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The cause of “chewing disease” and sometimes death in horses, yellow starthistle contaminates hay and grain crops, orchards, vineyards, and open areas, and is one of the most serious weed pests on California rangelands. Infestations have increased 640 percent since 1958.

Yellow starthistle infestations are on the increase

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Its competitiveness and the removal of competing plants often result in solid stands on rangelands

The origin of yellow starthistle (*Centaurea solstitialis* L., Asteraceae) is most likely the Middle East, since the greatest diversity in the genus *Centaurea* occurs in that area. Dr. M. Zohary of the Hebrew University theorizes that overgathering and overhunting during the Holocene period may have caused a prehistoric food crisis, which may have driven humans from hunting-gathering to herding-planting. In the process, palatable plants may have been grazed off of enormous areas and replaced by plant communities dominated by highly aggressive and antipastoral species. Thorniness has become a naturally selected property of high survival value in these heavily grazed regions. Dr. Zohary noted that a disproportionate

number of thorny plants — hundreds of thistle species in the sunflower family — have evolved in the Middle East. However, most authors believe that yellow starthistle is a European plant that originated in the Mediterranean basin. It is presently widespread and is found in most temperate areas of the world. It occupies dry, open areas of southern Europe and has become naturalized where such habitats exist in parts of central Europe.

The question of the origin of the North American plants, as well as their evolution since their introduction, is very important. We know that California populations exhibit variation within the species, and that hybridization in the genus *Centaurea* occurs readily in central and

southern Europe. The senior author's studies indicate that different California climatic conditions in valley than in coastal systems have resulted in characteristically different yellow starthistle populations.

Yellow starthistle is believed to have been brought into the United States on numerous occasions, possibly with alfalfa seed, since this and other *Centaurea* species are common contaminants of the seed. G. W. Hendry and G. W. Hendry of the University of California and M. K. Bellue of the California Department of Food and Agriculture (CDFA), who analyzed adobe bricks from early buildings in California, found no yellow starthistle in bricks of the Spanish period (1769 to 1824), but did find seeds in the Mexican or post-mission period after 1824. Also, the earliest known herbarium specimen of yellow starthistle was collected in 1869; subsequent collections occurred in 1887, and more frequently during the 1890s, all from northern California.

Economic importance

The ability of yellow starthistle to colonize and spread on disturbed sites is well known. This ability results in part from its suspected toxic effect on some associated species, its competitiveness, and the removal of competing vegetation because of grazing, often resulting in solid

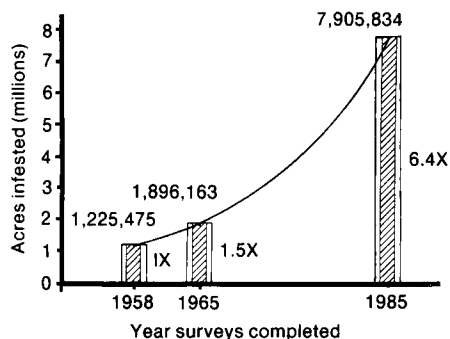


Fig. 1. Yellow starthistle increased 1.5 times in gross acreage from 1958 to 1965 and rose 4.2 times from 1965 to 1985.

stands of starthistle. It is a pest in rangelands and invades grain fields, orchards, vineyards, cultivated crops, pastures, roadsides, and wastelands in California and other areas in western North America. The plant is also considered an important contaminant of commercial seeds and hay, and is an important weed of alfalfa and cereal grains in California, although it has been lessened considerably in the latter two with the use of phenoxy herbicides.

Its toxicity to horses is well documented; when ingested in quantity, yellow starthistle results in a neurological disorder called equine nigropallidal encephalomalacia, or "chewing disease." Continued feeding on yellow starthistle plants over an extended period causes death.

Distributional surveys

Information on acreage infested by yellow starthistle was compiled by Walter S. Ball of CDFA from questionnaires submitted to county agricultural commissioners in 1958. Of the 47 counties replying, 43 reported a total of 1.2 million acres infested with yellow starthistle at that time (fig. 1). In a 1965 survey of county agricultural commissioners, compiled by James W. Koehler (CDFA), 49 of the 53 counties replying reported a total of 1.9

million acres infested with yellow starthistle.

Between 1980 and 1985, we conducted a survey to update the information on the yellow starthistle infestation in California. We distributed questionnaires to county commissioners, as in previous surveys, as well as to UC Cooperative Extension farm advisors, and others, and collected information by phone. Although this procedure relies on the best subjective judgment of cooperators and not on quantifiable field surveys or data, an acre-by-acre survey of the California counties would be an economically unfeasible, awesome task.

Yellow starthistle in California increased 1.5 times in gross acreage during the seven years from 1958 to 1965. In the 20 years since 1965, gross acreage appears to have increased 4.2 times, and since 1958 (27 years), 6.4 times, based on the estimates produced by the surveys.

Lake County, with an estimated gross acreage of 800,000, has the largest yellow starthistle infestation of any California county, followed by Siskiyou with 768,000, Humboldt with 686,000, and Trinity with 612,000. The counties of Alpine, Imperial, Inyo, Mono, and San Francisco reported no known infestations of yellow starthistle. The total estimated gross acreage of yellow starthistle in California, as reported in the 1985 survey, is 7.9 million acres.

The unique topography of California divides the state into natural drainage areas, which in turn affect the character of both native and naturalized vegetation as well as the climate. We examined the distribution of yellow starthistle, based on the 1985 survey, in terms of each drainage area (fig. 2). The Sacramento Drainage has the largest estimated gross acreage of yellow starthistle in California with a total of 3.2 million acres. The second largest is in the North Coast Drainage with an estimated 2.8 million acres, followed by the San Joaquin Drainage with 1.5 million acres. The Central Coast Drainage with

355,000 acres and the Northeast Interior Basins with 58,000 acres together constitute only 5.2 percent of the total gross acreage of yellow starthistle in California. The South Coast Drainage and the Southeast Desert Basins have relatively low infestations.

Many factors may be responsible for the differences in gross acreages of yellow starthistle. We will discuss only some that may play a role in the present distribution — precipitation and grazing versus cropland disturbances.

Precipitation is important, because yellow starthistle is a winter annual whose seedling development is synchronous with and initiated by the winter rains. During the subsequent period of seedling establishment, sustained soil moisture is critical to supporting continued growth and development of the seedlings.

Grazing is instrumental in producing the amount of disturbance, as well as in the removal of competing vegetation, that favors the colonization and spread of yellow starthistle. Cropland disturbance limits infestations because, if intensive agriculture is practiced, it consistently interrupts the plant's life cycle.

The major part of the estimated yellow starthistle gross acreage is in the Sacramento and the North Coast drainages. Both drainage areas receive large amounts of precipitation during the rainy season. Annual precipitation during 1931 to 1955 ranged from 12 to 80 inches in the North Coast Drainage and 12 to 72 inches in the Sacramento Drainage. A large part of these drainage areas consists of rangeland where the livestock industry prevails. In the North Coast Drainage, other disturbances result from logging and the movement of livestock to montane pastures, especially in summer.

Such movements of equipment and animals may greatly enhance the spread of the plant. Since this is a pioneering plant, it grows best where there is an ele-

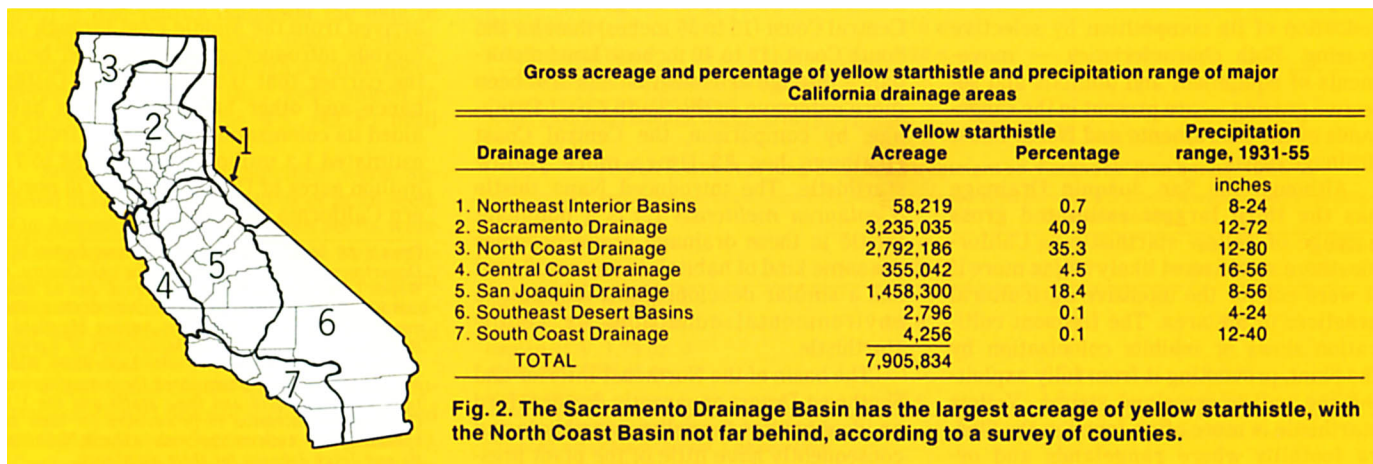


Fig. 2. The Sacramento Drainage Basin has the largest acreage of yellow starthistle, with the North Coast Basin not far behind, according to a survey of counties.

Yellow starthistle infestations reported in California

County	Gross acreage infested in county			County	Gross acreage infested in county		
	Level*	Acres	Comment		Level*	Acres	Comment
Alameda	H	20,000	In all but urban areas	Placer	H	274,000	Covers half of county
Amador	H	243,000	Western section throughout foothills	Plumas	L	800	Along roadsides and some dryland pastures
Butte	H	463,000	Throughout western and central areas	Riverside	L	251+	Infestations near Beaumont, Elsinore, Cleveland Nat. Forest
Calaveras	H	100,000	Throughout county up to 4,000 feet	Sacramento	H	320,000	Scattered throughout county
Colusa	H	246,000	Throughout valley floor	San Benito	H	72,000	Along ditches, roadsides, canal banks, pastures
Contra Costa	H	470,400	Scattered infestations throughout county	San Bernardino	H	2,890	Western side of county, near Chino, Cajon Junction, other
Del Norte	L	4	Near Klamath Glen, Gasquet, and by Collier Tunnel	San Diego	L	15	Small infestations along ditch-banks, canals, fencerows
El Dorado	H	5,000	Western area to 3,500 feet	San Joaquin	H	72,000	Scattered all over county
Fresno	H	3,000	Increasing in distribution	San Luis Obispo	H	10,000	Widely distributed, central county
Glenn	H	10,000	Throughout county, both valley floor and foothills	San Mateo	L	27	Only a few plants in scattered areas, center of county, Hwy 101, along coast
Humboldt	H	686,000	Countywide, roadsides, mountain valleys, pastures wastelands	Santa Barbara	H	3,000	Extensive in Los Padres Nat. Forest
Kern	L	100	Spreading very slowly in Tehachapi foothills	Santa Clara	H	5,000	Heavy along right-of-ways and in foothills
King	L	10	Scattered, small infestations throughout county	Santa Cruz	L	75	Mostly in noncrop areas
Lake	H	800,000	Throughout; density varies	Shasta	H	400,000+	In most parts of county under 3,200 feet
Lassen	L	500	Heaviest infestations near Shasta county line	Sierra	L	5	Mostly roadside infestations
Los Angeles	L	2	About 20 small active infestations	Siskiyou	H	768,000	Central areas including Shasta Valley, some in Scott Valley
Madera	L	300	In previously cultivated areas returned to native pasture	Solano	H	20,000+	Common in almost all dryland pastures and roadways
Marin	H	2,000	In Laguna Lake and Novato areas	Sonoma	H	100,000	Widespread throughout
Mariposa	H	200,000	Along ditches and roadsides	Stanislaus	H	227,000	Mostly valley floor, roadsides, canal banks, waste areas, pastures
Mendocino	H	250,000	Scattered to heavy infestations in rangelands and cereal-growing areas	Sutter	H	200,000	Scattered throughout
Merced	H	1,000	In dry fields, fencerows, ditchbanks, irrigation borders	Tehama	H	40,000	More prevalent on valley floor than in foothills
Modoc	L	120	Scattered, mostly in noncrop areas	Trinity	H	612,672	Along highways, roads, logging areas, open fields
Monterey	H	6,000	Major infestations in Hunter-Liggett Reservation	Tulare	H	10,000	Mostly in western section
Napa	H	242,560	All over county in rangelands, roadsides, wastelands	Tuolumne	H	212,818	Widespread up to 2,800 feet
Nevada	H	200,000	Covers half of county, widely scattered	Ventura	L	5	Very few plants, mostly on range and grain land
				Yolo	H	198,600	Widely distributed throughout foothills, western section.
				Yuba	H	407,680	Distribution countywide

NOTE: The following counties had no known infestations: Alpine, Imperial, Inyo, Mono, Orange, and San Francisco.
*Infestation levels: H=infestations over 1,000 acres; L=under 1,000 acres.

ment of disturbance to promote initial establishment, but it requires subsequent periods of minimal disturbance to further colonize and spread. Furthermore, yellow starthistle has a broad tolerance range (ecological amplitude), which favors it in competition, and it also benefits from a reduction of its competition by selective grazing. Both characteristics — movements of equipment and animals and selective grazing — are present in the rangelands of the Sacramento and North Coast drainage areas.

Although the San Joaquin Drainage has the third largest estimated gross acreage of yellow starthistle in California, there would most likely be far more if it were not for the intensive agricultural practices in the area. The frequent cultivation slows or inhibits colonization by the plant, preventing it from fully exploiting the valley grassland steppe. Yellow starthistle is more often found in the Sierra foothills where rangelands and or-

chards coexist. During 1931 to 1955, annual precipitation of the San Joaquin Drainage ranged from 8 to 56 inches.

Much less yellow starthistle is present in the Central Coast and South Coast drainages. The range of annual precipitation from 1931 to 1955 was greater for the Central Coast (16 to 56 inches) than for the South Coast (12 to 40 inches). Land disturbance through urbanization has also been more extensive in the South Coast Drainage; by comparison, the Central Coast Drainage has 83 times more yellow starthistle. The introduced Napa thistle (*Centaurea melitensis* L.) is a dominant thistle in these drainage areas, occupies the same kind of habitat, is an annual, and has a similar developmental response to environmental conditions as yellow starthistle.

The basin of the Northeast Interior and Southeast Desert apparently do not afford an ideal habitat for yellow starthistle and consequently have little of the plant pres-

ent. These basins are essentially too dry, the precipitation range for the period 1931 to 1955 being 8 to 24 inches and 4 to 24 inches, respectively.

Conclusion

This "pioneering" plant has presumably arrived from the Middle East through numerous introductions, alfalfa seed being the carrier that is most suspect. Disturbance and other human activities have aided its colonization and spread from an estimated 1.2 million acres in 1958 to 7.9 million acres in 1985, much of it in northern California.

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