Ukiah Region Estimation of Water Use - 1913 Alfalfa Field

Dan Putnam, PhD, University of California, Davis

The following is an estimation of water use by an alfalfa crop, circa 1913. Alfalfa was a common crop grown in the early part of the 20th Century. It was one of the most important crops irrigated by farmers during the development of farms in the late 19th Century and early 20th Century in California. Hay for horses, milk, butter and meat were frequently the most economically important farm products, even as they planted orchards and vineyards and marketed truck crops.

The area under consideration is a 164 acre tract just north of Ukiah, and near the current Lake Mendocino, which contained 162 acres of alfalfa and 2 acres of orchards. Soils at this site are considered good agricultural soils, alluvial, with good drainage and excellent rooting depth to 60 inches, have low to moderate erodability, and moderate water-holding capacity. These soils are suitable to the planting of orchards, vineyards, or alfalfa and pastures. Soils are primarily Pinnobie loam, Pinole gravelly loam, and flood plain zerofluvents. Drainage may be somewhat excessive on portions of the field. The well-drained, somewhat sandy nature of the soils would indicate a frequent irrigation regime would be needed.

An alfalfa crop produced in 1913 in Mendocino County in the Ukiah area is likely to have had the following characteristics. These are assumed for the purposes of this estimation:

- Alfalfa is a perennial, and, after seeding, is likely to have persisted between 5 and 10 years.
- It would have been harvested between 4 and 6 times during the main growing season. Harvest methods varied between direct grazing, hand harvesting, and the use of tractor- or horse-drawn implements. Grazing is likely to have occurred during early spring and late fall, when haymaking is difficult.
- Fields were likely to have been leveled to some degree using horse-drawn or early tractor-drawn implements (for example, using the Fresno scraper).
- Surface irrigation with the check flood method was almost certain to have been used, wherein head ditches supply water to the field, supplied from local surface waters. Sprinklers were not widely available at the time, and were not important in alfalfa or pasture fields. Check flood irrigation remains the dominate method for alfalfa today.
- Irrigation occurred primarily during the months of May, June, July, August, September, and early October, with some irrigations in April and October, depending upon seasonal rainfall pattern and need for forage.
- We would assume approximately 50-60% irrigation efficiency due to more primitive land leveling and delivery methods which were likely at the time, and the sandy nature of the soil.
- Alfalfa evapotranspiration (ET), the amount of water actually demanded by the crop, is likely to be the same as current values, assuming only slight climate change during these years.

- ET for an alfalfa crop in the Ukiah area can be estimated as approximately 1.0 times the ETo, since most estimates for alfalfa coefficients (Kc) do not differ substantially from 1.0. In practice, the Kc of an alfalfa crop goes well above 1.0 during growth, and well below 1.0 during the cutting, and early re-rgrowth periods, but an average value can be estimated at 1.0 for practical purposes. Summation average ETo for the Ukiah region is 49.09 inches (UC Hopland Research and Extension Center).
- Rainfall summed for the Hopland station is 34.2" (data from UC CIMIS station). Although some of the rainfall should be credited to crop growth, most of the rainfall occurs during winter months, when the crop is largely dormant. Effective growth period was assumed to be from March through late October, and the ETc estimated at 45.6" during this period. Moisture from rain is only important in some years during early spring months, and is a primary consideration for the low irrigation estimate.
- Harvesting and Irrigation Schedule: Harvesting and irrigation schedules in alfalfa are closely linked, with irrigations only occurring between harvests or grazing events. Since equipment was more labor-intensive in 1913 and quality was not emphasized as it is today, only four hay harvests per year are indicated, but this does not preclude grazing harvests in the spring or fall, which are highly likely, both from a weed-control perspective (no herbicides were used at the time), and from a utilitarian point of view. In this era, farmers always had animals requiring feed, and would have grazed the fields during early spring and late fall (winter), a time of year that would not have allowed hay harvests.
- Estimated irrigation amounts are based upon the following factors
    - Yearly factors such as late spring rains, which would lessen the need for irrigation, and extent of heat during summer which would increase the need for irrigation (low estimate).
    - Adequacy of supply of water in the stream which would allow irrigation to occur. We will assume irrigation water was available.
    - Efficiency of system (runoff, deep percolation, delivery, etc.)
    - Logistical factors such as availability of labor. We will assume that this was not limiting.
- Deficit Irrigation. A low amount of irrigation applied below ET requirement of the crop would almost certainly result in low productivity and reduced yields. This is termed deficit irrigation. For the purposes of this estimate, we assume that the crop was fully irrigated, that is it was irrigated to obtain full yields. Logically, if the farmer had rights to use the water, and water was available, he would irrigate to obtain highest yields.
- Delivery Losses. Delivery conveyance losses by primitive ditches are significant factors that should be considered. While losses can be as much as 40% in unlined ditch systems, depending upon size, soil type and length, I have estimated this amount at a relatively conservative 15%, which takes into account the sandy nature of the soil (which increases losses) and the close proximity to the water source (which lessens losses).
- Efficiency estimates. Typically, farmers apply more water than the full ET value for the crop to account for non-uniformity of the irrigation system. Perfect

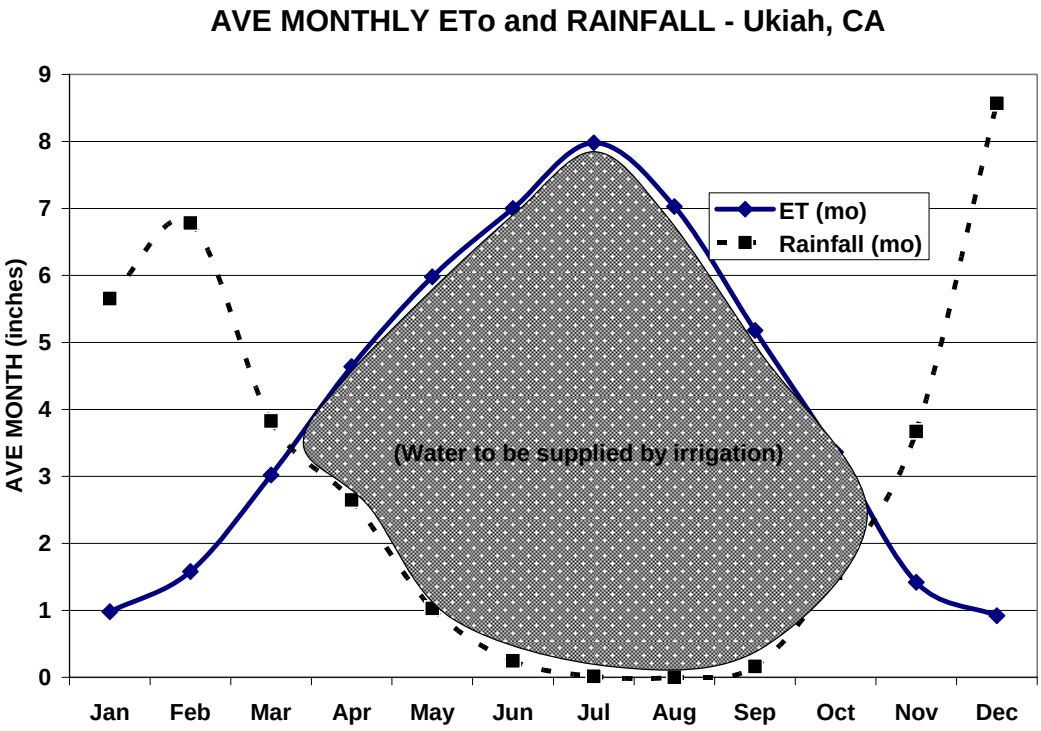
systems do not exist, but a perfect system would result in 100% of the applied water being used for ET for crop growth and thus applications would equal ET of the crop (in this case about 45”). A highly efficient, 90% efficient system, would require about 10% more water, a 80% efficient system about 20% more, etc. Often this additional water is returned to surface or groundwater through runoff or deep percolation.

- It is difficult to estimate the efficiency of a system that existed in 1913. However, we do know that horse- or primitive tractor-designed fields are generally fairly inefficient. Factors that affect efficiency for surface systems include land leveling, rate of flow, the design of the checks (width, length), soil texture, soil texture gradient. Runoff is common in such systems. Gradients in soil texture have large effects on irrigation uniformity, and gradients were present in this field. Small errors in land leveling (pre-laser technology) require that greater amounts of water are applied, as farmers continue to irrigate a section so that water reaches the ‘high areas’. Surface irrigation techniques are currently thought to have efficiencies between 50 and 85 percent. For the purposes of this estimate, we will assume the low end, since system design and leveling were likely to have been sub-optimum, and the soil is relatively sandy, with gradients in soil texture.
- Restrictions of surface systems. It is important to realize that farmers cannot apply small amounts of water using surface systems. Application rates are restricted to between 5” and 8” per irrigation event, since considerable amounts are required to simply push the water across the field and obtain coverage. I assumed a 6” application per irrigation for this field.
- In alfalfa systems, farmers can only irrigate between cuttings, due to the need to dry the field down for harvesting. There are typically 7-12 days when irrigation cannot be done due to harvests. With a 45-day cutting schedule in a hot environment like Ukiah, 2 to 3 irrigations between cuttings are the most likely scenarios.
- For the purposes of this estimation, I considered a ‘low application’ scenario and a ‘high application’ scenario for this field (Table 1).

Summary: Estimation of the water applied to this 162 acre alfalfa field would be approximately 932 AF on the low end, and 1310 AF on the high end. Additional amounts would be added for the two remaining acres of orchards. This estimate is based upon the sandy nature of the field, the putative primitive nature of the field design, the need for frequent irrigations due to sandy soils, an assumption that the field was irrigated to full ET, and not deficit irrigated, and a growing season from early March through October. Conveyance losses were estimated to be 15%. The higher irrigation amount would occur during a year with a dry spring, or hot summers. The low number might occur during a wet spring. The high estimate represents approximately a 54% efficiency level (compared with ET), which is the more likely estimate, due to the limitations of the systems at that time. The actual application rates in 1913 would depend upon the practical limitations of the pumping system, availability of water in a given year, rainfall and weather patterns, peculiarities of the field (sandy streaks, for example), and habits of the farmer.

Table 1. Estimation of irrigation applications and harvest schedules for a low irrigation regime and high irrigation regime for a 162 acre alfalfa field near Ukiah, CA. Units are inches per acre and summary is in Acre-Feed (AF).

				Water Applications (inches)	
Month	Dates	Activity	ET (inches)	Low	High
March	30		3.02		6”
April	1-14				6”
	15	(Grazing Harvest)			
	15-30	Irrigation	4.64	6”	6”
May	1-14	Irrigation			6”
(CUT 1)	15	Hay Harvest			
	15-30	Irrigation	5.98	6”	6”
June	1-14	Irrigation		6”	6”
	15-30	Irrigation		6”	6”
(CUT 2)	30	Hay Harvest	7.00		
July	1-14	Irrigation		6”	6”
	15-31	Irrigation	7.98	6”	6”
August	1-14	Irrigation		6”	6”
(CUT 3)	15	Hay Harvest			
	15-31	Irrigation	7.03	6”	6”
September	1-14	Irrigation		6”	6”
	15-30	Irrigation	5.18	6”	6”
October	1-14				
(CUT 4)	10	Hay Harvest			
	15-31	Irrigation	3.36		6”
November	1-14				
	15-30		1.42		
	30	Grazing Harvest			
Conveyance losses (15%)				9”	13’
Applications per acre			45.61”	69”	97”
162 acre Summary				932 AF	1310 AF


AVE MONTHLY ETo and RAINFALL - Ukiah, CA
AVE MONTH (inches)
9
8
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
ET (mo)
Rainfall (mo)
(Water to be supplied by irrigation)