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DROUGHT TIP

Managing Irrigated Pasture during Drought

The availability of water for irrigated pastures will likely diminish in the future as a consequence of reoccurring droughts and increased demands for water for the production of higher-value crops such as trees, vines, and vegetables, as well as for urban and environmental demands. Although irrigated pasture has declined in California and other western states, it still makes up nearly 7% of irrigated land in the state and accounts for a significant proportion of irrigated land throughout the West (table 1). Irrigated pasture ranks third in terms of water use among agricultural users (DWR 2013). Irrigated pasture has recently been surpassed by almonds and pistachios on a statewide basis but still remains number two behind alfalfa in many areas of northern California. Most of the irrigated pastures in California are found in the northern part of the state, but they are also found in Central Valley, coastal, and southern areas as well. The primary focus of this publication is the cool-season grass pastures commonly grown in central and northern California.

Irrigated perennial pasture grasses are the foundation of many crop and livestock enterprises. They are especially important in drought years when the productivity of annual rangelands is compromised and cattle producers are in dire need of alternative forage sources. Production systems that maximize forage production and pasture survivability in drought years are of utmost importance.

Grass Pasture Response to Drought

Forage crop yields are highly influenced by drought because nearly the entire aboveground biomass is harvested for forage. Therefore, when soil moisture is low enough to cause at least partial closure of stomata (pores primarily on the underside

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Table 1. Irrigated pasture acreage in the western states and the United States.

State	Irrigated pasture			Percent of irrigated land		
	2002	2007	2012	2002	2007	2012
Arizona	43,769	52,680	26,098	4.9%	6.4%	3.1%
California	760,302	741,911	490,553	9.6%	10.2%	6.7%
Colorado	411,906	571,192	406,654	18.9%	24.9%	19.3%
Idaho	458,432	432,671	320,782	16.2%	15.1%	10.5%
Montana	419,455	455,045	420,660	26.9%	29.2%	28.4%
Nevada	212,001	188,052	126,589	39.7%	37.4%	22.6%
New Mexico	190,627	181,776	90,214	29.1%	28.0%	15.3%
Oregon	491,801	511,453	363,479	34.7%	38.3%	28.7%
Utah	310,776	346,939	250,382	39.8%	44.1%	29.3%
Washington	153,227	146,399	83,433	9.2%	9.2%	5.4%
Wyoming	581,258	525,541	418,965	60.5%	51.3%	41.2%
Western states	4,033,554	4,153,659	2,997,809	18.8%	20.1%	14.5%
USA	4,977,214	5,062,201	3,729,847	9.9%	9.8%	7.2%

Source: USDA 2012.

of leaves), photosynthesis is reduced and yield suffers. Compared with a forage crop like alfalfa, most pasture grasses are less drought tolerant because they have a shallower fibrous root system that is less equipped than alfalfa to access deep soil moisture. Further, many grasses are not able to go into a state of drought-induced dormancy as does alfalfa.

Prolonged drought and a lack of adequate irrigation has both short- and long-term impacts on pasture productivity. The effects of inadequate soil moisture on irrigated pastures include

- reduced foliage growth
- decreased root health and growth
- diminished storage of carbohydrate reserves
- reduction in new meristematic tissue (growing tips), including new tillers, rhizomes, and stolons
- plant mortality

Perennial grasses undergo several responses to worsening and prolonged drought. Leaf growth and initiation are initially reduced

and eventually stopped as the drought progresses. Next, gas exchange through the stomata is reduced, and photosynthesis slows. Then, the leaf blades begin to weaken and senesce. All of these responses are yield-reducing effects of drought.

Plants may be able to survive until they are rewatered as long as meristematic tissues at the bases of enclosed leaves and roots do not become excessively dehydrated and lose their functional integrity (Volaire et al. 2009). The primary survival strategies used by perennial grasses to tolerate drought and avoid death are delaying dehydration by increasing water uptake or by reducing water losses from the plant. Drought-resistant cultivars often have higher rooting density and depth, enabling them to use deeper soil moisture than do less-tolerant cultivars. Dehydration tolerance is another mechanism for enhanced drought tolerance.

Even if perennial grasses are able to survive a drought, production the following year will likely be lower. This is due to reduced root growth, decreased rhizome (rootlike horizontal stem) growth in rhizomatous species, fewer new tiller buds, and lower energy reserves. The impact on production depends on the pasture species and the length and severity of the drought.

Species Selection

All perennial grasses are not created equal, and they differ widely in their drought tolerance, both in terms of their production potential under moisture-limiting conditions and their ability to survive extended periods without irrigation.

While cool-season grasses are the primary component of pastures in California and the focus of this publication, warm-season grasses are generally more drought tolerant. Warm-season grasses, typically dallisgrass (*Paspalum diatutum* Poir) and bermudagrass (*Cynodon dactylon* (L.) Pers), are typically used in portions of the Central Valley and the southern part of the state.

The most common cool-season grasses used in perennial pastures and grass hay fields in California include tall fescue (*Lolium arundinaceum* Schreb.) (fig. 1), orchardgrass (*Dactylis glomerata* L.), perennial ryegrass (*Lolium perenne* L.), and



Figure 1. Irrigated tall fescue pasture in Shasta Valley, Siskiyou County, CA, after a season with only one spring irrigation, August 2014. Photo: S. Orloff.

occasionally timothy (*Phleum pratense* L.) in wetter sites. These cool-season grasses differ in drought tolerance, with studies ranking their drought tolerance, in order from highest tolerance to lowest, as tall fescue, orchardgrass, perennial ryegrass, and timothy (Waldron et al. 2002; Orloff and Putnam, unpublished data). Bromegrass species are another cool-season grass option for managing drought. Research has shown the yield of meadow brome and smooth brome to be less affected by deficit irrigation than tall fescue, orchardgrass, or perennial ryegrass (Waldron et al. 2002). Smooth bromegrass and timothy are better suited for intermountain and coastal areas of California and generally are not well adapted to Central Valley locations.

Drought Tolerance of Pasture Species

Pasture species may respond quite differently to drought conditions, so it is important to identify the species most commonly found in your pasture. Further discussion on the drought tolerance of several cool-season grass species and cultivars can be found in the UC Cooperative Extension video “Perennial Forage Production with Limited Water: Consequences and Recommendations,” at <https://www.youtube.com/watch?v=ZnQhZCETzyQ> (Orloff 2014). Additional information is provided below.

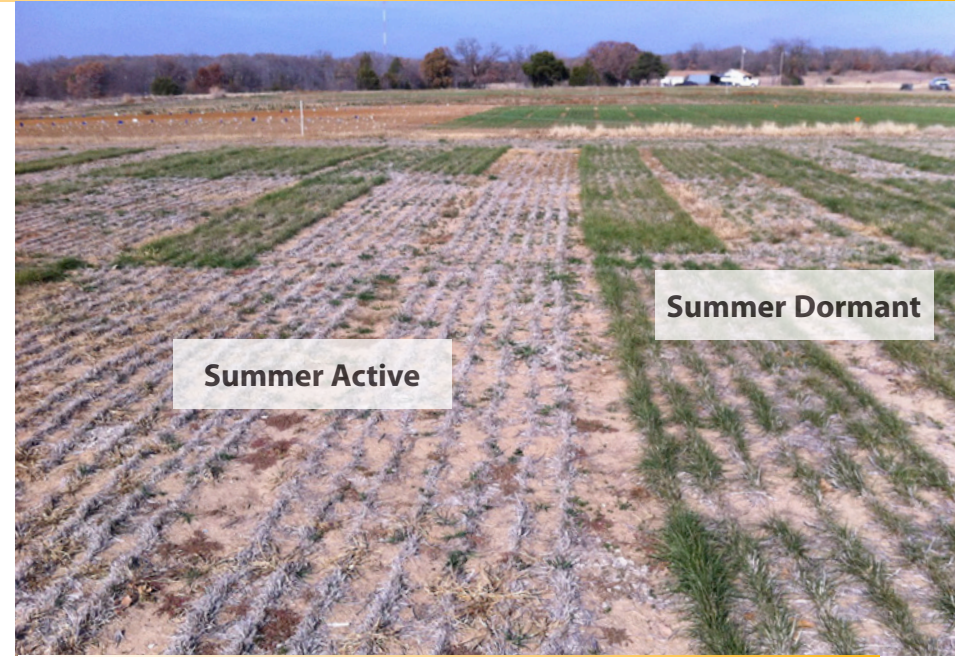


Figure 2. Tall fescue variety trial in southern Oklahoma in autumn, 2011. Trial was sown in October 2010 with excellent stands in all cultivars. Following the extremely hot and dry summer of 2011, only summer-dormant cultivars survived. Photo: C. Brummer.

Tall Fescue

When deficit irrigated, the yield of tall fescue is reduced by a high percentage compared with other species such as bromegrasses or wheatgrass. However, because tall fescue is so much more productive than other species, its net yield is still usually greater. Tall fescue is also higher yielding under full irrigation, so it is generally considered to be the best species for irrigated perennial pastures in California: growers seek a species that will produce well when ample irrigation water is available and be able to survive through drought periods. Summer-dormant tall fescue varieties (i.e., Flecha and Prosper) are not as productive as their summer-active counterparts when sufficient water is available (Orloff and Putnam, unpublished data), but they have superior survival under severe drought conditions (Malinowski et al. 2005; Brummer, unpublished observations). Summer-dormant tall fescue may be a viable option for irrigated pastures that are allowed to completely dry down (when irrigation ceases) through the summer (fig. 2).

Orchardgrass, Timothy, and Ryegrass

In some areas, orchardgrass, timothy, and perennial ryegrass are grown for hay or sometimes used in pasture mixes. In the proper environment these species can be highly productive and palatable and can command a high price in the marketplace. However, these species generally perform best in cooler environments with ample irrigation and generally do not yield well or persist under deficit irrigation or after prolonged dry periods. Little is known about the drought tolerance of specific cultivars, but there are examples of individual cultivars with improved drought tolerance, such as Pauite and Berber orchardgrass cultivars.

Brome and Wheatgrasses

Smooth brome, meadow brome, and wheatgrasses may be a wise choice for dryland conditions or partially irrigated pastures when full irrigation is not feasible, even in years with normal rainfall. However, they generally do not perform as well under full irrigation, so they are less profitable in years when irrigation water supplies are sufficient.

Legumes

In addition to perennial grasses, most grazed irrigated pastures also contain a legume component to improve the nutritive value (primarily protein content) of the forage and to fix atmospheric nitrogen. The most commonly used perennial legumes are white clover (*Trifolium repens* L.), red clover (*T. pretense* L.), strawberry clover (*Trifolium fragiferum*), and birdsfoot trefoil (*Lotus corniculatus* L.). Of these, trefoil is the most drought tolerant. Often, when irrigation water is inadequate and moisture stress results, clover is the first to succumb—even before the grasses. Sometimes alfalfa is used in pasture mixes, but it typically does not persist over the long term due to frequent grazing and competition from the grasses. It is better suited for situations where the pasture is grazed only once per year and the forage is harvested as hay other times of the year.

Management Practices to Enhance Survival

Knowing which grass species are best able to withstand drought is useful information; however, most producers are not looking to replant their pastures, and perennial pastures in California

typically remain in production for decades. Instead, producers seek information on production practices to enhance forage production in moisture-limiting conditions and ways to improve the odds of survival for their existing pastures.

Irrigation Strategy

One question producers ask is whether they should completely cease irrigation partway through the season or space out their irrigations and water at a suboptimum level as long as possible into the growing season.

Generally, water use efficiency, or how much forage is produced per unit of water, is higher in spring. Therefore, production would likely be maximized by full irrigation in the spring, but it may be wise to conserve some water if feasible for later use in the summer for improved grass survival if drought conditions are severe and water availability is extremely low. Soil type and climate are also important factors, as well as are the irrigation practices that can be employed. Irrigation practices are often not fully under the control of the producer and depend on the severity of the water shortage and water availability, for example, whether irrigation water is available for the entire season or just in the spring.

Additionally, the answer may depend on the grass species and the ability of that species to go into dormancy. Although more research is needed to determine the best approach for different perennial grass species, the following is known about two contrasting species.

- Timothy. Research with timothy (*Phleum pretense* L.) showed that stopping irrigation after the first cutting is important for plant survival because plants entered dormancy and were able to maintain desirable levels of water-soluble carbohydrates in the stubble and corms that would later be used for regrowth (Fransen and Hudson 2006). Irrigating after harvest during a drought period decreased the sugar content because sugars were remobilized for new growth, thereby weakening the crop during the stressful period.
- Tall Fescue. Experience with irrigated tall fescue pastures has shown better survivability when irrigation continued further into the season, even when it was insufficient to fully meet crop needs.

One or two irrigations in midsummer has made the difference between nearly complete plant mortality and pasture survival.

Grazing Height and Intensity

In the fall after a drought period when alternative grazing options are limited, ranchers may be tempted to ignore the importance of grazing height and graze pastures to ground level to maximize utilization. However, grazing height is more important than ever after grasses have gone through a drought period. Even though the stubble may appear brown and the plants seem dead, the pasture is simply dormant or just starting to die back. Also, drought-stressed plants are weak and therefore more sensitive to overgrazing and trampling from hooves.

If plants are mowed or grazed too short,

- the newly forming tillers can be starved of important sugars and starches
- the plant is more exposed and less protected from extreme weather
- root formation is curtailed
- new tillers the following spring grow slower with fewer roots to support them

The plant crown and stubble are where the plant stores sugars and carbohydrates for respiration and subsequent plant growth. Therefore, it is important not to graze the bottom 3 to 4 inches of the grass plant, which is the storage site for most of the energy critical for next year's production. Around 85 to 90% of the stored grass sugars are in the stubble internodes (stem segment between nodes). Only a small amount of sugar is stored in the roots. If grass plants do not have adequate stubble for carbohydrate storage, plant mortality can occur. As water becomes available, sugars and starches in the crown and stubble can be remobilized and used for respiration and new plant growth.

Grazing height also has a profound impact on root growth (Crider 1955), and an extensive, vigorous root system is imperative not only for full production but also for recovery after drought. Root growth is initiated and new growing points (or meristems) are formed during the fall. This sets the stage for potential forage production the following year. Root shedding in grasses typically

occurs from late June until early September, at which time the roots begin to regenerate. Then, over the winter, root shedding occurs again (roots turn from white to tan to brown to black as they decompose) until new roots grow again in the spring from the meristems produced in the fall.

Even though it may be tempting to graze drought-stressed pasture close to the ground to maximize the use of available forage, this is a mistake in the long term and is likely to affect future productivity. Leave 3 to 4 inches ungrazed from fall throughout the winter, even if that plant material appears dead.

Designate a Sacrifice Area

Preventing cattle from grazing stubble below 3 to 4 inches is nearly impossible if the animals remain on a pasture. Therefore, the best strategy is to designate a small part of the property for overgrazing or as a sacrifice area that will sustain some damage in order to house the animals so the remaining pasture will not be overgrazed. This area can be a small pasture, dry range, dry lot, or a corral area. In effect, this area is sacrificed to protect the larger pasture from overuse at critical times.

Nutrient Management

The fertility status of the field is another factor to consider to help revive grasses after drought stress. Fall is a good time to fertilize pastures, including moisture-stressed pastures, with phosphorus (P) and potassium (K) if dictated by a current soil test. Often, the P and K needs of grasses take a backseat to nitrogen fertilization in spring. However, P and K are very important for the development of new roots and meristematic tissue in the fall, and K improves winter hardiness (especially important for bermudagrass). If growers apply P and/or K in the fall, they do not need to reapply these elements in spring. An application of P or K in fall will not leach from winter rains as does nitrogen or sulfur.

While it is important to fertilize with P and K (if needed) in the fall, excessive rates of nitrogen at this time are discouraged because it can make plants more susceptible to winter injury in high-elevation areas with cold winters. Plants store sugar reserves and accumulate winter protection compounds such as proline (an

antifreeze-like compound) in autumn as they prepare for winter (Thomashow 1990). Nitrogen fertilization in fall encourages active growth, limiting the storage of these key compounds.

Overseeding to Rejuvenate Drought-Affected Pastures

Sometimes, plant mortality following a drought is so severe that it reduces the plant stand (plants per square foot), and corrective action must be taken to increase the plant density so that pasture productivity can rebound. If significant bare areas exist between plants that have survived drought, overseeding (seeding into an existing pasture) will likely be needed to increase the plant population or thicken the plant stand.

Success is greater if this is done in late winter to early spring in the intermountain area (or in the fall, provided irrigation water is available) when the existing plants will compete less with the overseeded species. Seeding in the fall can be effective in the Central Valley of California because temperatures are still warm enough at that time for seedling germination and establishment with fall rains. Weeds often invade the open spaces between surviving pasture plants, so effective weed control prior to reseeding is critical.

Perennial grass species can be overseeded using a no-till drill or by preparing a seedbed using a light harrow, which can break up the dead sod and improve seed-to-soil contact.

Often, grass species may survive an extended period without irrigation, but the legumes, especially clovers, are lost. Legume reseeding is a good practice in general, but it is particularly important for reintroducing legumes that die due to drought. Pastures affected by drought provide a unique opportunity to reintroduce legumes because there are typically open areas in the stand that afford the legumes a better chance of competing and becoming established.

A detailed explanation of overseeding to improve pastures is beyond the scope of this publication; for more detail see Fransen 2012 and Barnhart 2004.

Summary

With the increased climatic variability and reoccurring droughts that are projected for California, adaptive measures are needed to

sustain pasture productivity. Management decisions can affect the productivity of perennial grass fields during and after drought. The choice of grass or grasses may improve the chances of sustaining pastures during drought.

- Tall fescue varieties are generally better able to sustain long water deficits than are other cool-season grasses of similar nutritive value.
- Adding alfalfa to a cool-season grass mix, especially in hayed pastures that are only moderately grazed, will enable extraction of moisture from deeper in the profile than grass alone.
- Another way to improve drought survival and summer production is to use a warm-season grass like bermudagrass, which is well adapted to hot, dry conditions. However, as with other warm-season grasses, they are not productive from fall through spring, so if winter productivity is desired, these species are not recommended.
- Deficit irrigation strategies are likely to differ between species, with some late-summer irrigations likely to be beneficial for tall fescue but not for timothy.
- To maximize the likelihood of recovery, leave 3 to 4 inches of stubble ungrazed or unmowed, fertilize with phosphorus and potassium (but not nitrogen) in the fall if needed, and irrigate properly once irrigation water is available again.
- Reseeding or overseeding into existing stands may be necessary to rejuvenate severely drought affected pastures where plant density limits production potential.

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