



Managing yellow starthistle on rangeland

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Intensive cattle grazing in May and June reduced yellow starthistle plant size, summer and fall canopy size, and seed production in the first year of a 3-year, northern California study. Combining grazing and herbicide applications caused large reductions. Abundant late rains favored yellow starthistle growth.

Yellow starthistle, a summer-maturing annual plant introduced from Europe, is now a widespread noxious weed in California. Its invasiveness, ability to form tall dense stands, and spiny flower heads make it an undesirable plant on many pastures and rangelands during the summer and fall.

First recorded in California in 1869 near Oakland, yellow starthistle, *Centaurea solstitialis*, has since spread exponentially. By 1965, the California Department of Food and Agriculture estimated that yellow starthistle had invaded approximately 1.9

million acres statewide. By 1985 it was infesting 7.9 million acres of rangelands, pastures, hay and fallow fields, orchards and roadsides, according to a survey by D. M. Maddox and A. Mayfield (*California Agriculture*, November-December 1985). Among the reasons for its success as a weed are: large juvenile rosettes that shade neighboring plants (fig. 1); a taproot extending below the zone of root competition of associated annual species; a large seed output and long germination period; ability to regrow after heavy grazing (before the spine-producing stage); spiny habit in the reproductive phase that discourages grazing; late spring and summer growth exploiting residual soil moisture not used by winter annuals; efficient water use; insufficient insect predation or damage by pathogens; management practices that encourage its proliferation and spread; uncontrolled pioneer infestations due to declining county budgets for control of noxious weeds.

To find ways of managing yellow starthistle, we compared the weed's response to intensive cattle grazing with and



Yellow starthistle at flowering stage forms sharp spines that can injure grazing animals.

Cattle readily grazed yellow starthistle before it produced spines, seeking palatable green foliage in the early bolting, or stem elongation, stage (left). Only defoliated central stalks remained (right) after a heavy grazing during the late bolting stage. Although most plants were resilient enough to regrow, grazing affected the canopy and seed production; plant #1 (below) produced about 250 seeds; #2, 500 seeds; and #3, 750 seeds. Large, ungrazed plants produced 1,500 to 10,000 seeds.



without herbicide treatment. We have completed the first year of a 3-year study on two northern California ranches, one a cow-calf operation and the other a stocker operation. The study was designed to: test yellow starthistle suppression from competition by resident clovers and annual and perennial grasses; reduce yellow starthistle by defoliation during critical periods in its life cycle; and compare grazing management alone with a combination treatment of herbicide (2,4-D) plus grazing. This report presents our preliminary results.

Study sites and design

One site is on the O'Connell Ranch in Tehama County, 20 miles southwest of Red Bluff at an 800-foot elevation on Zamora clay loam soil. A 6.5-acre pasture has been divided into 12 paddocks to accommodate three treatments with four replications in a randomized block design. Stocker cattle were used as needed between February and late May. The dominant plants are a mixture of yellow starthistle, annual grasses, and rose clover with lesser amounts of lupine, fiddleneck, filaree, crimson clover, and hardinggrass.

The second site, on the Salvesson Ranch in Colusa County, is a cow-calf operation approximately 20 miles west of Maxwell in the Inner Coast Ranges at a 1300-foot eleva-

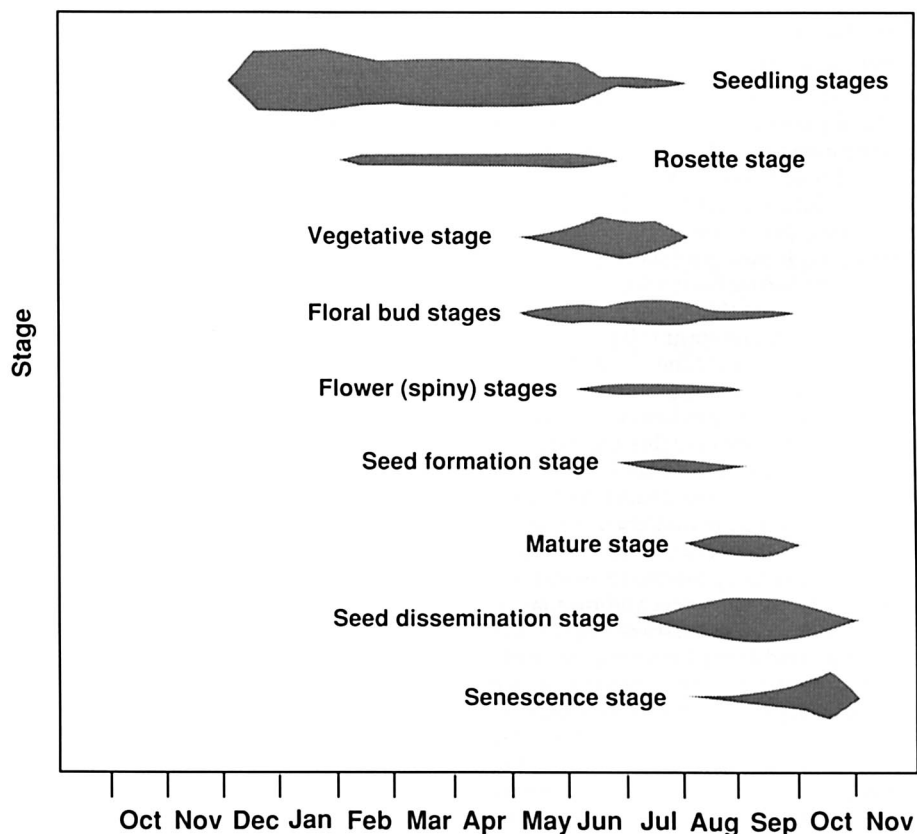


Fig. 1. Seasonal development of yellow starthistle in northern California. (Adapted from D. M. Maddox, USDA 1981)

tion on an unmapped alluvial soil. A 4.5-acre site was divided into nine paddocks for two treatments with three replications; three additional paddocks were used for pilot studies with various unreplicated treatments. Plants include yellow starthistle and other alien annuals, seeded forage such as rose and subterranean clover, hardinggrass and annual ryegrass, and a mixture of native annual and perennial herbaceous species.

We used an intensive grazing management approach at both ranches: high stocking densities (40 to 100 cows per acre) with short grazing periods (2.5 to 24 hours) adjusted to plant growth patterns and regrowth responses of the dominant species after grazing. Single-strand, portable electric cross-fencing was used to confine the cattle during grazing periods.

The treatment with 2,4-D phenoxyacetic acid consisted of a 30-foot swath extending through all the paddocks. We applied the spray (3/4 acid-equivalent/acre) at a volume of 30 gallons per acre with a six-nozzle boom operated from a CO₂ knapsack sprayer. We sprayed when yellow starthistle was in the rosette stage, before bolting (stem elongation) and flowering. This was February 25 at the Tehama County site after an early February grazing and May 3 in Colusa County after a grazing at the end of March.

Preliminary results

O'Connell Ranch. Our hypothesis was that soil moisture is the major factor during critical plant growth periods, and that competition for light is a secondary interacting influence. We expected that heavier (longer duration in the paddock) grazing would suppress competitive plants and leave more soil moisture for yellow starthistle during late spring and summer growth. To test this theory, we kept our stock density constant (100 animals per acre) and varied the time the animals were allowed to graze in the paddocks. We used a light, moderate, and heavy (check) grazing for our treatments at this site and grazed in February, April, and May.

Because of an unusual rainfall pattern of extreme drought from February to mid-April and 6 inches of rain from mid-April to June 9, it was not possible to assess what effects grazing duration and biomass removal had on soil moisture (fig. 2). Poor growing conditions for spring-maturing annuals resulted in insufficient growth, especially of grasses, and the late rains nullified whatever effects these plants may have had on soil-moisture extraction. Even in the light grazing treatment, where rose clover maintained a dense canopy throughout the winter and spring, starthistle rosettes emerged through the canopy and eventually dominated.

The herbicide-plus-grazing treatment caused a large reduction in yellow starthistle densities (mature plants, measured by 24 plots, 1 foot square, per paddock) compared with densities in the unsprayed portion of the paddocks (table 1). However, while overall densities were relatively low in the sprayed strips, the late rains resulted in abundant yellow starthistle growth in 6 of the 12 paddocks. Many of the mature plants produced dense canopies and thousands of seeds.

Salveson Ranch. Unlike the O'Connell Ranch, where our main interest was in using competition to suppress yellow starthistle, at the Salveson Ranch we focused on yellow starthistle reduction by defoliation during critical periods of its life cycle. Although we found no major reductions in yellow starthistle densities when comparing early and late grazing treatments, there were important differences in plant height, canopy size, and seed (achene) production.

The grazing periods that resulted in these differences were in late May and June (late grazing treatment). Cattle readily grazed yellow starthistle at every growth stage before it produced spines, but this period was more effective than others. First, because most of the yellow starthistle had produced elongated flowering stems, the plants were readily accessible to cattle. Second, since yellow starthistle was green and palatable, the cattle preferentially grazed it over the dried vegetation. Third, soil moisture levels were low or dropping and air temperatures were increasing, making drying due to injury from grazing more likely. Finally, most other resident annual plants had completed their life cycles and shed their seeds; the seed reservoir of these competing plants could thus be maintained or increased while yellow starthistle's seed output decreased.

To increase the number of yellow starthistle plants grazed during this period, we temporarily divided portions of the treatment paddocks to concentrate animals in areas with the higher starthistle densities.

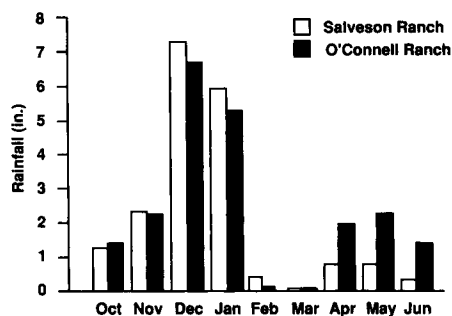


Fig. 2. Rainfall, 1987-88. O'Connell Ranch, Tehama County, had drought early in 1988, then late rains. Salveson Ranch, Colusa County, had little effective late-season rain.

The cows grazed the bolting starthistle plants, and in most cases defoliated the plant, leaving only a portion of the central stalk. About 20% of the plants died, but most were resilient enough to regrow by expansion of basal and axillary shoots. A month later, animals were placed back in these paddocks to graze the starthistle regrowth; although more defoliation occurred, it was less severe and surviving plants were able to flower and produce seeds. We estimate that the yellow starthistle canopy was reduced by at least 75%, leaving a better environment for fall and winter growth of other resident species.

The combined herbicide and grazing treatment caused large reductions in yellow starthistle densities, similar to those in the Tehama County site (table 2). However, since there was little effective rainfall late in the season, the reduction in yellow starthistle biomass in the sprayed area was greater than in Tehama County. Although some plants managed to produce seeds, they were stunted and lacked the large canopies characteristic of those at the other site with more rainfall.

Nutritional value. We determined crude protein and acid detergent fiber of yellow starthistle samples that were hand-collected late in May in the rosette and bolted, early-bud stage from both ranches. Crude protein

TABLE 1. Yellow starthistle density, O'Connell Ranch, Tehama County, 1988

Grazing treatment	Mature plants/sq ft*	
	Unsprayed	Sprayed
Heavy (check)	13	1
Moderate	16	1
Light	13	2
Average	14	1

* Actual quadrat size 0.1 square meter (1.08 square feet).

TABLE 2. Yellow starthistle density, Salveson Ranch, Colusa County, 1988

Grazing treatment	Mature plants/sq ft	
	Unsprayed	Sprayed
Early	9	1
Late	5	1
Average	7	1

TABLE 3. Protein and acid detergent fiber (ADF) percentages of yellow starthistle from both ranches, May 20 and 25, 1988

Growth stage	Protein %	ADF %
O'Connell Ranch:		
Rosettes, just before bolting	10	26
Bolting, early bud	13	28
Salveson Ranch:		
Rosettes, just before bolting	13	28
Bolting, early bud	11	32

exceeded 9%, and acid detergent fiber concentrations were less than 32% (table 3). The nutritional value of yellow starthistle in early stages thus appears to be acceptable as a component of a ruminant's diet. Toxicity is not a problem with ruminants but is well known with horses. Ruminants should never be encouraged to graze yellow starthistle after it produces spines; the stout, sharp, 1-inch spines can injure grazing animals.

Conclusion

Our preliminary results show that both herbicide plus grazing applications and grazing alone provide some measure of success in managing yellow starthistle. The herbicide applications substantially decreased yellow starthistle densities. However, they also eliminated all other broad-leaved plants within the sprayed strips and reduced total biomass production.

Intensive grazing in late May and June had little effect on yellow starthistle densities, but it reduced plant height, canopy size, and seed production in the unsprayed areas. This late-season grazing occurred after annual grasses, legumes, and most other resident annuals had matured, allowing for seed bank replenishment and leaving appreciable amounts of plant residue on the ground.

As with all of California's annual range vegetation, rainfall had a major influence on yellow starthistle's density, plant size, and productivity at the two sites.

While we have achieved some management success, we expect some starthistle reestablishment. We therefore intend to apply greater grazing pressure during the critical control period with the objective of further reducing seed output. We are also establishing a site on the UC Davis campus to test sheep as biocontrol agents for yellow starthistle management.

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Orchard floor treatments, at midseason, included clean cultivation (foreground), planted annual grass killed with an herbicide application (background), and mowed, planted annual grass (distant background). Permanent cover was also tested.

Improving orchard soil structure and water penetration

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Soil surface crusts can severely limit water infiltration and tree crop production. Vegetative cover and gypsum treatments in an orchard increased soil structural stability and may reduce crust formation in the long term. Tillage improved short-term water penetration by temporarily breaking up the crust.

Slow water penetration is a major factor limiting crop production in California's orchards. Causes of this problem include surface crusts, tillage-induced compacted layers, and restrictive soil layers such as

clay-rich subsoil horizons. Low water intake rates are associated with reduced yield, increased disease susceptibility, and poor water use efficiency (increased runoff and evaporation losses).

Surface crusts result from structural deterioration of surface soil and its organization into a dense, restrictive layer at the soil surface. Management practices, soil properties, and irrigation water quality each may contribute to structural deficiencies that can lead to crust formation.

Cultivation contributes to structural deterioration of soil in several ways. Removal of the protective plant cover from between orchard tree rows makes these areas susceptible to mechanical disturbance by raindrops and overland water flow. Raindrop