thus encouraging parasite build-up and mosquito infestations. 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. It is very important to allow sufficient time for the soil surface to dry before grazing. The tight water schedules of some irrigation districts sometimes make efficient water management difficult, but the pasture manager must do the best job possible under his own set of conditions.

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 the same field.

Another common and efficient practice uses excess water to irrigate adjacent, lower-lying fields. In many cases water can be recirculated at a cost per acre-foot substantially lower than the original cost of pumping it from the ground. Surveys indicate that the cost of power for pumping runoff water will range from $1 to $1.50 per acre foot. The annual fixed cost will range from $1 to $5 per acre foot, depending on the size of the system and the amount of pipe needed.

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.

While surface water seldom picks up high salt concentrations from the soil itself, it may pick up pesticide residues and salts from surface-applied fertilizers. Water should be checked for chemical content to insure that it is safe for the use intended. Recirculation systems result in increased yields, better weed control, reduced mosquito populations, and road protection, but they do not eliminate the need for careful and efficient water management.

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

FERTILIZATION

Irrigated pastures, like any crop, require a high level of soil fertility for maximum yields. Animal manure provides valuable soil nutrients, but returns only a portion of the total nutrient supply in the forage eaten by the animals. Addition of commercial fertilizers is recommended both for establishment and for continued high production over a period of years. Elements most commonly deficient are phosphorus, nitrogen, and sulfur, occasionally potassium in limited areas.

Phosphorus deficiency is widespead 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, apply supplemental nitrogen—manure or commercial fertilizer—to obtain a satisfactory growth of grass. Manures or other organic nitrogen sources must be mineralized by soil bacteria to ammonium or nitrate before the nitrogen can be used by grasses. Nitrogen is rapidly converted to the nitrate form, after which it leaches quickly in sandy soils or may be lost if soils remain saturated or

Fertilizer Conversion Scale

(Given in pounds)

In this circular, the nutrient phosphorus is expressed as actual amounts of the element applied. Because phosphorus sometimes is expressed as P_2O_5 (phosphorus pentoxide) the conversion scale at the right is printed to help you determine the actual amounts of phosphorus from the amount of fertilizer applied. To convert P_2O_5 to P take the amount of P_2O_5 and divide by 2.3.

waterlogged for extended periods. It is doubtful that a commercial nitrogen application remains 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. Sulfur is rarely deficient in southern California or where pumped underground water contains sulfate.

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

Fertilizing the established pasture

Commercial fertilizers 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, 20 to 55 pounds of P annually may be required to provide satisfactory growth of legumes. On moderately deficient soils, 10 to 35 pounds of P may be sufficient to maintain adequate growth. Where phosphorus is in short supply, phosphorus application 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. If you suspect sulfur deficiencies in your pasture, use single superphosphate, which contains about 12 per cent sulfur.

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

Under some conditions nitrogen applications may be necessary and desirable. If the soil is deficient in phosphorus and or sulfur, these elements must also be applied before the nitrogen will become effective. Nitrogen may often be used to increase the growth of grass in the forage mixture.

Under average irrigation conditions a single application of 30–40 pounds of nitrogen will be effective for no longer than about a month. Where early spring feed is needed, a late winter application of nitrogen will usually provide earlier grass growth and frequently more total feed. Where legumes predominate and a threat of bloat exists, application of nitrogen may greatly increase the growth of grass present. However, continued application of heavy amounts of nitrogen usually stimulates so much grass growth that the legumes are crowded out of the pasture mixture. In the hot, interior valleys where some legumes do not thrive in the summer heat, production of vigorous growing grasses, such as Dallisgrass, is increased by nitrogen alone or with phosphorus if needed. Under such conditions, for maximum economic forage production apply 30 to 40 pound of nitrogen every 30 days. An alternative method is the continuous use of low concentrations of nitrogen solutions in the irrigation water throughout the summer months.

Liquid-manure pits offer a way of returning nutrients to pastures. The material may be pumped into tank wagons and distributed daily or returned to pastures through irrigation systems. Liquid manures contain both nitrogen and phosphorus, and may be expected to stimulate grass to a greater degree than the legumes. (For more information on fertilization, see University of California Bulletin 815.)

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 produce feed of good quality, maintain high production, obtain efficient utilization, and avoid soil compaction. Controlled grazing can help accomplish these objectives.

Grazing methods

These may be classified as extensive or continuous grazing, rotation grazing, and daily ration or strip grazing.

Continuous grazing requires 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. 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 growing intervals between each grazing.

Intensive grazing, fairly high stocking rates, and a rotation grazing system improve utilization of all pastures for maximum production per acre.

Improper grazing, poor irrigation, low fertility, and lack of periodic mowing contribute to weediness and poor production. Grazing of cattle will help control weeds on pastures that have been grazed exclusively by sheep.

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 onto 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, page 28). 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.

However, the extra fencing, labor, and management costs may be great enough to make the added returns from strip grazing questionable when compared with a well-managed rotation system.

In selecting a grazing system, consider the response of the plants, animals, and the soil as well as economic factors. From this standpoint, rotation grazing is recommended, if only because its careful use can aid materially in avoiding soil compaction and related problems.

Feed quality

The quality of feed produced 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 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 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 both groups may show wide variability in moisture percentage. In studies conducted at Davis, 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. It is not known to what extent animals may compensate for degree of succulence when grazing a 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 good dry hay on the pasture.

In good irrigated pasture, the quantity of protein is adequate for most purposes. 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 disgestibility of this crude protein usually amounts to about 60 per cent of the total, but may range from 50 to 85 per cent.

PLANT-ANIMAL RELATIONSHIPS

The needs of the plant as well as the animal must be considered in the development of any sound program of pasture management.

In devising any system of controlled grazing, whether rotation or daily 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. Substances 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 carbohydrates 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. Surpluses again are 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 at Davis shows the extent to which yields are improved by permitting additional leaf growth to accumulate. The data in the table below show an average of two different mixtures used in the study. It is evident that protein percentage decreases as yields increase.

Protein content is an indicator of forage quality, but other considerations may be equally important. As forage matures, its acceptability, and therefore its intake, decline. Lignification of plant cellulose and hemicellulose decreases its digestibility by ruminants. Net energy decreases. The levels of protein listed in the table probably all are adequate to meet the nutritional needs of livestock for protein. Because of the other quality factors listed above, however, this does not necessarily mean that, for example, the approximate ton-and-a-half increase in dry-matter yield for trefoil-grass between four- and five-week cutting intervals will produce a proportionately greater yield in terms of animal product. 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 number of fields in a rotation plan will depend on individual ranch conditions; often more than five or six may be possible. In general, the more fields there are available, the greater are the flexibility and versatility of the system. For example, one or more fields may be harvested for hay during the season of peak growth, or taken out for other crops in a rotation plan during pasture re-establishment. Modifications of grazing management such as using different classes of livestock on pastures of different quality and productivity also are possible. Good management becomes even more important as the program becomes more complex.

Experimental studies, together with the practical experience of farmers, show that a growth interval of 20 to 30 days between grazings is satisfactory. Even shorter

Test with two irrigated pasture mixtures shows the effects of frequency of cutting on yield and protein percentage.

(Yields and protein figures at 12 per cent moisture)

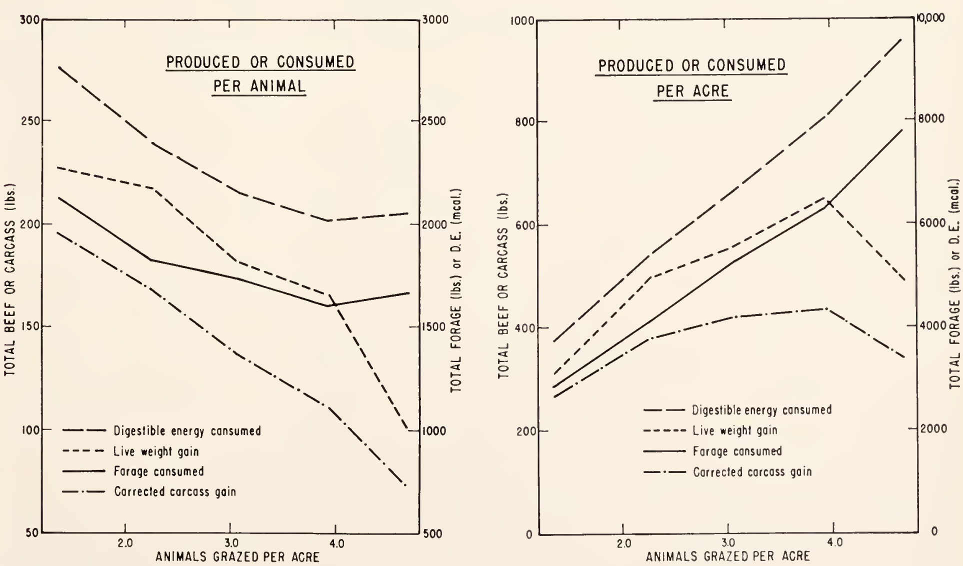
Harvest interval	Ladino-grass mixture		Trefoil-grass mixture	
	Seasonal Yield	Protein	Yield	Protein
	tons per acre	*per cent*	*tons per acre*	*per cent*
Two weeks	5.59	23.8	3.64	21.6
Three weeks	6.65	20.5	4.57	18.8
Four weeks	7.33	19.1	5.23	16.5
Five weeks	8.00	17.2	6.92	16.4

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.

It is important to irrigate immediately following grazing to prevent heat damage to exposed Ladino stolons. Subsequent irrigations during the regrowth periods can be adjusted a day or two either way from the pre-determined schedule to accommodate labor and water supply.

Not all of the feed produced in a pasture is actually consumed by the grazing animal. Some of it is wasted as a result of trampling, manure droppings, or leaf fall. Animals can be forced to utilize a larger percentage of the forage but in doing so, daily gains or milk production may be reduced. This production loss may be avoided by grazing high-producing cows and fattening animals on fresh pasture. Dry cows or growing animals can then be used to clean up the fields.

Stocking rate (the number of animals per unit of pasture) can materially influence yields and therefore profits. This problem can be approached from two sides. From one direction we achieve maximum production per acre. From the other side we achieve maximum production per animal. Operating at either extreme results in inefficient use of animal or forage resources. Instead of operating with a relatively light stocking rate and achieving maximum performance *per animal* it may be more profitable to have more animals and get greater production *per acre.* The University's Department of Animal Husbandry recently conducted studies on stocking rates. A number of small pastures were grazed at different stocking rates from 1.35 steers per acre to 4.68 steers per acre in a replicated experiment. The performance of the animals and of the pastures was carefully measured and the data are summarized in the graphs on page 28. Total beef or carcass produced per pasture or per acre was greatest when stocked between 2 and 4 steers per acre. There is a levelling of total gain somewhere in this area of stocking, especially when measured as corrected carcass gain. At stocking rates between 3 and 4 steers per acre, 69 to 75 per cent of the feed consumed was used for maintenance of the animal. At the highest rate of stocking, 4.68 steers per acre, 80 per cent of feed consumed was



Left: Influence of stocking rate per animal. Right: Influence of stocking rate on production or consumption per acre. Both charts are based upon the same experiment.

used for maintenance. At this high rate of stocking too much of the feed was used for maintenance and consequently beef production per acre dropped.

The diagram below shows the basic plan for rotation grazing using a six-field system, allowing a 5-day grazing period and a 25-day recovery interval (30-day cycle). This system can be modified, as shown by the dotted lines, by electric fencing to allow a daily rationed system if desired. The table on page 29 shows the complete 30-day grazing-irrigation-regrowth cycle. As shown, there is a 10-day interval between irrigations, allowing irrigation immediately after grazing and a four-day interval between irrigation and the beginning of a grazing period. Many other combinations are possible, depending on the number of pastures available and the length of recovery interval. Often it will not be possible to maintain exactly equal intervals between successive irrigations. Each operator will have to work out his own system, based on a pasture rotation plan, availability of irrigation water, and personal preferences. Recognize also that plant needs for water will vary during the season. However, five rules generally will apply to all cases:

- Allow a 20- to 30-day recovery interval.
- Graze uniformly and completely, but not below a 2- to 4-inch stubble.
- Irrigate immediately after grazing.
- Irrigate at 7- to 10-day intervals.
- Allow sufficient time between irrigation and the beginning of grazing for the soil surface to dry.

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 should be lengthened.

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.

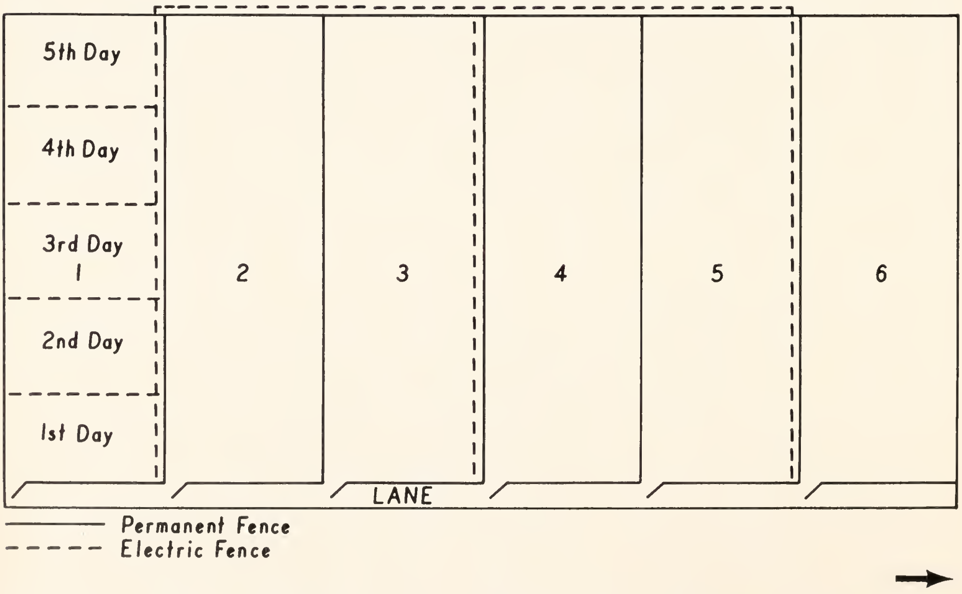


Diagram of a daily rationed grazing layout. The same basic plan can be used for rotation grazing. The chart on page 29 shows a 30-day grazing-irrigation-regrowth cycle.

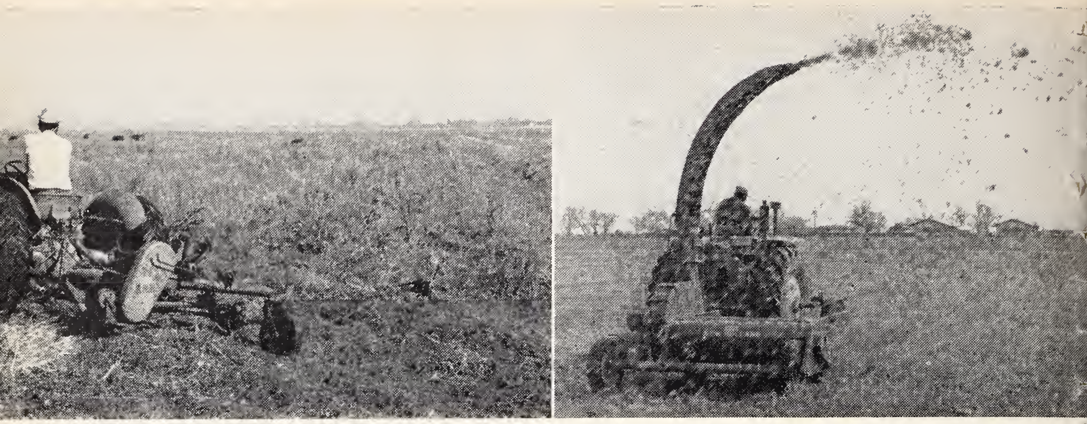
Grazing, Irrigation, and Regrowth Periods for a 30-day Cycle

Day	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

WEED CONTROL

Land grading

Proper and careful land grading is the first step for weed control 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, and will also provide mosquito breeding areas. High spots which receive insufficient irrigation also tend to encourage other types of weeds, such as yellow star thistle, which do well under dry conditions.



Clipping by various methods is essential for weed control and is especially important during the first winter and spring on a new pasture. Clipping to remove coarse stalks and seedheads of vigorous grasses greatly improves utilization.

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, which in turn enhance pasture quality.

Chemical control

This is most effective when used to supplement good management and cultural methods.

Control of seedling broadleaved weeds in newly seeded pastures can be accomplished with 4-(2,4-DB). Either 1 lb acid equivalent of amine or ¾ lb acid equivalent of ester formulation may be used. For best results treat the pastures when the weeds are in the 1- to 3-leaf stage and before the clover starts to flower. Water the pastures well just before treatment and withhold irrigation for at least five days after application to avoid pasture plant injury.

Federal registration limitations prohibit grazing within 30 days after application of 4-(2,4-DB).

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 broadleaved weeds. Weeds on supply ditches can also be controlled by 2,4-D.

The following points are important when spraying Ladino or trefoil pastures with 2,4-D:

- The best time to spray is in the spring after the legumes have started growing well. Do not spray dormant legumes (November to January).
- The amine form of 2,4-D appears to be safer to use than does the ester form.
- Use from ½ to ¾ lb of 2,4-D acid equivalent per acre. If buckhorn is the principal weed to be controlled, use ¾ lb of 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. Established sedges and dock are difficult to kill and may re-

Livestock traffic on wet soil is a main cause for soil compaction and poor water penetration, low production, and weediness.

quire treatment for several years before they are controlled.

- 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.
- Localized infestations of persistent perennial weeds may be controlled by spot treatment of a higher concentration of 2,4-D. Use 2 lbs of actual acid per 100 gallons of water and spray to thoroughly wet the weeds. This higher rate may cause some damage to the clover, however.
- Do not graze 2,4-D-sprayed stands during the recovery period—about 30 days for Ladino clover and the trefoils.
- Federal registration limitations prohibit grazing dairy cattle within 7 days after application of 2,4-D.
- Both 2,4-D and 4-(2,4-DB) are classified by the California State Department of Agriculture as injurious herbicides. A permit from the County Agricultural Commissioner is required for the purchase of 2,4-D and for the purchase of 4-(2,4-DB) under certain conditions.

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 fer-

Warning on pesticide residues

These recommendations for weed control are based on the best information currently available. Treatments based upon these recommendations should not leave residues that will exceed the tolerance established for any particular chemical. To avoid excessive residues, follow directions carefully with respect to dosage levels, number of applications, and minimum interval between application and harvest.

The grower is legally responsible for residues on his crops as well as for problems caused by drift from his property to other properties or crops.

Weed control practices change from time to time and University recommendations are reviewed and revised each year. For the most recent recommendations consult your local Farm Advisor.

tility, 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. Old weedy pastures are best handled by plowing out and rotating with a grain or other forage crop for a year and then reseeding on a releveled and properly prepared seedbed.

Poisonous weeds occasionally cause stock losses, but are rarely a problem where pastures are well 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 at maximum production indefinitely. Ordinarily, a pasture remains profitable not longer than four to six years, and then begins to become weedy and difficult to irrigate.

Satisfactory pasture renovation can best be accomplished through rotation with other crops, preferably at the end of the fourth or fifth grazing season. 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, better control of weeds, and the elimination of mosquito producing areas. New planting also permits use of improved varieties or strains.

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 most rapid 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. The type of machinery available for mowing or clipping will partly determine the height of cutting but about 3 to 6 inches of stubble is suitable.

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 the manure 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 acceptable market grade. Young cattle and particularly calves 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 on 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:

- Mow strips in the pasture (for dry feed) the day before cattle are turned in.
- Do not turn hungry animals in on new, luxuriant, or immature growth, especially in spring, without first giving them a fill of dry grain 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 feeds known at present for preventing bloat.
- 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.
- An adequate supply of nitrogen will produce maximum grass growth, avoiding an overabundance of legume in the pasture.

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. The exact amount of molybdenum in plants that is toxic to cattle is not known. Some believe that it is around 5 to 6 parts per million (ppm) on an air-dry basis, others say that it is about 10 ppm and still others place it at between 15 and 20 ppm. Actually the disease results from a molybdenum-copper imbalance in the animal, and it is probable that no fixed amount will fit all cases.

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
Bermudagrass	3 to 11

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

It is important to keep the pastures in an actively 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 toxicity 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.

Recent experience in Australia and at the Nevada Agricultural Experiment Station indicates that preventive treatment using injections of an organic copper solution (copper glycinate) is effective. Details are available from the University of Nevada Bulletin 206, Molybdenosis.

Pasture mixtures for affected areas. Because legumes generally contain a higher content 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 toxic 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 seedheads 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 ergot-infected 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 seedheads will practically eliminate the ergot problem.

Legumes and grasses mentioned in this circular, with estimated seed numbers on a per pound and per square-foot basis

Common name	Scientific name	Approximate number of seeds	
		per pound (in thousands)	per sq ft broadcast at 1 lb/acre
	Legumes		
Alfalfa	*Medicago sativa*	227	5.2
Alsike clover	*Trifolium hybridum*	680	15.6
Birdsfoot trefoil			
Broadleaf, or erect	*Lotus corniculatus*	370	8.5
Narrowleaf, or prostrate	*Lotus tenuis*	370	8.5
Bur clover	*Medicago hispida*	170	3.9
Ladino clover	*Trifolium repens*	880	20.2
Red clover	*Trifolium pratense*	272	6.2
Strawberry clover	*Trifolium fragiferum*	288	6.6
Sweet clover			
Yellow-blossom	*Melilotus officinalis*	259	5.9
White-blossom	*Melilotus alba*	259	5.9
Subterranean clover	*Trifolium subterraneum*	54	1.2
	Grasses		
Annual (domestic) ryegrass	*Lolium multiflorum*	227	5.2
Bermudagrass	*Cynodon dactylon*	1,787	41.0
Dallisgrass	*Paspalum dilatatum*	269	6.1
Meadow foxtail	*Alopecurus pratensis*	544	12.5
Orchardgrass	*Dactylis glomerata*	654	15.0
Perennial (English) ryegrass	*Lolium perenne*	227	5.2
Reed canarygrass	*Phalaris arundinacea*	544	12.5
Rhodesgrass	*Chloris gayana*	2,143	49.2
Smooth bromegrass	*Bromus inermis*	136	3.1
Sudangrass	*Sorghum vulgare* var. *sudanense*	54	1.2
Tall fescue	*Festuca arundinacea*	227	5.2
Tall wheatgrass	*Agropyron elongatum*	64	1.5
Timothy	*Phleum pratense*	1,134	26.0

Co-operative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture co-operating. Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914. George B. Alcorn, Director, California Agricultural Extension Service.

25*m*-11,'67 (H3546) J.F. 141

DID YOU LIKE THE SAMPLE?

This publication is one of many that are written, produced, and distributed by the University of California Division of Agricultural Sciences.

They cover many subjects, from agronomy to zoology.
They cover many crops, from alfalfa to zucchini.
Some report new research findings . . . some tell "how to do it."
Most are free . . . for some there is a charge.
All are listed in a catalog that is issued annually.

To get a copy of the catalog, visit the office of your local University of California Farm Advisor, or write to:

Agricultural Publications
University Hall
University of California
Berkeley, Calif. 94720