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Managing Irrigated Pasture during Drought

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Introduction

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 vegetable crops) as well as 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 Irrigated pasture ranks third in terms of water use among agricultural users (DWR, unpublished data). Irrigated pasture has recently been surpassed by almonds/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 will be the cool-season grass pastures 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.

Table 1. Irrigated Pasture Acreage in Western States and US (source: 2012 Census of Agriculture)						
	Irrigated Pasture			Percent of Irrigated land		
State	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%

Grass Pasture Response to Drought

Forage crop yields are highly influenced by drought because nearly the entire above-ground biomass is harvested for forage. Therefore, when soil moisture is low enough to cause at least partial closure of stomata (pores that are primarily on the underside of the 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 to access deep soil moisture than alfalfa. Further, many grasses are not able to go into a state of "drought-induced dormancy" as is 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, including new tillers, rhizomes and stolons
- Plant mortality

Figure 1. *Irrigated tall fescue pasture in Shasta Valley, Siskiyou County, CA after a season with only one spring irrigation. August, 20014.*

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 blade begins to senesce. All of these responses are yield-reducing effects of drought.

Plants may be able to survive until they are re-watered 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 reducing water losses from the plant. Drought resistant cultivars often have higher rooting density and depth than less tolerant cultivars. Dehydration tolerance is another mechanism from enhanced drought tolerance.

Even if perennial grasses are able to survive a drought, production the following year is likely to be reduced. This is due to reduced root growth, decreased rhizome 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

Perennial grasses are not all created equally, and they differ widely in their drought tolerance, both in terms of their production potential under moisture-limiting conditions as well as their ability to survive expended periods without irrigation.

While cool-season grasses are the primary component of pastures in California and the focus of this paper, 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 the southern part of the state.

The most common cool-season grasses used in perennial pastures in California include tall fescue (*Lolium arundinaceum* Schreb.), orchardgrass (*Dactylis glomerata* L.), perennial ryegrass (*Lolium perenne* L.), and occasionally timothy (*Phleum pretense* L.) in wetter sites. These cool season grasses differ in their drought tolerance, with studies ranking the drought tolerance of tall fescue > orchardgrass > perennial ryegrass > timothy (Waldron et al., 2002; Orloff and Putnam, unpublished data). The yield of bromegrasses such as meadow brome and smooth brome has been shown to be less affected by deficit irrigation than tall fescue, orchardgrass or perennial ryegrass (Waldron et al., 2002). A discussion on the drought tolerance of several cool season grass species and cultivars can be found at https://www.youtube.com/watch?v=ZnQhZCETzyQ.

Drought Tolerance of Tall Fescue. When comparing yield under deficit irrigation to yield with full irrigation, tall fescue often shows greater reductions than brome species or wheatgrass. However, the total yield of fescue under deficit irrigation is still higher than the other species due to its higher production potential. 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 able to survive through drought periods. Smooth brome, meadow brome and wheatgrasses maybe a wise choice for dryland conditions or partially irrigated pastures when full irrigation is not feasible even in years with normal rainfall. Summer dormant tall fescue varieties 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, unpub. obs.). Summer dormant tall fescue may be a viable option for irrigated pastures that are allowed to completely “dry down” (irrigation ceases) through the summer (Figure 2).

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.*)* and birdsfoot trefoil (*Lotus corniculatus* L.). Of these, trefoil is the most drought tolerant. Oftentimes 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 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. Instead they 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. (Perennial pastures in California typically remain in production for decades.)

Irrigation Strategy.

Should I cease irrigation completely part way through the season or space out my irrigations and water at a suboptimum level as long as possible into the growing season? The answer may depend on the grass species and the ability of that species to go into dormancy. 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 useful for regrowth (Fransen and Hudson, 2006). Irrigating after harvest during a drought period deceased the sugar content because they were remobilized for new growth, thereby weakening the plant during the stressful period.

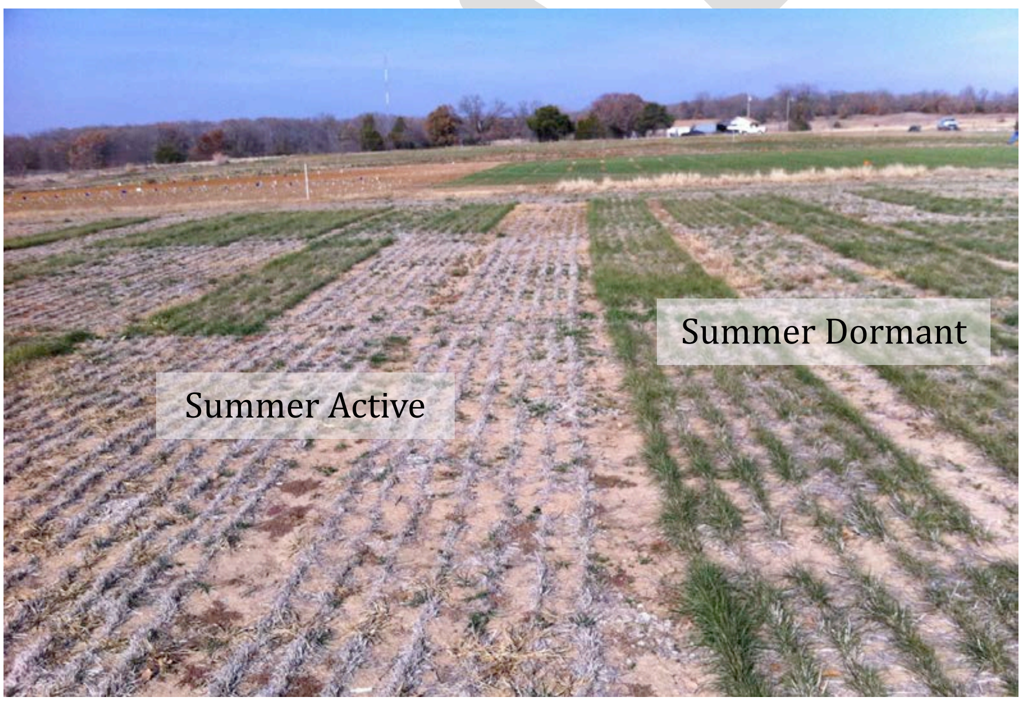

Figure 2. *Tall fescue variety trial in southern Oklahoma in autumn, 2011. Trial was sown in October 2010 with excellent stands in all cultivars. Following the extremely hot and dry summer of 2011, only summer dormant cultivars survived.*

Experience with irrigated tall fescue pastures has shown better survivability when irrigation continued further into the season even if it were insufficient to fully meet crop needs. One or two irrigations in mid-summer has made the difference between nearly complete plant mortality and pasture survival in tall fescue. More research is needed to determine the best approach for different perennial grass species. Soil type is an important consideration as well with which irrigation practices can be employed is oftentimes not under the control of the producer and depends on the severity of the water shortage and water availability—whether irrigation water is available for the entire season or just in the spring. 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 extremely low.

Grazing Height and Intensity Effects on Survival.

In the fall after a drought period when forage resources are extremely tight, ranchers may be tempted to ignore the importance of grazing height and graze pastures to the ground 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 senesced or dormant. The plant crown and stubble are where the plant stores sugars and carbohydrates for respiration and subsequent plant growth. Alfalfa stores most of its reserves in the tap root and crown. In contrast, around 85 to 90% of the stored grass sugars are in the stubble internodes – 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. Therefore, it is important not to graze the bottom 3-4 inches of the grass plant, which is the storage site for most of the energy critical for next year's production.

Grazing height 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.

If plants are mowed or grazed too short the following can occur:

- 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

So 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 3-4 inches un-grazed from fall throughout the winter, even if that plant material appears dead. Finally, drought-stressed plants are weak and therefore more sensitive to overgrazing and trampling from hooves.

Sacrifice Area.

Preventing cattle from grazing stubble below 3-4 inches is nearly impossible if the animals remain on a pasture. Therefore, the best strategy is to designate a small part of the property as a "sacrifice area" 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 over-use 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) as dictated by a current soil test. Oftentimes the phosphorus and potassium 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 do 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. Plants store sugar reserves and accumulate winter protecting 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 Rejuvenating Drought-Affected Pastures

Sometimes plant mortality following a drought is so severe that corrective action is required to increase the plant density so that pasture productivity can rebound. If there are significant bare areas between plants, overseeding is likely needed. Success is greater if this is done in late winter to early spring (or in the fall provided irrigation water is available) when the existing plants are less competitive with the interseeded species. 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 harrow. Harrowing can be important to break up the dead sod and to improve seed-to-soil contact. Oftentimes 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 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 affording the legumes a better chance of competing and becoming established. A detailed explanation of overseeding is beyond the scope of this paper and is covered in more detail elsewhere (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 other cool-season grasses of similar nutritive value. Adding alfalfa to a cool-season grass mix will enable extraction of moisture from deeper in the profile than grass alone. Another direction 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.

Irrigation strategies under deficits 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, it is important to leave 3-4 inches of stubble un-grazed or un-mowed, fertilize with P and K (but not N) in the fall if needed, and irrigate properly once irrigation water is available again. Reseeding may be necessary to rejuvenate severely drought-affected pastures where plant density limits production potential.

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