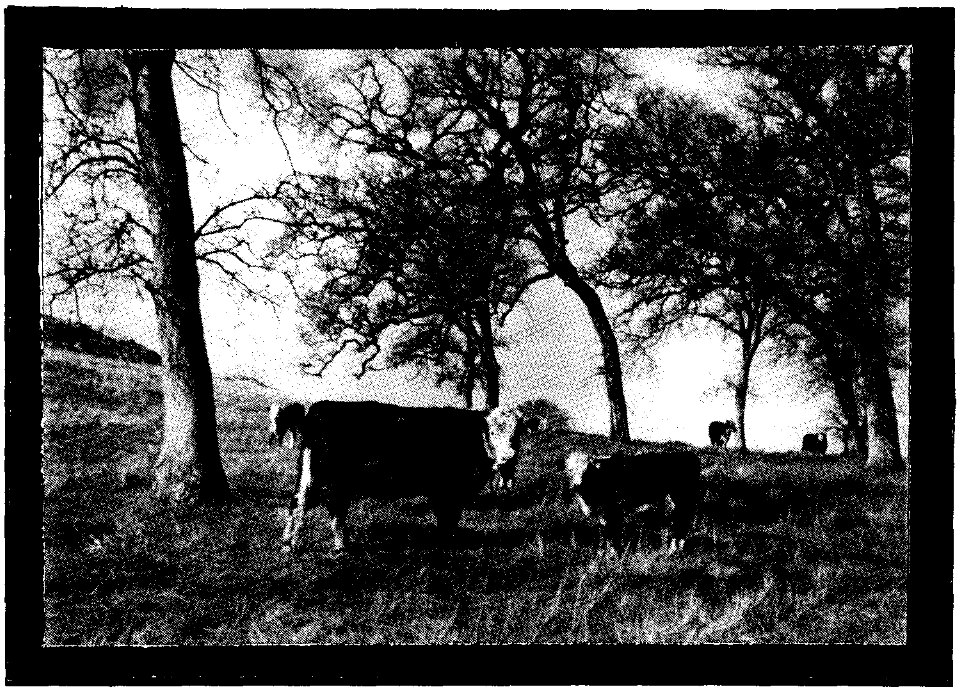
UNIVERSITY OF CALIFORNIA

SIERRA FOOTHILL RESEARCH AND EXTENSION CENTER

Beef & Range Field Day

"Weed Management on Grazing Land"



April 17, 1997

Browns Valley, California

THE UNIVERSITY OF CALIFORNIA

SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Presents:

Annual Beef & Range Field Day

"Weed Management on Grazing Land"

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UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
UNIVERSITY OF CALIFORNIA, DAVIS

April 17, 1997

BEEF & RANGE FIELD DAY

UC Sierra Foothill Research & Extention Center
8279 Scott Forbes Road, Browns Valley

APRIL 17, 1997

AGENDA

Theme: Weed Management on Grazing Land

Morning	MC: Jim Oltjen, Extension Specialist, Dept. of Animal Science, UC Davis
9:30am	Introductions - Mike Connor, Superintendent, SFREC
9:35am	Welcome - Harry Carlson, Director, DANR Research & Extension Centers
9:40am	Weeds are not a problem!!! - Roger Ingram, Livestock/Farm Advisor, UCCE Placer/Nevada Co.
10:05am	Important Ecological Characteristics of Yellow Star-Thistle (YST) - John Gerlach, Graduate Student, Agronomy & Range Science, UC Davis
10:25am	Yellow Starthistle Management Methods and Status - Joe Di Tomaso, UCCE Weeds Specialist, Seed Bank Management, Fire, Herbicides
11:05am	The Future of YST Biocontrol - Joe Balciunas, USDA Ag Research Service, Albany, CA
11:25am	Population dynamics in California Annual Grasslands Seedbeds - Jim Young, USDA Ag Research Service, Reno NV
NOON	BBQ Tri-Tip Lunch Served by the Yuba-Sutter Cowbelles
Afternoon	MC: Larry Forero, Livestock/Farm Advisor, UCCE Shasta/Trinity Co.
1:20pm	Travel to oak plots
1:30pm	Weed Control Methods for Oak Plantings - Doug McCreary, Area Natural Resources Specialist, IHRMP, UC Berkeley
1:45pm	Travel to YST study plot across from H1 Pasture
1:55pm	Starthistle Management Trial - Mike Connor
2:10pm	Annual Clover Seedings for YST Management - Fred Thomas, Cerus Consulting, Richvale
2:20pm	Perennial Grass Seedings for YST Management - Roger Ingram
2:30pm	Agents for Biocontrol of YST - Baldo Villegas, Calif. Dept. of Food and Ag., Sacramento
2:45pm	Walk to bottom of H-2 pasture
2:50pm	Weed Management in Irrigated Pasture - Glenn Nader. Livestock & Nat. Resources Advisor, UCCE Sutter/Yuba Co.
3:15pm	End of program

TABLE OF CONTENTS

Weeds Are Not A Problem!!!

Roger Ingram
UCCE Farm Advisor, Placer-Nevada Counties

We possess the technology to eradicate weeds. We have various tools at out disposal:

- Disking
- Mowing
- Spraying
- Burning
- Seed Bank Management
- Seeding
- Biological Control

Judicious use of these tools can be an effective approach in changing a landscape of weeds to productive rangeland , irrigated pasture, or any other desired landscape.

Is This Where We Need To Spend Our Time?
Right now as this article is being written in late March, we are in a drought. Little rain in February and March has resulted in most places being short of feed. Not only is the current feed supply lacking, there is little opportunity to build a feed bank to get through the six month dry season. Do you need to be worrying about weeds or do you need to be implementing strategies to deal with the drought?

If you do a economic analysis of the enterprises on your ranch and find you are losing over $250,000 a year predominately do to overhead expenses with regards to labor, do you need to be worried about weeds? One ranch that participated in a Back In The Black economic analysis training was facing just this kind of scenario. The point is to use your time to produce the results needed to deal with issues and problems that are priorities in your operation.

We Want To Deal With Weeds
If you get to the point where your priority is to deal with weeds, resist the temptation to reach for the remedy toolbox. In order to determine the proper tool we need to ask a fundamental question - **"What are the reasons this weed is thriving and other plants are not?"** Too often, we choose a quick fix approach which treats symptoms rather than underlying causes. An example might help illustrate what I am talking about. Let's say somebody was rhythmically pounding a hammer on the side of your head every second. Someone comes along and offers some aspirin which you immediately swallow. For a short period of time, the pain from the headache lessens. Unfortunately, since your head is still getting pounded by the hammer, the headache soon returns. Until you decide to deal with the hammer, nothing will change.

Deal With The Hammer
I want challenge you to deal with the hammer. Find the underlying reason(s) the weed is there in the first place. In order to deal with the hammer, we need to understand some basic ecological processes.

Energy Flow
Plant grow by capturing sunlight energy. The leaves of grass plants are like solar panels. Solar energy capture allow photosynthesis to take place. Photosynthesis produces food for the plant.

Plants grow in the form of a **S-shaped curve**. If all the leaves are removed, regrowth starts slowly. This is called **Phase I**. The growth that exists is highly nutritious, but there is little quantity.

Once enough leaf forms to capture sunlight energy, grow becomes as rapid as environmental conditions allow. **This is called Phase II**. Growth is both nutritious and plentiful.

If we do not graze the plant gets so big it cannot support itself. **This is called Phase III**. The outside leaves of the plant get so tall that is shades out the centers. The plant starts to die from the center outward. Growth is plentiful, but low in protein. A process called lignification occurs which increases the amount of fiber.

If we graze into Phase I, energy has to be mobilized from roots to produce enough top growth. There are two costs to this process - recovery from grazing is longer and root dieback occurs. If we continue a management strategy that continually grazes into Phase I, eventually there is no root structure to support plant. The plant dies and bare ground occurs - providing an excellent environment for weed encroachment.

Energy Flow Strategy
Keep plants in Phase II
Maintain as close to 100 % ground cover as possible.

Water Cycle
Most of us know or can find out the amount of total rain that falls on our property. Few of us know how much of that rain is captured on our property. When water falls, several things can happen:

- Runs off
- Evaporates
- Soaks in and is absorbed by the roots
- Soaks in and enters the ground water table

The goal is to try and capture as much rain as possible on our land. If we have bare ground, raindrops hit the soil with so much force that a hard crust forms. This crust can be so hard that little rain is absorbed.

If plants are present, the leaves and litter intercept the falling raindrops reducing the force of impact. A hard crust does not form. More water soaks in for use by our plants. If there are some bare spaces, litter can form dams to help slow water movement and increase the amount that soak into the soil.

A high root volume and organic matter content helps the soil's infiltration rate and water holding capacity. If we graze into Phase I repeatedly, we will markedly reduce root volume and organic matter content of the soil.

Water Cycle Strategy

- **Keep plants in Phase II**
- **Maintain as close to 100 % ground cover as possible.**
- **Keep the top six inches of the soil surface loose and friable**
- **Maintain a high volume of roots and organic matter content in the soil**

Nutrient Cycle

We tend to think of the soil as to what we see on the surface. In reality, the soil is a reservoir of a tremendous amount of life in the forms of protozoa, bacteria, worms, and many other organisms. If we have a lot of activity taking place in the soil, we have rapid cycling of decaying litter and manure. This provides nutrients and organic matter. High amounts of organic matter feed soil organisms, keep the soil surface loose and friable, and creates plenty of pore space to soak up water.

One key ingredient of organic matter is having a high population of roots. If we graze in such a way that encourages root dieback, we will have less organic matter for our soil organisms - reducing their population. We end up with reduced rates of cycling and hard soil surfaces.

Nutrient Cycle Strategy

- **Maintain a high population of roots and organic matter by keeping plants in Phase II**
- **Maintain as close to 100 % ground cover as possible**
- **Keep the top six inches of the soil surface loose and friable**
- **Maintain a high population of soil organisms**

Footprints

If our long term strategy is to keep forage plants productive, then we need to pay attention to energy flow, the water cycle, and the nutrient cycle. **The only way to do that is to walk in your fields and look down.** Evaluate whether energy is being captured, would water soak in or run off, is the soil surface hard or friable, is litter and manure being cycled rapidly into the ground?

Animal Impact
One of the most effective tools we have comes from the use concentrated action of animal hooves for a short period of time. Their hooves act as a plow helping p break the hard crust of the soil surface. If you have ever seen the movie "Dances With Wolves", you have seen animal impact. There is a scene where dawn is breaking and reveal a wide swath where buffalo had been stampeding the night previous. This swath looked like the land had been plowed.

Animal impact can be achieved by picking out an area of weeds or bare soil and feeding a few flakes of hay or salt the last day of the graze period while there is still soil moisture. The action of the animals pushing each other out of the way tramples the weeds and breaks the hard soil surface.

Animal impact can also be achieved through the use of multi-species grazing. Different species consume different parts of plants and different species of plants. One effective tool at our disposal are goats. They can impact a wide variety of plants consuming woody plants, shrubs, forbs, and grasses. Goats can dramatically change an unproductive landscape to one that is highly productive.

Final Thoughts

We have a broad rang of tools at our disposal. Each of them can be effective if used properly. Resisting the urge for the quick fix and searching for ecological clues help us to understand the true nature of the problem. Armed with this knowledge, we can effectively choose the tool or tools which will give us long-term results.

More Information

Here are some useful references for more detailed information:

Pratt, David, *Pasture Ecology*, Livestock and Range Report No. 941, Summer 1994. David can be reached at 707-421-6790.

Pratt, David, *Principles of Controlled Grazing*, Livestock and Range Report No. 932, Spring 1993.

Peischel, An, *Goats - Enhancing Land Productivity*. An can be reached at 916-679-1420.

Important Ecological Characteristics of Yellow Star-thistle

John Gerlach, Ecology Graduate Group
University of California, Davis

Yellow star-thistle *(Centaurea solstitialis)* is one of the most important introduced plants in California because it has dramatically expanded its range, has been shown to significantly reduce the quality of range forage, and is expected to have an enormous impact on native species. Its incredible rate of range expansion appears to be driven by changes in seed dispersal processes and by changes in vegetation and soil disturbance patterns.

Yellow star-thistle was most likely brought to California from Chile in 1850 as a contaminant of alfalfa seed and was first introduced at Benecia, Davis, Marysville, Sacramento, and the Sonoma valley. It quickly spread to many other locations in California and in the United States through the transportation of contaminated alfalfa seed and hay. Later introductions into California may have occurred through contaminated alfalfa seed imported from Argentina, Chile, France, Italy, and possibly Turkestan. During the first half of the 1900's the intensification of farming on the valley floor, the improvement of seed cleaning techniques, and the development of effective herbicides eliminated yellow star-thistle from most agricultural fields and temporarily limited the area of the infestation. However, the distribution of the yellow star-thistle changed. It was pushed to field margins and to the borders of the large cattle ranches that were established in the foothills after the open ranges on the valley floor were closed after 1866.

Since 1960, the area of infestation has grown at an explosive rate as the yellow star-thistle has invaded grassland and foothill woodland ecosystems. This period coincides with a period of extensive road building and suburban development, activities that move yellow star-thistle seed large distances and establish new populations. Those widely scattered satellite populations produce enormous quantities of seed which either simply fall to the ground or are spread into adjacent grassland and woodland through human activities such as hiking, hunting, horseback riding, and ranching. Yellow star-thistle seed is also moved by wild animals such as deer. These two processes, the establishment of new satellite populations through long distance seed dispersal and the subsequent invasion of the surrounding vegetation, generate the explosive rate of range expansion.

The persistence of satellite populations and their ability to invade relatively undisturbed California annual type grassland are determined by ecosystem properties and by the biology of yellow star-thistle. For example, unlike the seedlings of purple needlegrass, yellow star-thistle seedlings can survive in the low light environments that exist under the canopies of annual grasses. They persist in these low light conditions by being developmentally flexible. When immature yellow star-thistle plants grow in full sun they form 2 inch high rosettes and hold their leaves horizontal to the surface of the soil. When they grow in the dense shade of tall annual grasses they abandon their compact rosette form and increase their height to about 10 inches by greatly increasing the length of the stem between leaves and by holding their leaves vertically. This upright growth form allows them to obtain much more light until they bolt through the canopies of the dead annual grasses in late spring.

The ability of yellow star-thistle seedlings to acquire solar energy and grow abundant root tissue under the canopies of annual grasses also gives them access to the large amounts of stored soil moisture that is not used by most of the exotic annuals. In many years, the dominant annual grasses and forbs complete their life cycles before the last rains of the wet season and the soil remains very moist throughout the summer drought. In essence, the ecosystem properties of climate, soil, and dominant vegetation type interact to cause a significant ecosystem resource to remain available for the taking. Yellow star-thistle is able to use this available soil moisture resource because it is developmentally flexible and has a long life cycle for an annual plant. Adult yellow star-thistle plants are also extremely strong competitors for soil moisture. They develop very extensive root systems and can extract soil moisture from drying soils as intensively as adult blue oak trees.

The biological characteristics that enable yellow star-thistle to invade these ecosystems threaten native species and ecosystem processes. Native species like blue oak and purple needlegrass depend on stored soil moisture for summer growth and survival. Because yellow star-thistle uses deep stores of soil moisture earlier in the summer than either blue oak or purple needlegrass, every year becomes a drought year from the perspective of the native species. Large populations of yellow star-thistle also significantly alter the water cycle of grassland and foothill woodland ecosystems by transferring large amounts of stored soil moisture to the atmosphere through transpiration. Soils in the foothill grassland and oak savanna ecosystem are typically 3 feet deep and can store a maximum of 4 inches of rainfall for each foot of soil depth. Therefore, the equivalent of 12 inches of rainfall can be stored in the soil during the dry season. Because annual grasses are shallow rooted and not very drought tolerant, they usually extract only about 2 inches of stored rainfall. Yellow star-thistle, which is very deep rooted and much more drought tolerant, is able to extract up to 8 inches of stored rainfall for each three feet of soil depth. This means that an additional 6 of rain each year is needed to saturate the soils of these ecosystems.

Yellow Starthistle Management Methods and Status

Joseph M. DiTomaso, Non-Crop Weed Ecologist, University of California, Davis

Introduction and Spread

The center of origin of yellow starthistle (*Centaurea solstitialis* L.) is believed to be Eurasia, where it is native to Balkan-Asia Minor, the Middle East and southcentral Europe (Maddox, 1981). It has been speculated that the introduction of yellow starthistle into California occurred on multiple occasions, but early introductions in the 1850's were probably always associated with seed contamination in alfalfa imported from Chile in South America (Maddox et al., 1985). The first reported collection of yellow starthistle in North America was make in Oakland in 1869. Its subsequent spread was slow until the mid-1900's. By the late 1950's, the weed invaded over 1 million acres of California. Since then, it has spread exponentially to infest rangeland, native grasslands, orchards, vineyards, pastures, roadsides, and wasteland areas. Infestations reached nearly 8 million acres in California by 1985 (Maddox and Mayfield, 1985). Today, it is thought to have spread to over 10 million acres, and can be found in 52 of the 58 counties in California. Yellow starthistle can be found in 23 of the 48 contiguous states, extending as far east as New York. It has also extended into Canada from British Columbia to Ontario.

Control

Several methods have been used to control yellow starthistle (Lanini et al., 1996). These include tillage, mowing, grazing, reseeding, biological control, and chemical treatments. Effective control using any of the available techniques depends upon proper timing.

Many of these methods cannot be used in specific environments. For example, steep hillsides prevent the use of tillage and mowing, and the effectiveness of grazing depends upon proper timing and animal density. Furthermore, mowed, tilled, or foraged plants often regrow and grazing cannot be continued once the spiny inflorescence has appeared. Biological control of yellow starthistle has shown some promise, although establishment of introduced insects has not been rapid and little evidence indicates that weed populations are being reduced in these test sites. Reseeding programs and other cultural techniques (e.g., fertilization strategies) have not been tested to a large extent in California. In many cases, herbicide use is either prohibited or discouraged, particularly when the management objective is to enhance native broadleaf plant diversity. In addition, there are a number of potential environmental hazards associated with herbicide use, and many of these compounds may damage desirable forage species (e.g. clovers).

Mechanical removal

Hand pulling, *hoeing*, or *weedeaters* are still effective methods of controlling early infestations or occasional skips using other control strategies. They can eliminate the production of new seed which will quickly lead to larger populations

Tillage can control yellow starthistle. However, it will expose the soil for rapid reinfestation if subsequent rainfall occurs. Under these conditions, repeated cultivation is necessary (Lanini et al., 1996). During the dry summer months, tillage practices designed to detach roots from shoots prior to seed production are very effective. For this reason, the weed is rarely a problem in agricultural crops.

Mowing offers an economical and environmentally safe option for yellow starthistle control. In many situations, mowing can serve as an alternative to herbicides, while providing selective control since most of the desired vegetation will have already senesced. However, effective use of mowing on yellow starthistle control depends upon proper timing and growth form. Early work by Thomsen et al. (1994) demonstrated that repeated cutting at the early flowering stage could provide significant, but not complete, control of yellow starthistle. In contrast, mowing during the bolting stage increased the infestations. This is the situation which often exists along highways, where mowing is conducted early in the season to prevent roadside grass fires.

We recently examined the phenological development of yellow starthistle flowers, and the effect of mowing height, repeated cuttings, timing of mowing, and growth form on recovery and seed production. Our findings indicate that the ideal mowing period occurs when approximately 2 to 5% of the spiny heads are in flower. Thus, a 1 to 2 week window of opportunity exists for utilizing mowing as a yellow starthistle management strategy. Plants mowed at earlier stages of growth recover quickly, whereas mowing at later stages of flowering allow significant seed production. Additional evidence indicates that changing cutting height at various levels between 2 and 8 inches above the soil surface does not dramatically affect the efficacy of mowing. Most importantly, however, when yellow starthistle plants occur in the absence of competition with grasses, individual plants are large and rounded in outline, with numerous stems branching from near the base of the plant. Regardless of the stage of development or the number of repeated cuttings, mowing was ineffective in controlling these plants. By comparison, in competition with grasses or in areas with less fertile soil conditions, nearly all individual starthistle plants were more erect with little basal branching. Under these conditions, a single mow at the early flowering stage was observed to be very effective for the control of yellow starthistle. Thus, the successful application of mowing as a yellow starthistle control strategy depends upon both proper timing and an understanding of the physical form of the plants.

Cultural Control

Intensive *grazing* by sheep, goats or cattle prior to the spiny stage but after bolting can reduce biomass and seed production (Thomsen et al., 1993, 1996). To be effective, large numbers of animals must be used for short durations. Grazing is best between May and June, but depends on the location. Yellow starthistle can be a good forage species.

Revegetation with seeding-adapted annual legumes provides some level of control in pastures (Thomsen et al., 1996). Subterranean clover (*Trifolium subterraneum*) proved to be the best of 66 legumes tested. This effect was enhanced when revegetation was combined with repeated mowing.

A sustainable weed management program in rangeland is predicated on establishing desirable competitive plant species that will effectively prevent the rapid reestablishment of yellow starthistle. These species must fill the niche that was occupied by yellow starthistle. In the absence of appropriate desirable species, it is likely that other inferior range species, such as downy brome or medusahead will replace yellow starthistle and expand their populations.

Prescribed Burning

Under certain conditions, burning can provide effective control and enhance the survival of native forbs and perennial grasses (Hastings and DiTomaso, 1996). However, to be effective, yellow starthistle must be burned before it produces viable seed but after seed dispersal and senescence of desired annuals. Dried vegetation, particularly grasses, can serve as fuel for the burn.

In our study, we showed that a single burn had little effect on the vegetative cover of yellow starthistle. However, we demonstrated that three consecutive years of burning reduced yellow starthistle infestation by 91% in grassland areas. This corresponded to a 99.5% reduction in the fall seedbank (Hastings and DiTomaso, 1996). Of equal interest, a single year of burning resulted in a 3-fold increase in native forbs. Furthermore, three years of controlled burning increased the cover of the native perennial grass purple needlegrass (*Nassella pulchra*) by 800%.

Herbicide treatment

A number of non-selective *preemergence herbicides* will control yellow starthistle, including simazine, diuron, atrazine, sulfometuron, chlorsulfuron, bromacil, tebuthiuron, oxyfluorfen and prometone (Elmore, 1994). All these compounds are registered for use on either right-of-ways or industrial sites, but few can be used in rangeland or natural ecosystems. Chlorsulfuron is the only currently available selective compound effective for the control of yellow starthistle in non-crop areas. In rangeland, no preemergence herbicides provide selective control of yellow starthistle without injuring desirable grasses. Chlorsulfuron does not have postemergence activity and therefore, must be used in combination with either 2,4-D, dicamba, or triclopyr to provide some level of yellow starthistle control in grasslands.

A major problem for the control of yellow starthistle with *postemergence herbicides* has been its ability to germinate continuously throughout the winter and spring and into the summer when moisture is available. As a result, the most effective chemical strategy for yellow starthistle control is repeated applications of 2,4-D, dicamba, or triclopyr. One late application, at the end of the rainy season, is not sufficient as many plants are too large and escape injury. Thus, our current situation for chemical control of yellow starthistle is not ideal and often results in failure. All these growth regulator herbicides are selective on only broadleaf species and can be used in late winter or early spring to control seedlings without harming grasses. Once plants have reached the bolting stage, most effective control can be achieved with glyphosate. The best time to treat with glyphosate is after annual grasses or forbs have senesced but prior to yellow starthistle seed production. Glyphosate is also an important tool in a follow-up control strategy to prevent yellow starthistle escapes from producing seed. Our studies have shown that glyphosate provides excellent control of yellow starthistle at all stages of development, even when plants are in the early flowering stage (DiTomaso and Kyser, 1996).

Clopyralid is a growth regulator herbicide recently submitted to California EPA for registration in non-crop areas, including pastures and rangeland. It has been demonstrated to be very effective for the control of yellow starthistle, as well as other invasive composites (Whitson et al., 1987), but does not injure grasses. In our trials, we have shown complete control of yellow starthistle at rates as low as 1 oz ae/A (March application). The increased efficacy of clopyralid can be partially attributed to its postemergence and preemergence activity, as well as its increased sensitivity on composite species. Most legume species have also been shown to be quite sensitive to clopyralid. In contrast, many other broadleaf species, including crucifers and filarees, appear to be relatively tolerant to the herbicide.

Combinations

Many combination of techniques may prove to be more effective that a single method. For example, prescribed burning followed by spot application of postemergence herbicides can prevent small skips from rapidly re-infesting an area. Similarly, combining mowing and grazing, revegetation and mowing (Thomsen et al., 1996), or herbicides and biological control may provide better control than any one of these strategies used alone. Effective combinations may depend on the particular location, or the objectives and restrictions imposed on land managers.

Conclusion

To achieve effective long-term control of yellow starthistle, whether it be by chemicals or other means, several factors must be considered. First, initial control efforts should focus on small patches. Like wildfires, small infestations quickly spread to form larger problems. Spot eradication is the least expensive and most effective method of preventing establishment of yellow starthistle. Once these have been controlled, emphasis can shift to the larger infestations. Second, control efforts should include follow-up treatments when necessary. For example, many plants may escape control because of the cover provided by old yellow starthistle stems (Lass et al., 1993) or poor treatment coverage. These skips need to be controlled prior to flowering to prevent reseeding of the infested area. Finally, any effective effort to manage yellow starthistle will require a multi-year control program. Three years of consistent control, without subsequent reseeding, should provide better than 90% control of yellow starthistle. Even after effective management has been achieved a follow-up program should be initiated which would include site restoration to prevent rapid reestablishment.

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The Future of Yellow Starthistle Biocontrol

Joe Balciunas, USDA Agriculture Research Service
Albany, California

Many land owners want the same success with starthistle that occurred with the insect that controlled Klamath weed. Presently, there have been five seed head feeding insects released. Given that starthistle is estimated to produce 50 to 200 million seeds per acre and its populations have expanded in California for than 100 years, it may not be realistic to expect biocontrol agents that have only been released during the past five years to provide satisfactory control. It may take a long time for these agents to get a foot hold and catch up to large populations of starthistle. I spent a month surveying for other starthistle control agents in its native home of Turkey. Starthistle there is limited in size and number and is hard to locate. An organism called apions looks promising since it feeds on other parts of the plant than the seed head. The larvae burrow in the root crowns and later in the stems. This organism could provide a cumulative impact on starthistle, since it could damage the plant and limit the number of seed heads formed. The five seed head feeding insects could then more effectively control the reduced amount of seed heads that are left by the apions. We have petitioned to bring this pest here for screening to make sure it feeds only on starthistle. Biocontrol of starthistle should be considered a long term solution. This method may provide the only answer to starthistle control on rangelands where the costs of herbicides may be too expensive.

Population Dynamics in California Annual Grasslands Seedbeds

James A. Young, Range Scientist
USDA, Agricultural Research Service, 920 Valley Road, Reno, NV.

With considerable trepidation, I looked at the proposed title for my presentation, "What Takes Its Place When Yellow Star Thistle Is Removed". My truthful answer is, "I do not know." This was reinforced by the rest of the program. Yellow star thistle plant physiology from a cutting-edge-of-science graduate student. Seed bank, herbicide, and fire management from a noted state weed specialist. The two obvious successional choices of annual legumes or perennial grasses were to be covered by other speakers. Dr. R. Merton Love always partially justified his advocacy of Harding grass on the basis that it suppresses summer growth of yellow star thistle, but obviously this aspect was already covered.

My role as resident fossil among range scientists suggests I might be able to offer somewhat of an historical perspective on yellow star thistle on foothill ranges. I was not working here when the station was established, but I had active research projects on the station during its modern expansion in the late 1960s. Yellow star thistle has been well established in California for years. Perhaps, one of the first collections was near Grand Island, Colusa County in 1879. Other *Centaurea* species (e.g. *C. melitenis*) have been documented as established in California during the Spanish colonial period. We conducted extensive experimentation in seedbed micro environmental measurements and population dynamics. Obviously, we should have learned a lot about yellow star thistle seed and seedbed ecology during these studies. We did not, because yellow star was a very minor species on the station during that period. The great expansion in distribution and dominance of yellow star thistle occurred after the 1960s.

The basic physical and biological parameters of annual grassland seedbeds remains the same with or without yellow star thistle. Species composition is largely controlled by the amount and distribution of litter. Annual grasses are favored by litter coverage, and filaree and clover species are among those species favored by open seedbeds. Species adapted to bare seedbeds often have some mechanism for self burial. This is most highly developed in filaree, where the fruit is buried through the action of the hygroscopic, spirally wound, geniculate remnant style. Most grass caryopses have difficulty taking up moisture from the germination substrate faster than they lose it to the atmosphere, without some coverage such as litter. Medusahead is adapted to germinate within litter accumulations without the callus portion of the caryopses touching the soil.

The most striking aspect of annual grassland seedbed dynamics is the sudden onset of germination after the first biologically effective rain in the fall. The process is regulated by a delicate balance between sufficient moisture in relation to temperature. Early in the season it requires a relatively big moisture event to initiate germination. The amount of moisture necessary to initiate germination declines as the temperature declines and therefore, a drop in rate of evaporation. The startling rapidity of germination and activation of soil micro organisms has always been fascinating. A bank of several thousand viable seeds per square foot is converted to seedlings, or rendered non viable within a few days. Litter and standing dry herbage disappear within a month, especially with grazing animals present. Survival in this micro jungle comes down to, "You are first to establish or you are gone." Post germination dominance depends on inherent competitiveness for light, nutrients, and moisture, but do not be late to enter this competition or you are out-of-luck.

. In biological systems, there are always exceptions to the general rule. We have just stressed that simultaneous germination is obligatory to compete in this environment. Simultaneous germination with the first moisture event is a high risk commitment. What happens if the first moisture event is wet enough to initiate, but prolonged enough to sustain seedling growth? Many years ago, we published the results of an August moisture event that initiated germination. The loss in seedlings after such an event is somewhat compensated for by the vast over- production in seeds. Beyond this cushion, there are seeds in the annual grasslands that have continuous versus simultaneous germination. The annual legumes are excellent examples of species that build seedbanks and have continuous germination. Hard seed coats, with sequential softening based on position in fruits (burs), insures continual germination.

There is another evolutionary pathway that allows taking advantage of both simultaneous and continuous germination. Some plants are capable of producing morphologically distinct seeds with either simultaneous or continuous germination characteristics. The achenes of yellow star thistle are an example. Plants grown from seeds of either type will produce seeds of both morphologic and physiologic systems. Phenotypic plasticity is a great attribute in weeds.

A new generation of scientists is unraveling the intricacies of yellow star thistle seed and seedbed ecology. When they are finished, they can truly answer the question I was charged with, "What will replace yellow star thistle after it is controlled?"

Weed Control Methods for Oak Plantings

Doug McCreary, Natural Resources Specialist
Integrated Hardwood Range Management Program, UC Berkeley

For a number of years there has been concern that several species of native California oaks are not regenerating well in certain locations around the state. That is, there do not appear to be enough young trees to take the place of mature oaks that naturally die or are cut down. This concern has led to efforts to learn how to artificially regenerate these species on hardwood rangelands. By supplementing natural regeneration with planted acorns or oak seedlings, these woodlands could then be managed on a sustainable long-term basis. Artificially regenerating oaks would also allow resource managers to restore degraded areas where oaks once flourished, but are currently not growing.

One of the main obstacles encountered in attempting to establish oaks artificially is weed competition. Much of the hardwood rangelands in California has a dense understory of introduced Mediterranean annuals. These non-native grasses and forbs were brought to California in the 1700's and have spread widely -- displacing most of the native perennial bunch grasses in most locations. Unfortunately these annuals are vigorous competitors for moisture and nutrients -- especially in the early spring -- and can make it very difficult for oak seedlings to become established. We have done several experiments on weed control around oaks here at the SFREC and have determined that controlling weeds in oak plantings is critical to successful regeneration. Eliminating competing plants around young trees not only frees up valuable resources necessary for survival and growth, it also removes a habitat that is particularly favorable for several animals that can severely damage oak seedlings. For instance, if weeds are allowed to grow, they can quickly produce a dense stand of plants that is an ideal habitat for *Microtus californicus*, commonly called voles or meadow mice. These rodents seem intent on destroying young oaks by stripping the bark from their main stems. While oaks can still sprout from their base even after their shoots are girdled and killed, voles can keep young seedlings suppressed for many years, and eventually kill them.

The dense annual vegetation on hardwood rangelands also provides an ideal habitat for grasshoppers. While the populations of these animals seem to vary greatly from year to year, in years when they are numerous, damage to oak seedlings from grasshoppers can be devastating. Several years of observation indicate that the degree of damage to oak seedlings is directly related to their proximity to dense herbaceous vegetation. Where this vegetation is removed or eliminated, there are far fewer grasshoppers present, and subsequent damage from them is greatly reduced or eliminated entirely. Where the adjacent vegetation is thick and continuous, grasshoppers are extremely abundant, and damage to young oaks is generally severe.

For these reasons, we always try to provide some weed control around new plantings of oaks -- at least for the first two years after establishment. Eliminating weeds can be done in a variety of ways, including physical removal (scalping, mowing or weed-eating); applying herbicides; or suppressing weeds with mulches including organic materials (chips, compost, straw, etc.), or physical barriers such as black plastic or semi-permeable mats that block sunlight but allow water to percolate through. Each of these approaches is discussed below:

Physical weed removal

Several years ago we initiated an experiment to compare four weed-control treatments around young oak seedlings, including weed-free circles with diameters of 2, 4 and 6 feet, and a control with no weed removal. Weed removal was provided by scalping -- using hoes or McClouds to scrape away all surface vegetation, leaving bare soil. Scraping the soil in the early spring not only removed weeds that were currently growing, but greatly reduced the seed bank in the soil. This essentially eliminated competition in the early part of the growing season. Unfortunately, later in the spring numerous weeds returned and a repeat scalping was necessary to keep the areas bare. All treatments resulted in significantly better field performance than the control, and the larger the weed-free circles, the greater the subsequent seedling growth. However, it was extremely difficult and time consuming to scalp a 6-foot diameter circle around each seedling. Scalping also becomes even more difficult in rocky or dry soil. We can therefore not recommend scalping, except when it is done on a small scale, around only a few plants. In our trial, we concluded that of the treatments evaluated, scalping a 4-foot circle was best, when the benefits of the treatment were weighed against the difficulty of providing it.

We have also eliminated weeds around oaks using lawn mowers and weed-eaters. These treatments have their limitations since they only remove the top of the plants and don't kill them. If done early in the growing season, the plants will grow back rapidly. We therefore generally only mow in early or mid-summer, when most annuals have stopped growing and are turning brown. In this condition the plants aren't competing seriously with oak seedlings (except perhaps for light), but they are still providing ideal habitat for voles and grasshoppers. Cutting them back therefore reduces the potential for future animal damage.

Herbicides

Herbicides are chemicals that damage or kill plants. When attempting to eliminate weeds around oaks with chemicals, it is critical that the proper herbicides be used, and the label on the container is followed, so that only the target plants (in this case grasses and forbs) are affected, and the non-target plants (oaks) are not affected. Some chemicals are applied directly to the leaves of the target plants (postemergence herbicides) where they are absorbed, causing the plants to die. Others are soil active, and are applied preemergence, where they are taken up by plant roots. These herbicides are more effective on seedlings than on more mature, deep-rooted plants. In most of the oak trials we have been involved with, we have used Roundup (glyphosate) to eliminate weeds. This is a broad-spectrum postemergence herbicide that affects a wide range of plants. We spray it around planting spots in the early spring, after most of the weed seeds have germinated. If the oaks have leafed out, or shoots from newly germinating acorns have emerged from the soil, it is important not to spray them, since they can be seriously damaged by the herbicide. We have sprayed directly over the tops of dormant deciduous oaks (with no leaves) in the late winter, but have even sustained some damage to seedlings if their buds were quite swollen. Therefore when we apply Roundup around oaks, we generally cover or protect the seedlings, or directionally spray the chemicals away from them.

A problem with Roundup is the fact that if the chemical is applied in the early spring (which is generally necessary to get rid of the weeds before they deplete the soil moisture), it does not completely kill all of the competing plants such as starthistle, mustard or turkey mullen which germinate late in the season. Consequently, in the late spring and early summer, these plants often create a new batch of competitive weeds that need to be removed by one of the methods described herein. It should be noted that the application of postemergence herbicides around young seedlings is much easier if the plants are protected with treeshelters, since these devices effectively protect the plants from drifting sprays. Finally, herbicides are generally the easiest and cheapest method of weed control, but require great care in their application.

Mulches

As indicated above, there are a variety of organic and inorganic materials that can be used as mulches around young oaks. All of these materials tend to suppress weeds by physically covering them, eliminating the light necessary for photosynthesis and growth. They also tend to conserve soil moisture by reducing evaporation from the soil surface, resulting in more available moisture for the oak seedlings. Ted Adams Jr., a Wildland Specialist at UC Davis, compared two types of black plastic mulches in a study at SFREC and found that both significantly improved the field performance of planted oaks compared to unmulched controls. Interestingly, porous plastic mats did not promote any better survival or growth than black plastic sheeting. However, a problem with the plastic sheeting was that it provided protection for rodents, resulting in increased damage from voles. Another problem with all mulches is that they don't last forever. Plastics tend to become brittle and photo-degrade, while organic materials gradually decompose. Occasionally, weeds will also grow up through holes in the plastic, or through shallow places in the organic mulch. For maximum benefit, these weeds should be regularly removed.

Conclusions

This discussion indicates that there are a variety of approaches that can successfully be used to address the problem of weed competition around planted oak seedlings. While we strongly recommend that some type of weed control be incorporated into an oak planting program -- especially during the first two years -- the actual procedure or technique chosen may depend on a host of variables including soil, topography, equipment or materials available, oak species planted (deciduous or evergreen), and even one's philosophical orientation. For instance, some individuals prefer not to use herbicides of any sort, even if they are cheap and easy to apply, because of concerns about health and/or environmental contamination. Whichever method is chosen, weed control will greatly improve the chances for the success of oak plantings by both reducing competition and eliminating habitat for damaging animals.

Starthistle Management Trial

Glenn Nader, UCCE Sutter/Yuba/Butte Livestock Advisor
Mike Connor, Superintendent, UC Sierra Foothill REC

Successfully managing yellow starthistle (YST) requires the understanding of the following concepts:

① Starthistle biology including seed production and viability
② Site competition by other plants after control
③ When to use herbicides

Several effective methods of starthistle management have been reported in research or field applications. Observations at the Sierra Foothill REC by Fred Thomas and in Sikiyou county by Dan Drake suggest that rose clover seeding can effectively decrease starthistle stands. Glenn Nader noticed that landowners that seeded high rates of perennial ryegrass had decreased starthistle. Annual ryegrass seeded in the fall or winter has often been successful in crowding out YST at SFREC. Many land owners have reported failure of 2,4-D to control starthistle, but at SFREC 2,4-D has provided good control in some cases. Timing of the application seems to be critical. It is thought that starthistle in the late rosette stage is less susceptible to 2,4-D. A new herbicide (Transline) will be available this fall that at higher rates could control starthistle for two years. It also has a larger window of successful application dates than 2,4-D.

Based on the fact that starthistle seedling germination responds to sunlight, it was postulated that a fall cultivation could increase the germinations that would be susceptible to 2,4-D or Transline control. With the Transline potentially providing two years' control, a large amount of the starthistle seed resources could be exhausted.

A yellow starthistle management trial was established to quantify the ability of different practical methods to control starthistle. The plots were established on November 1, 1996 and fenced off from grazing. The plot area had a relatively uniform, moderately dense YST stand based on plant skeletons left over from the winter-spring of 1995-96. Spring and fall grazing was moderate, leaving about 900 pounds per acre of residual dry matter.

The treatments were organized in a randomized block design with four replications. They are as follows:

- 2,4-D late
- 2,4-D early
- Annual ryegrass harrowed in
- Annual ryegrass following discing
- Hykon rose clover harrowed in
- Hykon rose clover following discing
- Transline
- Transline following discing
- Control (no treatment)

Transline (2 oz /ac) and 2,4-D (2 lbs/ac) were applied on March 13, 1997. The later application of 2,4-D (2 lbs/ac) was applied April 9, 1997. All seeding was done on November 1, 1996. Clover plantings were fertilized with 300 pounds per acre of 18-0-46-18S.

The plots will be compared for the number of starthistle plants present on April 15th and the data will be provided during the afternoon session. The project will continue by determining plant composition and seedling counts later this year, and for at least one more year, to determine the long-term results of these treatments. Grazing will be allowed after plant counts in the spring.

Annual Clover Seedings For Yellow Star Thistle Management

Fred Thomas
CERUS Consulting

Introduction

The planting and managing of annual legumes as a tool in the control of rangeland weeds has been recognized and recommended by the University of California for over 40 years. The 1965 publication, *Improvement of Medusahead-Infested Rangeland,* states that the "best results in controlling medusahead by plant competition have been obtained by the establishment of annual legumes." Recent use of annual legumes as a biocontrol method in weed management strategies continues to be developed.

Advantages of Annual Legumes as Biocontrol Tools

The following advantages of annual legumes highlight their attractiveness when included with other management tools.

Forage: For the livestock producer there is no greater advantage than having high protein feed in place of the Yellow Star Thistle. Many long term studies throughout the state and at Sierra Field Station of the above species have shown a doubling or tripling of livestock gains compared to unimproved rangeland.

Long Term Control: The use of high hard seeded varieties such as Rose Clover, *Trifolium hirtum,* in acidic gravelly loam or California Burr Clover, *Medicago polymorpha,* in basic clay loam soils, will provide long term competitive suppression of other annual weeds.

Regulations/Litigation: In comparison to chemical methods of vegetation management there is a much smaller risk of legal or governmental problems associated with their use.

Combats Chemical Resistance: Along with discing, hoeing, or other destruction techniques; plant competition with annual legumes represents another method of reducing weed populations to be used with chemical tools.

Plant Materials

Crimson Clover, *Trifolium incarnatum*. Very vigorous seedling vigor and large leaves cause this plant to be aggressive early and the tall growth habit forms a dense mat. It will naturalize in the cooler coastal corridor, but fades from the environment in the interior valleys. It will tolerate a mowing. Wildlife and livestock eat the flowers and further eliminate its persistence.

Subterranean Clover, *Trifolium subterraneum* L. Subclover is not vigorous as a seedling and requires grazing to cause axillary branching to become suppressive. It will colonize a site if it is mowed or grazed, but does not move off site because of its rhizobial specificity. There are a dozen varieties to choose from for soil pH, rainfall, soil type, maturity, and suppression.

Medics, *Medicago sp.* The best known example is California Burr Clover, but there are many other species and varieties to use. Medics prefer the basic soils, pH 7.0 to 9.0. They also grow better on heavier soil types than light soil. They may be mowed early, but will require a higher mowing than subclover after they have reached 8 inches in height. All are very high hard seeded, drought tolerant and will persist in the environment where they are adapted.

Rose Clover, *Trifolium hirtum*. Rose Clover is the less aggressive and weed smothering of the plant materials. However in its niche of acid, gravelly, rocky soil it will dominate and crowd many weeds. It is environmentally invasive and has extremely high hard seededness. It can be mowed and livestock will graze it when it is dry. It is excellent forage for wildlife and birds.

Sierra Field Station

In the Fall of 1992 an annual legume plot was established as a varietal demonstration of the various clovers that are normally planted on rangeland. This unreplicated plot was a side by side comparison of newer versus older subterranean clovers to observe maturity, height, and persistence. The observations of this plot during the 1992-1993 rainfall season reinforced the long known fact that besides being excellent forage, annual legumes can be effective competitors with unwanted weeds.

The initial purpose of this trial was to observe varietal forage yields and stand persistence of the various clovers. Three important factors allowed us to also observe the genetic potential of these plants to act as weed control agents. First, it was a good rainfall year with an early germination, a wet (warm) winter and good spring rain. Second, the seeding rate was high and the plot was well fertilized with the essential nutrients; nitrogen, phosphorus, and sulfur. Third, the legumes were clipped (grazed) in early March hurting the photosynthetic ability of the weeds and invigorating the prostrate legumes to grow and smother the weeds.

The level of weed suppression was graded on a scale of 1 to 10, with 1 being poor weed suppression and 10 being excellent weed suppression. The following observations on weed suppression were made over the next two years.

Varieties Tested: Observations of Weed Suppression at Sierra Field Station, 1992 - 1994

Variety	Score	Reason
Crimson Clover	0	Rapid Winter growth and height.
Koala Subclover	9	Forms a dense stand after mowing.
Clare Subclover	7	Good Winter growth.
Karridale Subclover	7	Forms a dense stand after mowing.
Junee Subclover	7	Good Winter growth, allows late weeds
Hykon Rose Clover	5	Winter vigor, upright habit allows late weeds.
Mt. Barker Subclover	4	Slow Winter growth allows weeds to establish.
Dalkeith Subclover	4	Early suppression, but stops growing in April.
Nungarin Subclover	2	Sparse growth habit.
Santiago Burr Medic	2	Poorly adapted species to red, acid soils.

Brannan Island State Recreation Area

At Brannan Island State Park, near Rio Vista, eight acres were planted to native perennial shrubs and trees in 1992. The dominant weed was Yellow Star Thistle, *Centaurea solstitialis*, and the soil type was light dune sand. Because of the windy conditions the decision was made to mow and hoe the Star Thistle rather than spray an herbicide and risk accidental drift.

After hearing of the weed suppressiveness of Crimson Clover at Sierra Field Station, the project manager was willing to try an alternative to hoeing as a weed control method. The site was planted to Crimson Clover at 25 lb/acre, October 20, 1994. The clover was fertilized with 16-0-20-15 at 70 lb/acre. The wet season of early 1995 was very beneficial to the clover. The clover was left unmowed until late May. The result was a 90 percent reduction in the Yellow Star Thistle during the Summer of 1995 and an attractive spring bloom.

Management Enhancements

It is best to take a two year approach to controlling Yellow Starthistle. There are several techniques that will greatly enhance the ability of the annual clovers to suppress weeds. Both a Spring fallow or a chemical fallow will assist in reducing the Yellow Star Thistle seed production. The annual clovers must be inoculated with nitrogen fixing *Rhizobium* bacteria. In the Mediterranean climate, it is essential that the clovers be planted prior to the first germinating rain, so the Yellow Star Thistle does not have any growth advantage.

Fertilizing with a starter fertilizer such as 16-20-0 at a moderate rate, especially if it can be placed directly with the legume seed is another advantage. Using a controlled grazing method to graze subclover will make it more suppressive.

On large flats of rangeland with rich loamy soil, it would be possible to wait until the Yellow Star Thistle finally bolt through the clover and then the forage and weeds could be swathed and fed in place.

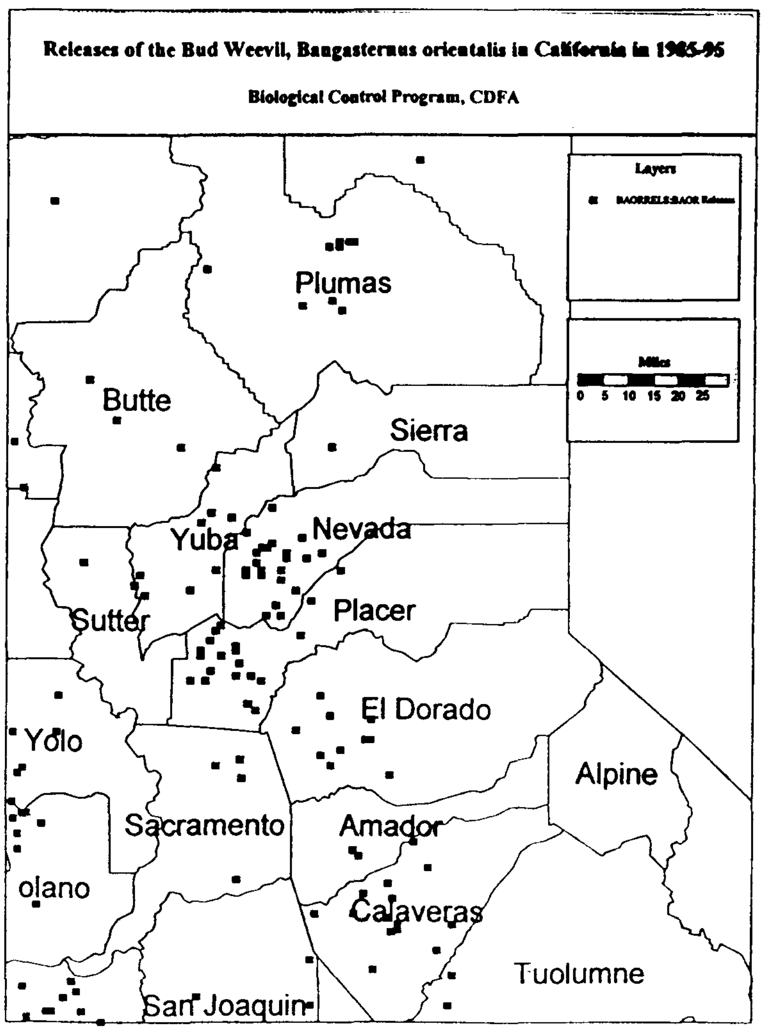
Agents for Biocontrol of Yellow Starthistle

Baldo Villegas, California Dept. of Food and Agriculture, Sacramento

While the USDA conducts the foreign screening of insects that attack star thistle, the California Department of Food and Agriculture (CDFA) coordinates the release sites through the county Ag. Commissioners. Nursery sites are established and once the star thistle pest increases it is redistributed to other areas. A committee of Ag. commissioners decide where the release sites are going to be. The introductions to date have been as follows:

Bud Weevil (Bangasternus orientalis)

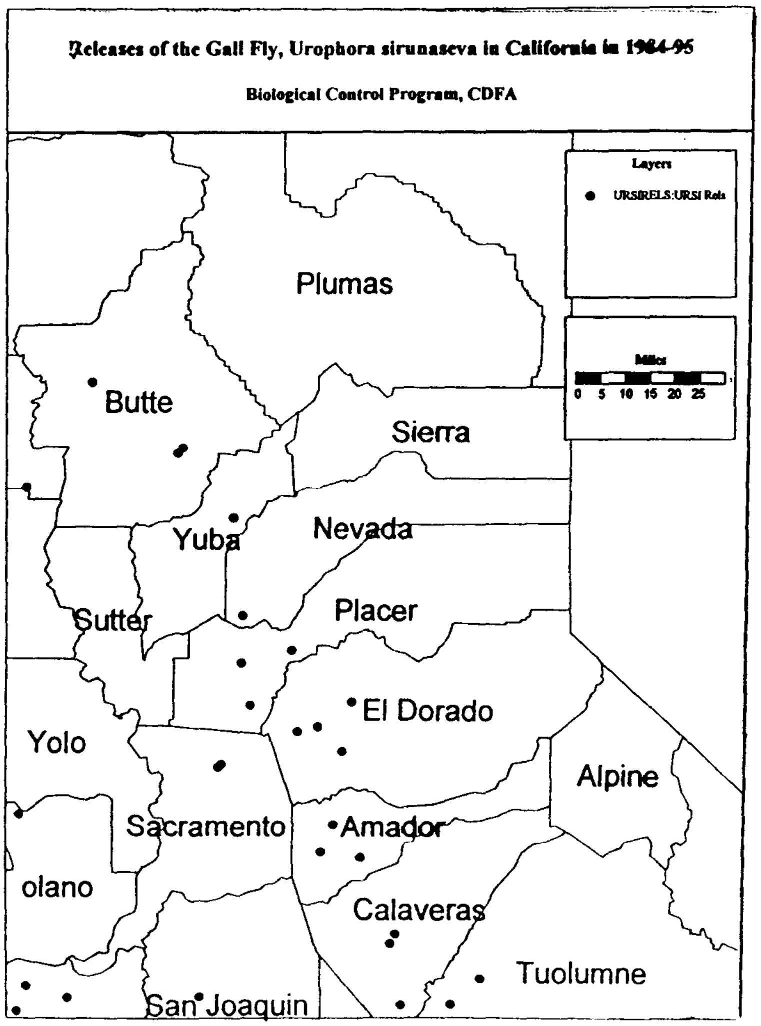
Introduced in 1988, it has the widest distribution of any Starthistle pest. A map of northern California release sites can be seen below.



It has been released in 49 counties and has populated all of the sites. Siskiyou and Placer are the counties with the best collection sites. It lays its eggs on the star thistle bracts and the larvae eat the receptacle. They produce only one generation per season, which limits its ability to catch all the different flowering periods. They also do not destroy all the seed heads on a plant. A private company has been collecting them in Placer County and plans to market them. It is not recommended to purchase these pests, since they have a wide distribution and with time they will increase in number. The only reason to buy them would be to provide a rapid increase in a local population and thus, bypass the time required to get a large population.

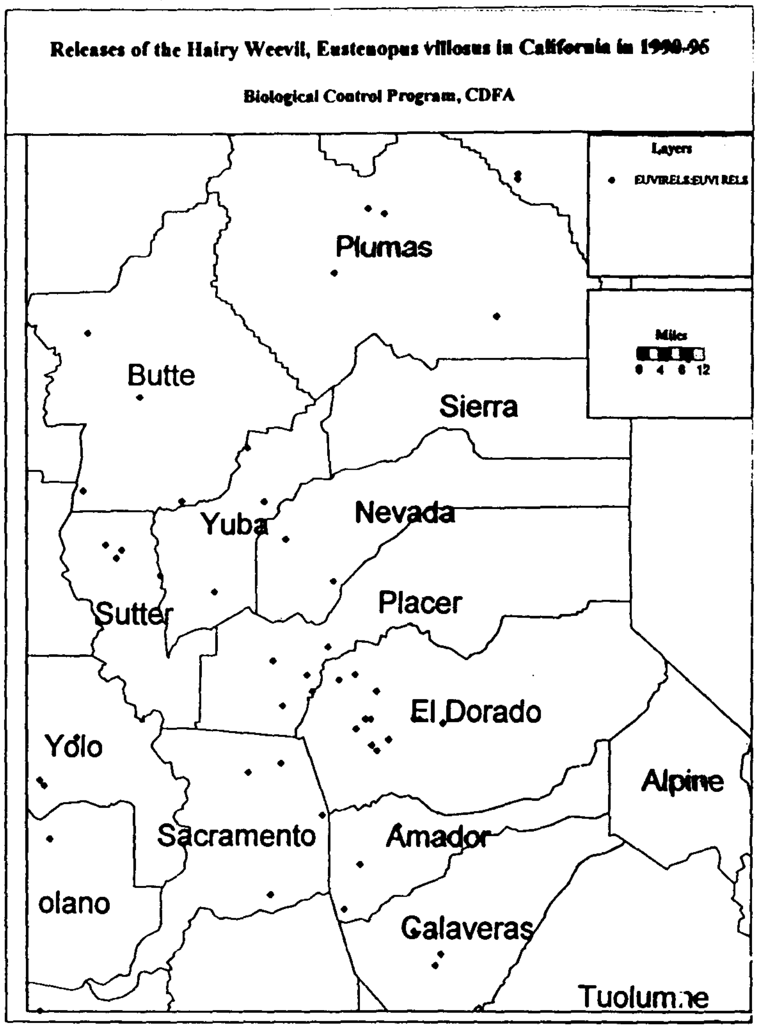
Gall Fly (Urophora sirunaseva)

It was first released in Placer county in 1984. It is now in 40 counties. It is a good flyer and can move up to 16 miles per year. It has increased in population in Siskiyou and Placer counties. It lays it eggs on the seed head, which creates a gall that causes an energy drain on the receptacles and fewer viable star thistle seeds are then produced. Field surveys have indicated that it is having a limited impact on star thistle. Release sites are on the map below.



Hairy Weevil (Eustenopus villosus)

The adults feed on the buds and receptacles. It has one generation per year. It does well in hot dry areas and doesn't do well in foggy areas. There are not many data on its impact on starthistle.



Seed head Weevil (Larinus curtus)

In 1992, 1270 seed head weevils were released in Amador, Placer, Sonoma, Sutter, and Yolo Counties. The larvae feed on the seed head. It is feared that this group may have carried a Nosema infection when brought in from Greece. Due to the potential contamination with this insect disease, no new releases or evaluations have occurred.

Peacock Fly (Cheatorellia australis)

It deposits its eggs on the seed head and when the larvae hatch they bore inside. They produce three generations per year. This is an added advantage to this pest. One problem is that it emerges early (April) before star thistle flowers. CDFA has had seven releases and seven recoveries. They have found them 100 miles away from the Trinity/Humboldt release site. It is no longer believed that the pest requires bachelor buttons as an intermediate host.

Diseases

Aschocyta Fungus: This fungus was isolated in 1993 by Dale Woods, of CDFA, from roots of diseased starthistle seedlings that were in a field plot in Solano county. Experiments are in progress to determine environmental factors affecting infection, growth, and host specificity. Temperature appears to critically impact the ability of the host plant to avoid or recover from infection. Under certain temperature regimes (41 F night and 59 F daytime) this fungus killed nearly 75% of seedlings by 21 days after inoculation. Since this is a native pathogen the permitting process for release should be quicker, as long as it does not impact other plants in the asterasae family.

Summary

As soon as any of these pests are produced commercially, CDFA will step out of distribution and evaluation.

These biocontrol agents all have serious limits to their effectiveness at this time. Reasons for this include their difficulties in adapting to California conditions and their inability to destroy large proportion of the tremendous seed production of yellow starthistle.

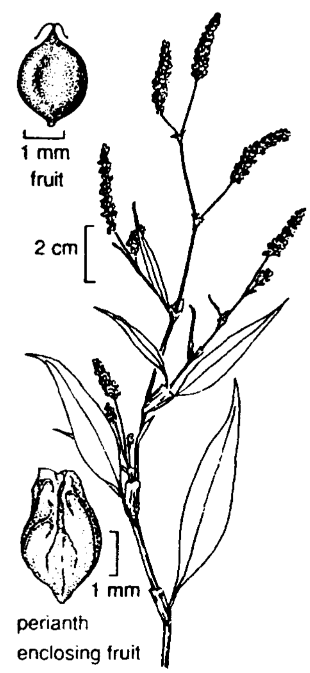
Weed Control in Irrigated Pastures

Glenn Nader Sutter/Yuba/Butte Livestock Advisor

Before discussing weed control it is always helpful to consider why the weed or weeds are there and what management steps can be taken for prevention. Just as some grazing systems enhance certain weeds, other more intensive short duration grazing systems can be used to reduce or prevent weeds. Fertilization can also be used to manage pasture composition. Irrigation management can create conditions that favor weeds. Changing water management to prevent several days of standing water will also prevent water-loving weeds from establishing.

Pale Smartweed (Polygonum lapathifolium)

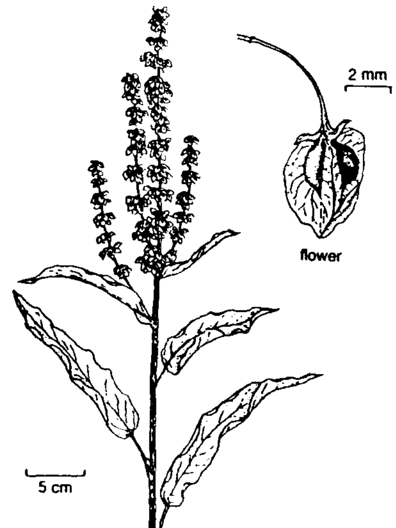
It is an annual plant introduced from Europe. Pale smartweed is best identified by its red stems. It is also known as willow smartweed, smartweed, and wireweed. It grows in irrigation ditches and disturbed (bare ground) sites in the pasture. The best way to prevent smartweed is to have a strong healthy pasture with no bare ground sites for it to establish in. Its seeds are prevalent in most ditch irrigation water. To control, consider spraying with 2,4-D ester in the early spring when the smartweed in just starting to sprout.



Polygonum lapathifolium

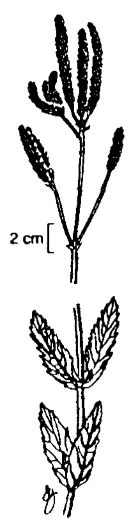
Curly Dock (Rumex crispus)

Curly dock is a perennial that can grow 2 to 5 feet in height. The young seedling is quite variable in color. During the cooler months the leaves turn reddish on the upper surface. Common names for curly dock are yellow dock, sour dock, narrowleaf dock, curlyleaf dock and curled dock. Curly dock has been reported to accumulate oxalates and is suspected to have produced losses of livestock due to poisoning. Use of 2,4-D will control the new seedlings, but generally just burns the plant top and allows resprouting. The best success controlling established dock will occur with 2,4-D use during the rapid growth of the dock plant.



Rumex crispus

Tall Verbain (Verbena bonariensis)



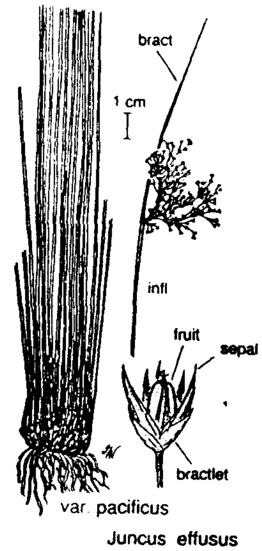
Verbena bonariensis

Tall verbain is native to South America. The mature plant is 2 to 6 feet tall. It is single stemmed at the base and sparsely branched above with purple flowers. Other common names are Argentine vervain, clustered flower vervain, and verbena. The plant has been successfully killed at SFREC by spraying 2,4-D. In order to protect clover plants, and to reduce pesticide use, selective control has been achieved using 2,4-D in wipers. The wiper solution is 50% 2,4-D ester. The wipers come in contact with the tall verbain and single it out for control. Small wipers can be purchased or rented for control of verbain.

Rush (Juncus effecsus variety pacificus and at higher elevations Juncus confusus)

It is a perennial that is unpalatable to livestock. It can rapidly overtake poorly drained areas. It is leafless and grows to 2 to 5 feet in height. Other common names for these plants are bog rush, common rush, and wiregrass.

In Lassen County pastures and meadows 2 lbs of 2,4-D ester/acre controlled Juncus balticus when applied at the time that the buttercups are in bloom. Roundup at the time of flowering will control rushes. Burning in the spring can provide fresh tender growth that is more susceptible to herbicides.



Grazing withdrawals from pastures

Roundup	25 days
2,4-D	7 days
Banvel	No withdrawal for non lactating (Dairy) animals. Animals cannot be sold
for	slaughter for 30 days after treatment.

Remember that 2,4-D and Banvel are both restricted use herbicides that require a permit from the County Agricultural commissioners office.

BIOLOGICAL CONTROL OF YELLOW STARTHISTLE IN CALIFORNIA: Current Status of the Biological Control Agents

by Baldo Villegas
CDFA Biological Control Program
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Five biological control agents have been introduced into California from Greece for the biological control of yellow starthistle (YST), *Centaurea solstitialis* (L.), since 1984 by the USDA-ARS in cooperation with the Biological Control Program and the California County Agricultural Commissioners and Sealers Association (CACASA). The five biocontrol agents consists of three weevils and two flies as follows: The hairy weevil (*Eustenopus villosus*), the bud weevil (*Bangasternus orientalis*), the seedhead weevil (*Larinus curtus*), the gall fly (*Urophora sirunaseva*), and the peacock fly (*Chaetorellia australis*). Except for the seedhead weevil and the peacock fly, these biological control agents are well established and widely distributed in most areas of California infested with yellow starthistle.

Three of the five biological agents have become widespread due to an active distribution program started by the Biological Control Program in 1988. This distribution program is a cooperative effort of the Biological Control Program, USDA-ARS, and the California County Agricultural Commissioners and Sealers Association. Through this distribution program new biological control agents are released at selected research sites in California. The sites are then monitored for establishment and preliminary impact damage on the YST plants. When the biological control agents become well established, some of the research sites are made available to the Biological Control Program to hold training workshops on the biological control agents. These workshops are scheduled in the spring and participants are selected either by need or by the members of the CACASA Biological Control Committee. Counties are then invited to attend workshops are trained on the biology, host damage, host damage recognition, and how to mass collect and release the biocontrol agents. The participating counties are then expected to take back their collections of the bioagents, release them at selected county nursery sites and report back to the BC Program on the status of each of the releases. Eventually each county will have their own nursery sites from which they can collect and distribute the biological control agents to other sites within the county.

Following is a summary of each of the biological control agents that have been released against yellow starthistle in California.

The Hairy Weevil, *Eustenopus villosus* (Boheman)

The hairy weevil, *Eustenopus villosus* (Boheman) (Coleoptera: Curculionidae) was introduced from Greece into California for the biological control of yellow starthistle, *Centaurea solstitialis* L. (Asteraceae). The USDA-ARS in cooperation with the Biological Control Program and the County Agricultural Commissioners, established the first colonies of this weevil in Nevada and El Dorado Counties in 1990 and Napa, Mendocino, and Shasta Counties in 1991. Populations were so well established in El Dorado and Nevada Counties in 1992 that the hairy weevil was made available for limited distribution to Sacramento and Placer Counties. The following year the same sites served as sources of weevils for 12 releases in ten counties. From 1994 through 1996 this state sponsored distribution program rapidly expanded. To date, some 111,172 hairy weevils have been released in 440 separate releases (427 sites) in 48 counties in California through this county distribution program.

Eustenopus villosus has one generation per year in the Sacramento Valley, emerging in mid May, mating and ovipositing in mid June. Eggs are inserted inside closed head buds. Larvae feed on receptacle tissue reducing the number and viability of seeds. Unlike the other yellow starthistle natural enemies, hairy weevil adults also cause extensive damage by direct feeding on young closed buds. This adult feeding damage can be very extensive at release sites three years and older sites to the point of reduced visible bloom on the yellow starthistle stand.

In 1996, five sites were used for holding the county workshops. These sites were located in Sacramento, El Dorado, Placer and two sites in Shasta Counties. From these sites a total of 64,420 hairy weevils were released at 228 different sites located in 37 counties. Of these, some 49,925 weevils were made available to 32 counties during 11 distribution workshops. Four counties, El Dorado, Glenn, Placer and Shasta, made their own in-county releases, totaling 11,195 weevils. Additional releases totaling 300 weevils were made by Biological Control Program staff at one site in conjunction with ongoing research on this agent.

To date, the hairy weevil has become established the 47 where it had been released through 1995. Through 1996 a total of 145 different sites were visited in 47 counties and establishment was noted at various levels in 135 of those sites. The best establishment were noted in Butte, Calaveras, El Dorado, Glenn, Nevada, Placer, San Mateo, Shasta, Trinity, Tulare, and Yolo Counties. This preliminary survey data also indicate that the hairy weevil establishes readily in most areas of California but prefers the hotter interior parts of the State. The weevil appears not to have established well in coastal areas of California that are affected by fog and persistent cool temperatures as well as areas where yellow starthistle persists over a long period of time due to the high water tables.

The Gall Fly, *Urophora sirunaseva* (Hering)

The gall *fly, Urophora sirunaseva* (Hering) (Diptera: Tephritidae) was introduced from Greece into California for the biological control of yellow starthistle, *Centaurea solstitialis* L (Asteraceae). The USDA-ARS, in cooperation with the Biological Control Program and the County Agricultural Commissioners, established the first colonies of the fly in Loomis (Placer County) in 1984-1985, and near Orinda (Contra Costa), Mankas Corner (Napa County), Ukiah (Mendocino County), and Hornbrook (Siskiyou County) in 1990-1991. Populations were well established in Placer County by 1992 and the gall fly was made available for statewide distribution. To date, over 43,000 gall flies have been released in 191 separate releases in 38 counties in California through this county distribution program.

U. sirunaseva has at least two generations per year. In the Sacramento Valley, adult flies emerge from overwintering seedhead galls from mid-April through May while adults of the first generation emerge from late June to mid-July. Oviposition occurs on intermediate, closed head buds. After hatching, the larvae migrate to the receptacle of the yellow starthistle bud. There, gall formation around developing larvae is induced, and there is one fly larva per gall. Up to 12 galls have been found in galled seedheads. Galls induced by the fly larvae are woody with those from the overwintering generation being stronger than those induced by the first generation larvae. Buds infested with the gall flies are believed to produce less seed due to the limited amount of receptacle area for seed production.

In 1996, no formal workshops were held on the gall fly as it appears to be widely distributed in California. A total of 2,210 gall flies were released in conjunction with research releases of *Chaetorellia* seedhead flies. These flies were released at five sites in four counties.

To date, U. *sirunaseva* has become widely established in California due to the efforts of all the counties participating in its distributions. The gall fly appears to have three major distribution areas, centering in around 1) Siskiyou and neighboring counties in northern California, 2) Mendocino County and neighboring coastal areas of northwestern California, and 3) Western slopes of the Sierra Nevada foothills of central California (Nevada County to Yolo then through Calaveras County and into Fresno County).

The Bud Weevil, *Bangasternus orientalis* (Capiomont)

The bud weevil, *Bangasternus orientalis* (Capiomont) (Coleoptera: Curculionidae) was introduced from Greece into California for the biological control of yellow starthistle, *Centaurea solstitialis* L (Asteraceae). The USDA-ARS, in cooperation with the Biological Control Program and the County Agricultural Commissioners, established the first colonies of this weevil near Lincoln (Placer County), Montague (Siskiyou County) and Rumsey (Yolo County) in 1985. Additional releases were made in Loomis (Placer County), Orinda (Contra Costa County), Santa Rosa (Sonoma County), Lotus (El Dorado County), and again at the Rumsey site in Yolo County in 1986-1988. *B. orientalis* appeared to be well established at the Placer and Siskiyou County sites by 1988 when it was made available to the County Agricultural Commissioners for statewide distribution. To date, over 81,000 bud weevils have been released in 428 separate releases in 49 counties in California through this county distribution program.

Bangasternus orientalis has one generation per year. Adult weevils emerge from overwintering sites from mid-April through May and find bolting yellow starthistle plants. After mating, female weevils start laying eggs on terminal leaflets and bases of young flower buds. When the female weevil lays an egg, she covers it with a mucous substance, combined with fecal particles and plant hairs. As the mucous mixture hardens, it forms a characteristic tear-shaped black protective cap. The eggs hatch within two weeks after oviposition and each larva burrows its way into the stem and up into the flower bud. There, the weevil larva feeds on the receptacle tissue as well as directly on the developing seeds. Larval development generally occurs from early May through mid to late July, followed by the pupal stage in late July and August. Adult weevils emerge through a visible hole in top of the seed head. These adult weevils presumably aestivate through the rest of the summer and fall, and overwinter in the duff and debris near the yellow starthistle plants.

In 1996, no formal workshops or county distributions were held on the bud weevil as it has been widely distributed to 49 counties through county distribution workshops from 1988-1995. However, a two releases totaling 400 bud weevils were released in conjunction with educational and research demonstrations at two sites in two separate counties.

The Flower Weevil, *Larinus curtus* (Hochhut)

The flower weevil, *Larinus curtus* (Hochhut) was first released in the Sutter Buttes of Sutter County in July 1992. During 1993-94, additional releases were made in Ione, Amador County; Woodland, Yolo County; Auburn, Placer County; Sugarloaf Ridge State Park, Sonoma County. For a total of 1,270 weevils. During the three years of releases discovery of the protozoan organism, *Nosema* sp., in the gut of some weevils from late collection shipments from Greece halted additional releases of those weevils into additional sites in California.

The flower weevil is native to the Mediterranean areas of Southern Europe and Asia Minor from Italy eastward to the Caspian Sea. It has one generation per year. The eggs are laid in the open flowers of yellow starthistle, and the larvae feed on developing seeds. According to R. Sobhian and L. Fornasari of the USDA-ARS European Biological Control Laboratory, the larvae of this weevil destroy over 96% of developing seeds in infested flowerheads. The weevil overwinters as an adult in ground litter in protected areas and emerges in June through July as yellow starthistle begins to flower.

To date, good establishment of the flower weevil has only taken place at the Sutter Buttes site. It was also recovered in low numbers at the SugarLoaf Ridge State Park site. At the Sutter Buttes site the weevil has spread up to 3 miles from the point of released and in July 1996, it was recovered at the foot of the Sutter Buttes in the Sacramento Valley floor.

The Seedhead Flies, *Chaetorellia australis* Hering and *Chaetorellia succinea* (Costa)

Starting in 1988, the first releases of the peacock fly, *Chaetorellia australis,* were made from Greece into California, Idaho, Oregon, and Washington for biological control of yellow starthistle. In California some 882 peacock flies were released from 1988-1994 at six sites in Contra Costa, Mariposa, Napa, Nevada, Plumas and Shasta Counties by the USDA, ARS, Biological Control of Weeds Laboratory in cooperation with the Biological Control Program and the California Agricultural Commissioners and Sealers Association. In 1993 establishment of the peacock fly was observed in Oregon and Washington, but neither colonization nor establishment was confirmed at any of the California sites.

In 1994, a new colonization effort was started again in California by the USDA, ARS in cooperation with the Biological Control Program, the California Agricultural Commissioners and Sealers Association, and the Oregon Department of Agriculture. Sites containing both cornflower (bachelor button), *Centaurea cyanus* L. (Asteraceae) and yellow starthistle in close proximity were given the highest priority, and second priority were given to sites with early blooming yellow starthistle. A total of 9,463 flies originating from a widely spread area of southern Oregon were released at 22 sites (25 releases) in 18 counties during 1994-1996.

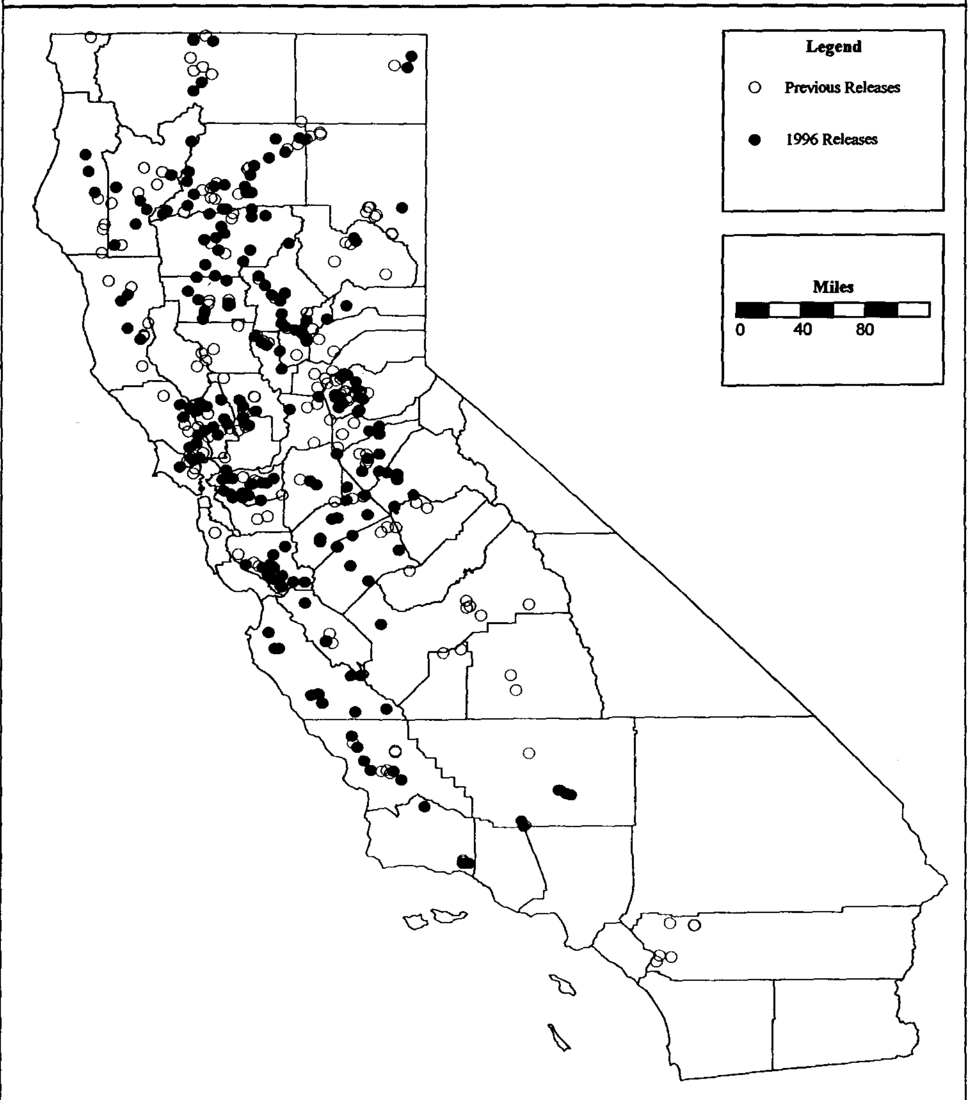
In June 1996 a discovery of a second seedhead fly, *Chaetorellia succinea*, was discovered by the Biological Control

Program in most of the sites where releases had taken place during 1994-1996 and in several areas in northern California where releases never took place. Dr. Joe Balciunas (USDA, ARS Biological Control of Weeds Laboratory, Albany, California) thoroughly reviewed the quarantine shipping records at the USDA, ARS facility in Albany and reported the following probable scenario. In 1991, a contaminated sample of yellow starthistle seedheads was received from Greece and the flies reared from this sample were mistakenly identified as all *C. australis* although voucher specimens kept from this shipment consist of both species. These flies were subsequently released in the Merlin area of southern Oregon approximately 61 miles north of the California state border. It appears that both species of flies were able to colonize and establish on cornflower and yellow starthistle. From there both flies moved on their own into northern California with *C. succinea* being able to move widely from the original release site. *C. australis*, on the other hand, was not found as widespread from the Merlin area as this species seems to be restricted to areas with naturalized infestations of cornflower.

With the discovery of a second species of *Chaetorellia* in California and Oregon, a complete survey of all previous *Chaetorellia* release sites was made during the remainder of 1996. During this survey, adult flies were collected by sweeping flowering yellow starthistle or cornflower plants and, if no flies were collected, seedhead samples were collected for subsequent rearing in the laboratory. Recoveries of *Chaetorellia* flies occurred at all 1994-1996 release sites where flies from southern Oregon were released, but no recoveries were made at any of the sites where releases took place from 1988 through 1991. *C. australis* appears to need cornflower for colonization as it was recovered from sites containing cornflower in close proximity to yellow starthistle (e.g., El Portal, Mariposa County; Yountville, Napa County; Fall River Mills, Shasta County; and Yreka, Siskiyou County). *C. succinea*, on the other hand, does not appear to need cornflower for colonization and establishment as it was reared only from yellow starthistle seedheads at all sites where it was released. Further biological studies are being planned in 1997 to elucidate seasonality, host preference, and impact on yellow starthistle on both species of seedhead flies.

Releases of the Hairy Weevil, Eustenopus villosus in California in 1990-96

Biological Control Program, CDFA



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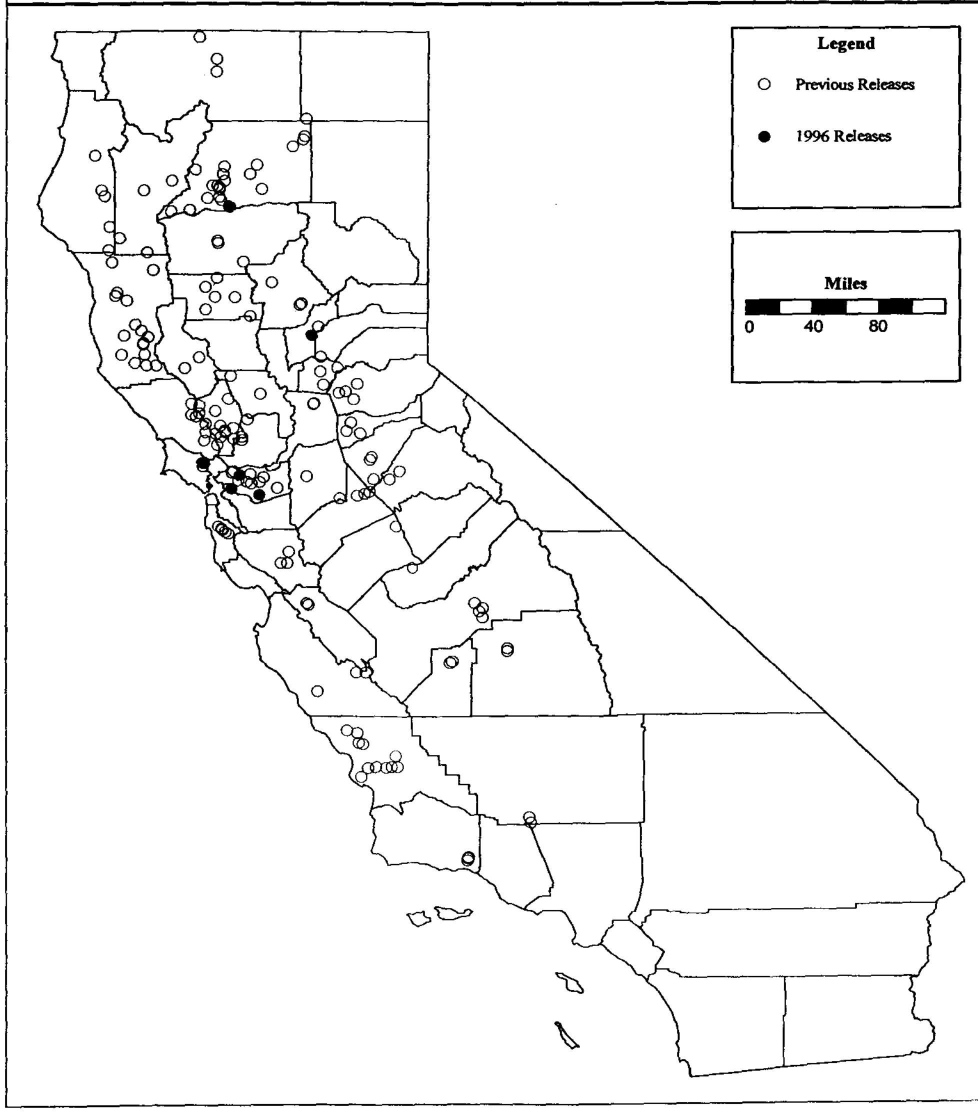
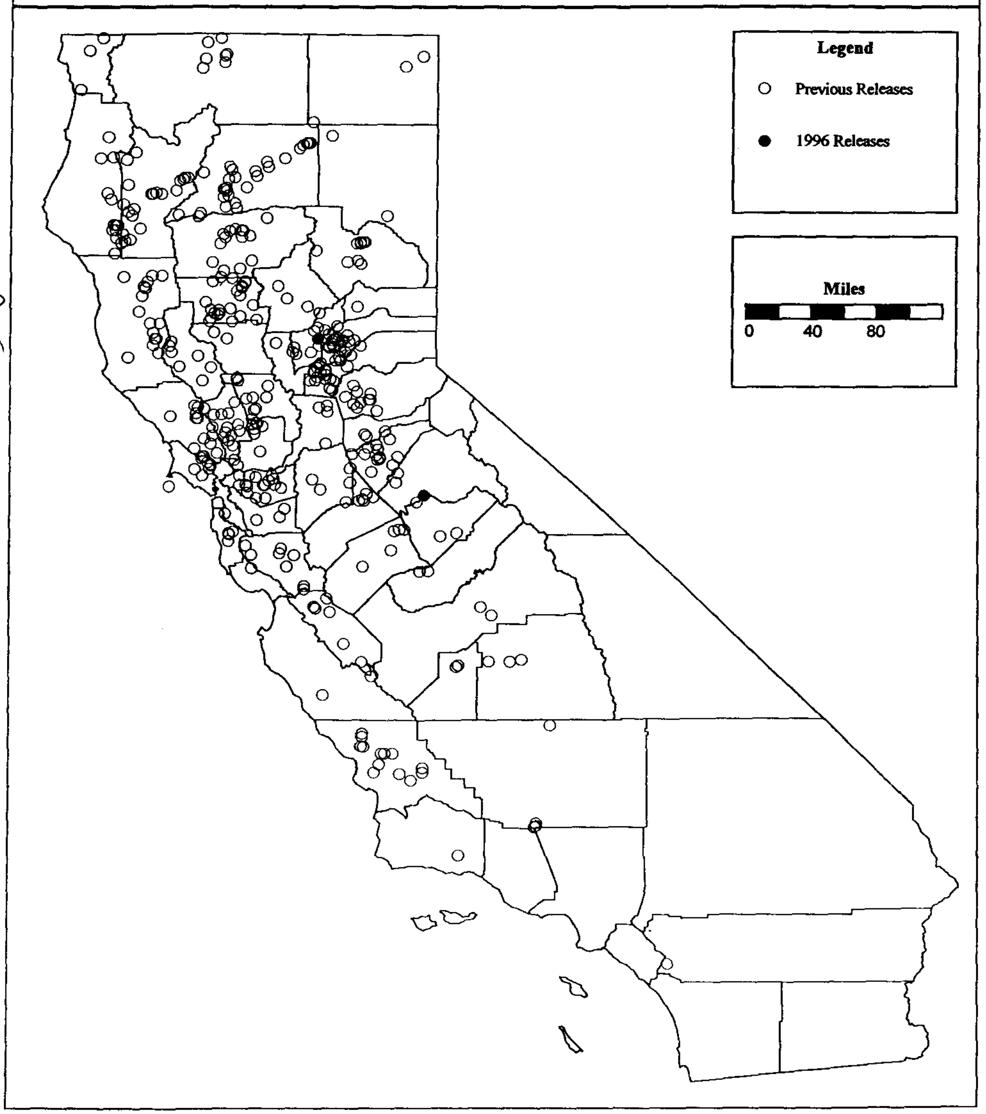
Releases of the Gall Fly, Urophora sirunaseva in California in 1984-96

Biological Control Program, CDFA



Releases of the Bud Weevil, Bangasternus orientalis in California in 1985-96

Biological Control Program, CDFA



Releases of Chaetorellia Seedhead Flies in California in 1988-96

Biological Control Program, CDFA