Estimation of the Requirement for Water and Ecosystem Benefits of Cow-Calf Production on California Rangeland

By Emily Andreini, Julie Finzel, Devii Rao, Stephanie Larson-Praplan, and James W. Oltjen

On the Ground

- Beef production is perceived as using large amounts of water, and some studies recommend decreasing or ceasing meat consumption to decrease water use.
- Water footprints include different types of water, including green water (i.e., precipitation used for plant growth), blue water (i.e., drinking water and irrigation water used to grow alfalfa and irrigated pasture), and grey water (i.e., freshwater required for integrating water pollutants to a level accepted by water quality standards).
- A static model depicting blue and green water use for cow-calf production on California rangeland was developed.
- In this study, green water, which is sourced from rainfall and not available for another use, contributed the largest component to the total water footprint of cow-calf production at each location.
- It is important to consider the water use associated with beef production in the context of ecosystem services cattle provide to rangelands, such as preventing grassland conversion to shrub lands or woodlands, and the role that grazing cattle play in management of rangeland.

Keywords: water use, beef cattle, rangeland, ecosystem benefits.

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The prolonged California drought raised concerns regarding the use of water for both animal and other agricultural sectors; beef production particularly came under scrutiny. Perceptions of large amounts of water use and land degradation by beef production led to a common recommendation of reducing meat consumption to decrease water use.[1,2] However, such generalizations, based on estimates of the virtual water content of meat, fail to describe the environmental relevance of water use in a product life cycle.[3] Virtual water refers to the volume of water that is used to produce the product, measured over the full supply chain; however, it does not consider what type of water (i.e., blue, green, grey) is used or when and where it is used by the product.[4] All components should be geographically and temporally specified.

Water footprints measure the amount of water used to produce goods and services. Water footprints vary in the forms of water consumption represented, as well as other factors that affect the comparison of footprints for different products.[5,6] The water footprint has three components: green, blue, and grey. Green water, derived from precipitation, increases soil moisture that is used by plants via transpiration. Blue water is the amount of surface water and groundwater (i.e., irrigation water and drinking water) required to make a product, such as beef. Grey water is the volume of freshwater required for integrating water pollutants to a level accepted by water quality standards.[4–6] The beef industry consumes different water types throughout the production chain and different production systems. In grazing-based (i.e., grass-fed) beef production systems, green water will contribute a larger amount to the total water footprint than blue and grey water.[7] In beef production systems where animals spend more time on grain (i.e., feedlots), blue water will contribute a larger portion of the water footprint due to the production of grain compared to the grazing system.[7] Appropriate comparisons of water footprints must consider the types of water and beef production system boundaries included in the water footprint to avoid comparative bias between footprints.

To determine the water requirements of beef production in the United States and evaluate high water-use estimates,

Table 1. Average forage production, precipitation, ET, and rangeland acres at the two UCANR Research and Extension Centers, HREC and SFREC, and at the USDA Forest Service SJER

	Location		
	SJER	HREC	SFREC
County	Madera	Mendocino	Yuba
ET zone	12	4	14
Potential ET* (cm/y)	130.1	113.6	133.9
Precipitation* (cm/y)	44.6	94.5	74.6
Forage production* (kg/hectare/y)	2,242	2,466	2,802
Rangeland* (hectare)	64,523	50,568	32,904

ET indicates evapotranspiration; HREC, Hopland Research Extension Center; SFREC, Sierra Foothill Extension Center; SJER, San Joaquin Experimental Range.

* Values reported are specific to ET zone within the county.

Beckett and Oltjen[8] quantified developed water, now considered blue water, used by all inputs of the beef production system. Water use was divided into drinking water, water for feed production (i.e., irrigation), and water for processing. Rainfall was not considered to be developed water; therefore, it was not included in the model by Beckett and Oltjen.[8] The model Beckett and Oltjen[8] developed depicted beef cattle production in the United States, taking into account the variation in production systems across regions of the country.

The study objectives were to quantify water requirements for cow–calf production in California at three different rangeland locations using methodology similar to that of Beckett and Oltjen.[8] An additional study objective was to review and compare ecosystem benefits associated with grazing cattle on rangeland. This was not previously examined by Beckett and Oltjen.[8]

Materials and Methods

A static model depicting water use for cow–calf production on California rangeland was developed on an Excel spreadsheet (Microsoft, Redmond, WA, USA). The scope of this study differed from that of Beckett and Oltjen[8] by focusing on cow–calf production on California rangeland rather than encompassing all stages of beef production within the United States. This study did not include the feedlot portion of the beef production system, focusing instead on green water consumption, as it related to grazing rangelands, and blue water for additional hay and irrigated pasture. The model focuses on cow–calf production only, due to the year-to-year variability in stocker cattle on California rangeland. Personal communication with University of California Cooperative Extension Livestock Advisors confirmed that the number of stocker cattle varies with weather and is difficult to measure. The water taken into account included precipitation (green water) and water from surface or groundwater resources, such as drinking and irrigation water (blue water). Water use for beef production was modeled at two UC Agriculture and Natural Resources Research and Extension Centers, Hopland (HREC) and Sierra Foothill (SFREC), and at the USDA Forest Service San Joaquin Experimental Range (SJER). For each research location's ET zone, cow-calf production was modeled in that county for the entire ET zone. The three locations chosen have different evapotranspiration (ET) zones, forage production, and rainfall. The different components of ET encompass the processes by which water changes from liquid to gas form.[9] Evapotranspiration processes include evaporation from plant surfaces and soil and transpiration from the plant.[9] Each field station monitors forage production and rainfall throughout the growing season (Table 1). Green water use for beef production was estimated based on the ET zone in which each site was located (Fig. 1).

For cow–calf production, our base assumptions were 85% calf crop (i.e., calves weaned per cow exposed to the bull), 18% heifer replacement rate, and 5% bulls per breeding female. These assumptions were similar to those of Beckett and Oltjen.[8] The average weight of cows, calves, replacement heifers, and bulls in the model was 544, 163, 327, and 816 kg, respectively. Animals in the breeding herd (i.e., cows, bulls, and replacement heifers) totaled 7,997 at SJER, 4,475 at HREC, and 3,719 at SFREC. These are the number of animals in the same ET zone as the research location's in the county modeled. Dry matter intake (DMI) of supplemental feed and forage provided by alfalfa and irrigated pasture was subtracted from the total DMI to determine rangeland forage intake (Fig. 2). We calculated annual DMI of the breeding herd as 2% of body weight (BW). DMI as 2% of BW was consistent with the assumptions made by Beckett and Oltjen.[8] For the type of beef animals in this model, the recent NRC[10] recommends calculating DMI as 2.1% of BW. Increasing DMI to 2.1% will increase the green water use by approximately 6%. Because