TechLine

Information About Invasive/Exotic Plant Management May, 2001

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has."

Margaret Mead

Integrated Management Costs and Efficacy Compared

As this issue of *TechLine* describes, successful invasive weed management is almost always an integrated combination of methods employed over time. However, the pros and cons (and relative costs) of the different methods available to land managers were not always well understood until recently. This issue details several studies that compare not only different management techniques, but evaluate their relative costs and effectiveness.

Yellow Starthistle Control Options Expand With Integrated Methods

Also detailed in this issue is an overview of successful yellow starthistle management and one of the integrated management studies underway in California.

For more information and complete references on yellow starthistle please visit: www.wric.ucdavis.edu/yst. This is one the most comprehensive websites on the management of yellow starthistle and is an excellent source of information on this spreading weed problem. All of this research points to the importance of careful planning and using integrated methods to achieve maximum results.

Inside TechLine

Cost and Efficacy of Spotted Knapweed Management with Integrated Methods

By Melissa L. Brown,
Biologist, Weed Mgt. Services, Helena, MT
Celestine A. Duncan,
Consultant, Weed Mgt. Services, Helena, MT
Mary B. Halstvedt,
Customer Agronomist, Dow AgroSciences, Billings, MT

Plots were hand-pulled two times per year at 4-week intervals for one and two years. Knapweed foliage and the top 1 to 2 inches of root were removed at early and late bud stages to prevent flowering.

Introduction

Spotted knapweed is a tap-rooted perennial forb that infests millions of acres in the West. The weed can be effectively controlled with several different herbicides, however political and environmental concerns preclude or limit herbicide applications on some sites. The objectives of this study were:

1. to determine the efficacy of various management techniques alone and in combination on spotted knapweed control;
2. to study the effect of various management techniques on the plant community;
3. to calculate the cost of integrating methods.

Study Sites

The study was conducted at two sites in Missoula County, west-central Montana ***(Table 1)***. Both locations were characterized as upland range sites dominated by either bluebunch wheatgrass (*Agropyron spicatum*) and rough fescue (*Festuca scabrella*) or crested wheatgrass (*Agropyron spp.*)

Experimental Design

Twelve, 20 by 30-foot treatment plots were arranged in a randomized complete block design and replicated 3 times at each site. Treatments included hand pulling, mowing, herbicides, and biological agents alone and in combination with each other ***(Table 2)***.

Materials and Methods of Treatments:

Herbicides: Tordon* 22K herbicide and Curtail* herbicide were applied at various rates, timings and combinations with other management methods using a CO_2-pressure regulated backpack sprayer and a hand-held boom to broadcast herbicides uniformly over vegetation in each experimental plot. Applications were made at 31 psi using 8002 flat fan nozzles and a total solution of 16 gallons per acre. *NOTE: Herbicide*

See "Costs" on page 4

Table 1 — Site Characteristics

	Missoula Gun Club	Blue Mountain
Elevation	3,200 ft., 12-14" P.Z.	3,600 ft, 12-14" P.Z.
Soil Texture	Loam	Cobbley-loam
Dominant Vegetation	Seeded with crested wheatgrass, Idaho fescue, junegrass, Canada blue-grass, and misc. forbs	Native range site, bluebunch wheatgrass, Rough & Idaho fescue, and misc. forbs
Spotted Knapweed Cover	76%	53%

Table 2. Treatment Rates, Timing, Percent Spotted Knapweed Control and Treatment Costs

[1]Due to low density of spotted knapweed plants, one plot received only 15 weevils in the Tordon 22K+ root weevil treatment.
[2]Values followed with the same letter do not significantly differ (p=0.05)
[3]Costs based on the following information:

Hand pulling – wages $9.00/hour **Weevils** – $1.00/insect **Mowing** – $50.00/acre
Tordon 22K – $86.00/gallon **Curtail** – $30.70/gallon **Ground application** – $20.00/acre

Treatment	Rates per acre & no. of times applied	Plant Growth Stage	Application Date 1997	Application Date 1998	Flower[2] Control 8/4/98	Plant[2] Control 8/4/98	Plant[2] Control 6/16/99	Cost /Acre[3] 2 YRS
			Mo./Day	Mo./Day	%	%	%	$
Hand pulling (bolted plants)	2 X	Early & late bud	y 6/20 7/20	y 6/20 7/22	100a	56d	25e	$13,900.00
Tordon 22K plus Hand pull (rosettes) + mature	1/2 pt 1 X	Bolt late bud	6/2 ----	----- 7/21	100a	98ab	94a	$97.90
Mowing	2 X	Early & late bud	6/20 7/20	6/19 7/17	99a	0f	0f	$200.00
Mowing plus Tordon 22K	1 X 0.5 pt.	Late bud Fall	7/20 9/29	---- ----	100a	100a	98a	$73.37
Mowing plus Curtail	1 X 1 qt.	Late bud Fall	7/16 9/29	---- ----	100a	93b	91ab	$77.67
Tordon 22K	0.5 pt.	Fall	9/29	----	100a	96ab	85b	$25.37
Curtail	1 qt.	Fall regrowth	9/29	----	100a	79c	68c	$27.67
Tordon 22K (Standard)	1 pt.	Bolt	6/2	----	99a	98ab	95a	$30.75
Curtail (Standard)	2 qt	Bolt	6/2	----	93b	93b	89ab	$35.37
Cyphocleonus achates	30 insects/ plot	Flower	8/27	----	0d	0f	0f	$90.00
Tordon 22K plus *Cyphocleonus achates*	0.25 pt. 30 insects/ plot[1]	Bolt Flower	6/2 8/27	---- ----	46c	46e	44d	$113.58
Untreated LSD (.05)					0d	0f	0f	

*Trademark of Dow AgroSciences, LLC
Tordon 22K is a federallyRestricted Use Pesticide.

"Costs'
Continued from page 2

rates were lower than standard rates (where herbicides are used alone) in treatments where techniques were combined.

Hand-pulling: Plots were hand-pulled two times per year at 4-week intervals for one and two years. Knapweed foliage and the top 1 to 2 inches of root were removed at early and late bud stages to prevent flowering.

Herbicide + Hand pulling: Plots receiving combined herbicide and hand pulling treatments were treated with Tordon* 22K at a rate of 0.5 pint per acre in June 1997, followed by pulling treatments in 1998. Herbicides were applied using methods described above.

Mowing: Mowing treatments were administered using a standard push-mower two times per year for one and two years. The first mowing took place when knapweed plants were bolting, and was followed by successive mowing at bud stage.

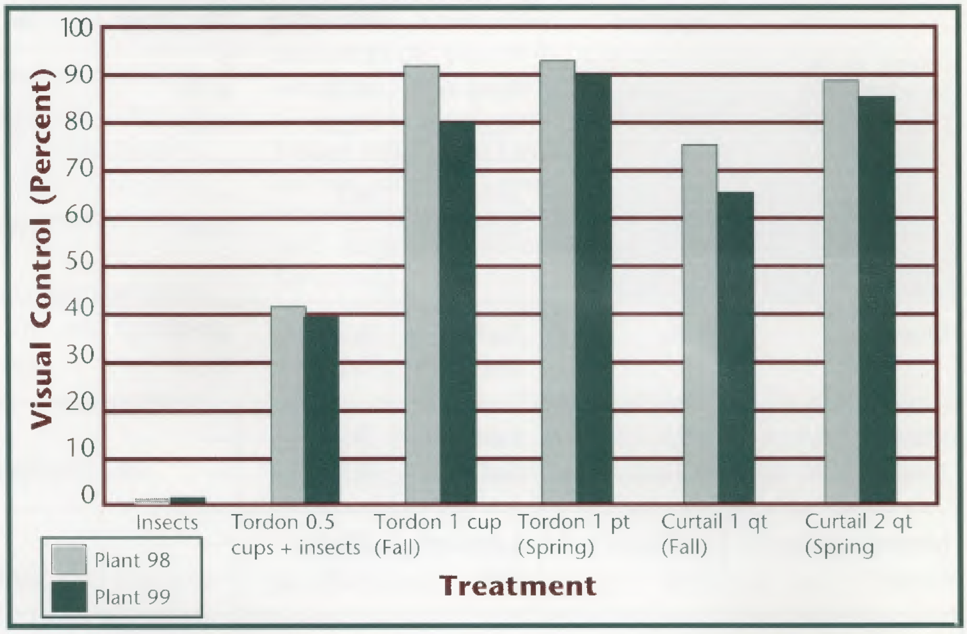
Mowing + Herbicides: Plots receiving combined herbicide and mowing treatments were mowed at the late bud stage and then treated with either Tordon 22K at 0.5 pint per acre or Curtail at 1 quart per acre in September 1997. Herbicides were applied using methods described above.

Insects, Herbicide + Insects: To prevent insect migration between plots, 6.5 by 18-foot metal enclosures were erected in the center of each biological control plot at both sites. Thirty knapweed root weevils (*Cyphocleonus achates*) were released inside each enclosure. Due to low density of spotted knapweed plants, one plot received only 15 weevils in the Tordon 22K plus root weevil

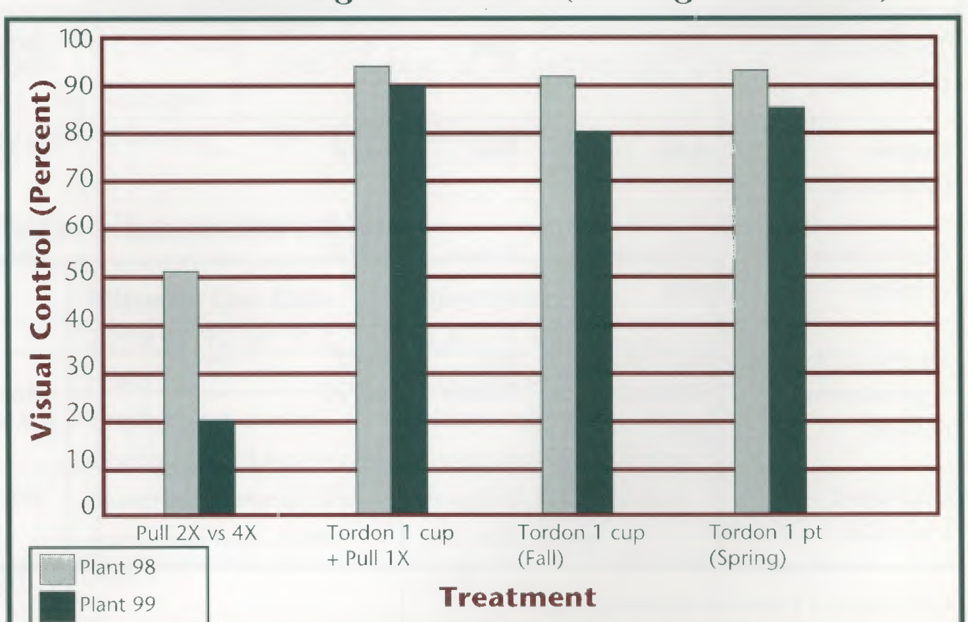
Cost of Weed Management Methods

Hand pulling – Wages $9.00/hour
Mowing – $50.00/acre
Tordon 22K – $86.00/gallon
Weevils – $1.00/insect
Curtail – $30.70/gallon
Application – $20.00/acre

Visual Spotted Knapweed Control with Insects and Herbicides 1 and 2 Years Following Treatment (Average of 2 sites)



Visual Spotted Knapweed Control with Hand-pulling and Hand-pulling Plus Herbicide Treatments 1 and 2 Years Following Treatment (Average of 2 Sites)



treatment. Plots receiving combined biological control and herbicide treatments were treated with Tordon 22K at 0.25 pint per acre in June 1997, prior to root-weevil release in August 1997.

Sampling Techniques

Post-treatment vegetation cover data for all treatments were collected in August 1997, June and August 1998, and June 1999. Visual percent control evaluations of each treatment were made in August 1997 and 1998, and June 1999.

Point-frame cover data were collected from five (5) evenly spaced locations along 16-foot transects through the center of biological control enclosures. In all other plots, post-treatment vegetation data were sampled from ten evenly spaced point-frame locations along transects running diagonal from the front-left to back-right corner. Point-frames were placed perpendicular to center over the transect line. Canopy cover was estimated for spotted knapweed, collective grass, litter, bare ground, and miscellaneous forbs.

Data Analysis

Percent cover and percent control data were analyzed using the LSD Means Comparison test at the p=0.05 level. A quadratic regression was used to analyze the effect of spotted knapweed cover on grass cover. Cost of each treatment per acre was calculated using an hourly wage for hand pulling, commercial mowing and chemical application rates, and local herbicide and biological agent prices.

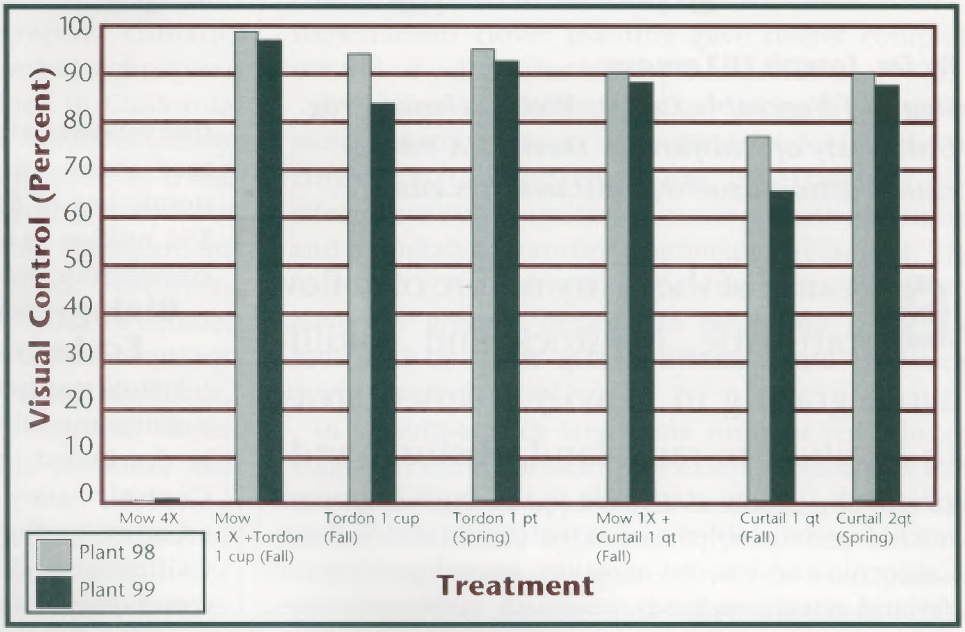
Results and Discussion

Tordon 22K herbicide at rates of 0.5 pint/acre and above, and Curtail herbicide at 2 quarts/acre provided greater than 90% control of spotted knapweed one year following application. Mowing alone did not provide control of knapweed plants, but reduced flowering. Mowing combined with Curtail at 1 quart/acre provided significantly better knapweed control than this herbicide rate alone. Hand pulling alone eliminated flowering and provided 56% control of spotted knapweed plants. Insects alone or in combination with Tordon 22K at 0.25 pint/acre (standard rate is 1 pt/acre) did not provide acceptable spotted knapweed control. Mowing twice for two consecutive years and *C. achates* alone did not control spotted knapweed.

Hand pulling for two years significantly increased bare ground, but did not affect grass, litter and other forb cover compared to the control. Herbicide treatments alone and in combination with hand pulling and mowing increased grass cover by greater than 44%. Mowing and insects alone had no significant effect on grass cover, litter, or forbs compared to the control.

Herbicides alone provide the most effective spotted knapweed control for the lowest cost. The most cost-effective treatments were Tordon 22K at 0.5 to 1 pint/acre, and Curtail at 2 quarts/acre ***(Table 2)***. Herbicides at half the standard rate (Tordon 22K at 0.5 pt/acre and Curtail at 2 qt/acre) can be combined with mowing or hand pulling to improve initial control or maintain control over a longer period of time. Insects alone and combined with herbicides may prove more cost effective if insects establish and maintain long-term control. Hand pulling twice for two consecutive years was the most expensive treatment and provided less than 60% control of spotted knapweed after two seasons. Hand pulling is not an economically viable option on dense and/or large knapweed infestations.

Visual Spotted Knapweed Control with Mowing and Mowing Plus Herbicide Treatments (Average of 2 Sites)



*Trademark of Dow AgroSciences, LLC
Tordon 22K is a federallyRestricted Use Pesticide.

Yellow Starthistle Management Possible with Planning and Integrated Approach

By Dr. Joseph DiTomaso
Dept. of Vegetable Crops, Weed Science Prog.
University of California, Davis, CA 95616
email: ditomaso@vegmail.ucdavis.edu

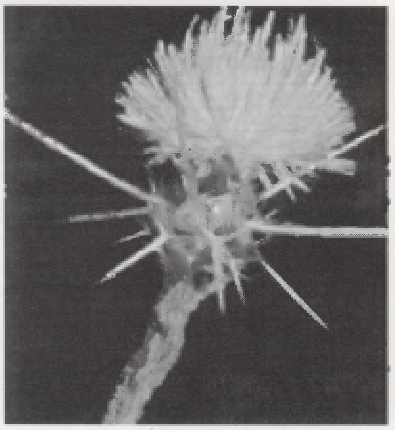
Because of the spiny nature of yellow starthistle, livestock and wildlife avoid grazing in heavily infested areas. In addition to rangeland, pastures and grasslands, yellow starthistle is the most important roadside weed problem in much of central and northern California and has, on occasion, caused problems in dryland cereals, orchards, vineyards, cultivated crops, and wastelands (Maddox et al. 1985).

It can also reduce land value and reduce access to recreational areas (DiTomaso et al. 1998, Roché and Roché 1988). In addition, starthistle infestations can reduce wildlife habitat and forage, displace native plants, and decrease native plant and animal diversity (Sheley and Larson 1994a).

Dense infestations not only displace native plants and animals, but also threaten natural ecosystems and nature reserves by fragmenting sensitive plant and animal habitat (Scott and Pratini 1995). A related species, *Centaurea melitensis* (tocalote), significantly reduces the seed production of the endangered plant species *Acanthomintha ilicifolia* (E. Bauder unpublished data) and yellow starthistle invasions on the Agate Desert Preserve in southwest Oregon threatens *Lomatium cookei*, a globally rare plant species (Randall 1994).

Water Consumption Impacts

Recent studies indicate that yellow starthistle significantly depletes soil moisture reserves in annual grasslands in California (DiTomaso et al. 2000d, Dudley 2000) and in perennial grasslands in Oregon (Borman et al 1992). Because of its high water usage, yellow starthistle threatens both human economic interests as well as native plant ecosystems (Dudley 2000). It was recently acknowledged by the State Water Resources Control Board that control of weeds could significantly conserve water. Based on a conservative estimate of the weeds coverage in the Sacramento River watershed, Gerlach estimated (in Dudley 2000) that yellow starthistle may cause an economic loss of $16 to $56 million in water conservation per year.



Biology and Ecology

Yellow starthistle is a winter annual widely distributed in the Central Valley and adjacent foothills of California and also common in many other western states. It is currently spreading in mountainous regions of California below 7,000 ft and in the Coast Ranges, but is less commonly encountered in the desert, high mountains and moist coastal sites. Yellow starthistle is typically found in full sunlight and deep, well-drained soils, where annual rainfall is between 10-60 inches.

Susceptible Landscapes

Yellow starthistle often becomes established following disturbances, either natural or through human activity. Although starthistle can invade some undisturbed areas, disturbance usually allows for more rapid establishment and spread. Following soil disturbance, sites should be monitored to prevent establishment and subsequent seed production in these susceptible areas. In many cases, disturbed sites should be re-vegetated with desirable species to slow the invasion of yellow starthistle.

Management Goals

The goal of any management plan should be not only controlling the noxious weed, but also improving the degraded community, enhancing the utility of that ecosystem, and preventing reinvasion or invasion by other noxious weed species. To accomplish this usually requires a long-term integrated management plan. A number of considerations can influence the choice of options, most important being the desired land-use objective. This can include forage production, preservation of native or endangered plant species, wildlife habitat development, or recreational land maintenance. Selection of the proper management tool(s) and program also depend on other factors including weed species and associated vegetation, initial density of yellow starthistle infestation, effectiveness of the control techniques, years necessary to achieve control, environmental considerations, chemical use restrictions, topography, climatic conditions, and relative cost of the control techniques.

Before 1987 there were few options in California (although other states had good herbicides for yellow starthistle control with products registered in those states, but not in California) for the control of yellow starthistle, and long-term sustainable management plans had not yet been developed. However, considerable progress has been made in the past decade.

Currently, there are a number of control options available for the management of yellow starthistle, including grazing, mowing, manual removal, clover or perennial grass reseeding, burning, chemical, and biological control.

Recent emphasis has been on the development of integrated systems for the long-term sustainable management of yellow starthistle. Such systems include various combinations of a number of these newly developed techniques. In many cases, three or more years of intensive management may be necessary to significantly reduce a yellow starthistle population.

Integrated Approaches

Most often a single method is not effective in the sustainable control of a range weed. A successful long-term management program should be designed to include combinations of mechanical, cultural, biological, and chemical control techniques. There are many possible combinations that can achieve the desired objectives, but these choices will have to be tailored to the site, economics, and management goals.

Sometime the control techniques must be in a particular sequence to be successful. For example, in a re-vegetation effort along a yellow starthistle infested canal and roadside the first step was to intensively manage starthistle (Brown et al. 1993, Thomsen et al. 1994). The second step was to reseed with deep-rooted native perennial grasses. In the final stage, native broadleaf forbs such as California poppy and lupines were seeded into the system.

In another study, Thomsen et al. (1996a, 1997) developed a long-term integrated approach for yellow starthistle control using combinations of grazing, mowing, and clover plantings. For example, seeding with subterranean clover, grazing three times, and mowing once at the early flowering stage resulted in 93% reduction in yellow starthistle seed production and a dramatic increase in standing dry matter (Thomsen et al. 1996a). In another experiment, two timely repeated mowings combined with a subterranean clover planting gave nearly complete control of yellow starthistle (Thomsen et al. 1997).

A number of other studies are underway to assess various combinations of techniques for starthistle control. UC researchers are investigating the effectiveness of integrating summer prescribed burning and clopyralid (Transline* herbicide) treatment. The objective is to determine which sequence is likely to have the greatest benefit for rangeland health, as indicated by plant species diversity and by forage quality and quantity.

In a multi-agency large-scale study at Fort Hunter Liggett in southern Monterey County, researchers are testing integrated approaches combining spring and summer herbicide applications, prescribed burning, and biological control agents. Five-year management plans have been developed for open grasslands 1) used primarily for military training, 2) surrounded by valley and blue oaks, and 3) with rare plants or species of concern. The goal of each of these management plans is to control yellow starthistle, enhance the integrity and utility of the ecosystem, and prevent re-invasion. **(This project will be featured in an upcoming *TechLine*.)**

Developing a Management Strategy

Once yellow starthistle is well established, eradication is not practical without extremely high financial and labor inputs. The ultimate objective under these circumstances is to manage the infested area and contain the large-scale infestation. However, the goal of any management plan should not simply be control of the noxious weed(s), but improvement of the degraded rangeland community, enhanced utility of the ecosystem, and prevention of reinvasion or invasion by other noxious weed species. In severely deteriorated starthistle-infested grasslands, it may be necessary to reintroduce desirable plant mixtures. Ideally, a healthy weed-resistant plant community would consist of a diverse group of species that occupy most of the niches.

An effective yellow starthistle management strategy should include three major goals; 1) effective control of the weed, 2) achieve the desired land-use objectives such as forage production, wildlife habitat development, or recreational land maintenance, and 3) prevent re-invasion of starthistle or invasion of

See "Starthistle" on page 8

*Trademark of Dow AgroSciences, LLC
Tordon 22K is a federally Restricted Use Pesticide.

"Starthistle"

Continued from page 7

equally invasive species. To accomplish these goals, land managers will require an understanding of the land use objectives, management limitations, and biology of the system.

Control options should include, whenever possible, an integration of mechanical, cultural, biological, and chemical techniques. A long-term commitment of three to many years will be necessary in nearly all cases to deplete the weed seedbank. It is not unusual for yellow starthistle plants to be larger after a single year of control (Callihan and Lass 1996). It will require a significant reduction in the seedbank and an increase in seedbank of the desirable competing species before dramatic results can be observed. Regardless of the approach employed, annual monitoring and evaluations should be conducted to determine the adequacy of the management plan (Sheley et al. 1999c). Changes in the management approaches may be necessary to adjust to any unforeseen problems and improve the strategy.

Once the desired objectives have been attained, a yearly follow up program will be necessary to prevent starthistle re-infestation. This may involve annual hand pulling, spot herbicide treatments, or even periodic burning (DiTomaso 2000). In addition, changes in grazing practices may be required to ensure that rangeland conditions do not become susceptible to rapid re-infestation. If follow-up is not made for 2 to 3 years following a control program, the grassland will usually become heavily re-infested in a short time.

References:

Borman, M.M., W.C. Krueger, and D.E. Johnson. 1991. Effects of established perennial grasses on yields of associated annual weeds. Journal of Range Management 44:318-322.

Brown, C.S., R.L. Bugg, and J.H. Anderson. 1993. Roadside planting of perennial grasses. Grasslands 3(4):1-3.

Callihan, R.H. and L.W. Lass. 1996. Yellow starthistle management with herbicides. Current Info. Series No. 1036, 12 pp. Univ. Idaho, College of Agriculture.

Callihan, R.H., R.L. Sheley, and D.C. Thill. 1982. Yellow starthistle: identification and control. Current Info. Series No. 634, 4 pp. University of Idaho, College of Agriculture.

DiTomaso, J.M. 1998. Biology and impact of yellow starthistle. Pg. 82-84, M.S. Hoddle, ed. In, California Conference on Biological Control. Innovation in Biological Control Research.

DiTomaso, J.M. 2000. Invasive weeds in rangelands: Species, impacts and management. Weed Science 48:255-265.

DiTomaso, J.M., C. Benefield, and G.B. Kyser. 1998a. Reproductive biology of yellow starthistle (Centaurea solstitialis) maximizing late season control. Kelly, M., E. Wagner, and P. Warner, eds. Proc., California Exotic Pest Plant Council Symposium 4:58.

DiTomaso, J.M. and J. Gerlach. 2000a. Centaurea solstitialis (yellow starthistle). C. Bossard, J.M. Randall, M. Hoshovsky, eds. Pages 101-106. In, Invasive Plants of California's Wildlands. UC Press, Berkeley.

DiTomaso, J.M. and J. Gerlach. 2000b. Centaurea melitensis (tocolate). C. Bossard, J.M. Randall, M. Hoshovsky, eds. Pages 98-100. In, Invasive Plants of California's Wildlands. UC Press, Berkeley.

DiTomaso, J.M., E. Healy, S. Enloe. 2000c. California's Noxious Weeds. http://pi.cdfa.ca.gov/weedinfo/

DiTomaso, J.M., G.B. Kyser, and M.S. Hastings. 1999a. Prescribed burning for control of yellow starthistle (Centaurea solstitialis) and enhanced native plant diversity. Weed Science 47: 233-242.

DiTomaso, J.M., G.B. Kyser, S.B. Orloff, and S.F. Enloe. 2000d. Integrated approaches and control option considerations when developing a management strategy for yellow starthistle. California Agriculture 54 (6):30-36.

DiTomaso, J. M., G. B. Kyser, S. B. Orloff, S. F. Enloe, and G. A. Nader. 1999b. New growth regulator herbicide provides excellent control of yellow starthistle. California Agriculture 53(2):12-16.

DiTomaso, J.M., S.B. Orloff, G.B. Kyser and G.A. Nader. 1998b. Influence of timing and chemical control on yellow starthistle. Proc., Calif. Weed Sci. Soc. 50:190-193.

Dudley, D.R. 2000. Wicked weed of the west. California Wild 53:32-35.

Enloe, S., J.M. DiTomaso, S. Orloff, and D. Drake. 1999a. Integrated management of yellow starthistle on California rangeland. Proc., California Weed Science Society 51:24-27.

Enloe, S., J.M. DiTomaso, S.B. Orloff, and D. Drake. 1999b. Selective yellow starthistle management and revegetation strategies for annual rangelands. Proc., Forest Vegetation Management Conference 20:29-32.

Maddox, D.M. and A. Mayfield. 1985. Yellow starthistle infestations are on the increase. California Agriculture 39(11/12):10-12.

Maddox, D.M., A. Mayfield, and N.H. Poritz. 1985. Distribution of yellow starthistle (*Centaurea solstitialis*) and Russian knapweed (*Centaurea repens*).
Weed Science 33(3):315-327.

Randall, J.M. 1994. Weeds and the preservation of natural areas. Proc., California Weed Science Society 46:143-154.

Roché, C.T. and B.F. Roché, Jr. 1988. Distribution and amount of four knapweed (*Centaurea* L.) species in eastern Washington. Northwest Science 62:242-253.

Scott, T. and N. Pratini. 1995. Habitat fragmentation: the sum of the pieces is less than the whole. California Agriculture 49(6):56.

Sheley, R.L. and L.L. Larson. 1994a. Observation: Comparative live-history of cheatgrass and yellow starthistle. Journal of Range Management 47:450-456.

Sheley, R.L., M. Manoukian, and G. Marks. 1999c. Preventing noxious weed invasion. Pages 69-72 in R. L. Sheley and J. K. Petroff, eds. Biology and Management of Noxious Rangeland Weeds. Oregon St. Univ. Press, Corvallis.

Thomsen, C.D., M.P. Vayssieres, and W.A. Williams. 1994. Grazing and mowing management of yellow starthistle. Proc., California Weed Conference 46:228-230.

Thomsen, C.D., M.P. Vayssieres, and W.A. Williams. 1997. Mowing and subclover plantings suppress yellow starthistle. California Agriculture 51(6):15-20.

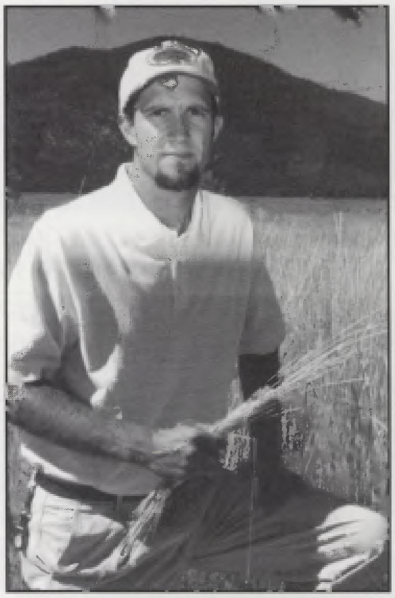
Thomsen, C.D., W.A. Williams, W. Olkowski, and D.W. Pratt. 1996a. Grazing, mowing and clover plantings control yellow starthistle. The IPM Practitioner 18:1-4.

Thomsen, C.D., W.A. Williams, M. Vayssiéres, and F.L. Bell. 1994. Yellow starthistle control. Range Science Report #33, 6 pp.

Thomsen, C.D., W.A. Williams, M. Vayssieres, C.E. Turner, and W.T. Lanini. 1996b. Yellow starthistle biology and control. Univ. Calif., Div. Agr. Nat. Res. Publication #21541. 19 pp.

Management Practices for Long-term Yellow Starthistle Control and Enhanced Rangeland Productivity

By Charles Henry
TechLine Editor



Steve Enloe is the project coordinator on an integrated study utilizing Transline, and perennial bunchgrass (intermediate wheatgrass) and rose clover reseeding of yellow starthistle-infested rangeland (below).

The aggressive invader from the Mediterranean, yellow starthistle (*Centaurea solstitialis* L.), currently infests over 10 million acres in California. It reduces rangeland productivity and carrying capacity, decreases land value, and threatens native plant biodiversity. Yellow starthistle is well adapted to California's annual grasslands, which comprise over 22 million acres in the state. It minimizes competition with annual grasses by utilizing deep soil moisture and entering its reproductive phase after annual grasses have senesced.

There are currently few sustainable and economically viable management strategies available to land managers in California for controlling yellow starthistle and increasing rangeland productivity. Burning, intensive grazing, tillage, and certain herbicides, such as 2,4-D and dicamba, have been somewhat successful. Outside California, Tordon* 22K herbicide has been used very successfully on yellow starthistle. However, long-term yellow starthistle management requires depleting its seedbank and establishing competitive plant species in the niche yellow starthistle occupied.

Transline* herbicide (clopyralid) is a registered selective broadleaf herbicide that provides excellent yellow starthistle control. However, there is concern that utilizing Transline alone may result in species compositional shifts to other competitive undesirables, such as medusahead (*Taeniatherum asperum*) or barb goatgrass (*Aegilops triuncialis*). Properly managed perennial bunchgrasses are robust and more resistant to annual invaders plus they are highly desirable for livestock forage and improved wildlife habitat. Similarly, forage legumes, such as rose clover, fix nitrogen and are very competitive with seedling yellow starthistle.

"There are plenty of pitfalls when attempting to re-introduce natives," Steve Enloe explains. "For instance, what are the best ecotypes for this valley? If a species is adapted for this valley, is it the best native for the next valley? Availability and cost of seed are other critical factors. The primary objective of the research is to determine the most sustainable and economically sound strategy for managing yellow starthistle and improving forage production and quality."

Enloe is a University of California Davis graduate student working with Joe DiTomaso and Guy Kyser in the Dept. of Vegetable Crops, Weed Science Program, University of California, Davis. Enloe is the project coordinator on an integrated

See "Intergrated Methods" on page 10

*Trademark of Dow AgroSciences, LLC
Tordon 22K is a federally Restricted Use Pesticide.

"Integrated Methods"
Continued from page 9

study utilizing Transline*, and perennial bunchgrass (intermediate wheatgrass) and rose clover reseeding of yellow starthistle-infested rangeland. The study was established in the spring of 1997 in Siskiyou County, CA in cooperation with county farm advisors Steve Orloff and Dan Drake.

"Previous research demonstrates that yellow starthistle success or failure is a function of eliminating the seedbank and preventing reinvasion. And we must be concerned not only with the reinvasion of yellow starthistle, but also creating opportunities for invasion by exotic annual grasses," Enloe explains.

Enloe says they want to test a system that includes only three years of spraying Transline herbicide. For grass establishment, Roundup herbicide was applied at 1 pt./acre two weeks before seeding. The Transline herbicide was applied at labeled rates in March of 1997, 1998, and 1999. The project coordinators used a rangeland, no-till drill to seed 12 lbs per acre of pubescent wheatgrass (*Thinopyrum intermedium*) with no seedbed preparation.

Treatment evaluations consist of the following: Late spring percent cover evaluations of yellow starthistle, wheatgrass, rose clover, annual grasses, and other desirable and undesirable forbs, and summer evaluations of yellow starthistle density and flower production. Yellow starthistle depletion from the seed bank will also be monitored each fall prior to germination. Total forage production and quality are also measured in the fall and spring.

"After the first application, we expected and observed an explosion of annuals such as mustards, cheatgrass, wild barley, and filaree," Enloe states. "Overall we achieved the desirable shift from yellow starthistle to wheatgrass with only small changes in forbs and annual grasses."

Early results from 1997 indicated Transline* herbicide provided excellent control of yellow starthistle, which subsequently resulted in an increase in desirable forage species. Wheatgrass establishment was good where starthistle was controlled, but was very poor where Transline herbicide was not applied.

"Pubescent wheatgrass seedlings need to be released from intense competition with yellow starthistle for successful establishment," Enloe explains. "Otherwise, you will obtain very poor wheatgrass stand and little return on your seed cost investment. Transline herbicide was an effective tool for providing that window for seedling establishment."

Spring cover analysis from 1998 through 2000 indicated that one Transline application alone was insufficient for long-term starthistle control. Yellow starthistle rebounded in 1998 and by 1999, plots treated with one application of Transline were not significantly different from the control plots. In 1998, plots treated with two years of Transline had less than 1% starthistle cover and had only increased to 5% cover by the spring of 2000. In 1999, essentially no plants were observed in plots treated for three years with Transline and in the spring of 2000, yellow starthistle cover was less than 1%.

"While we did achieve excellent control of yellow starthistle with multiple Transline applications, we did not eradicate it completely," Enloe says. "A small percentage of the seedbank persisted and may recover to reinfest those previously treated plots. However, it has not occurred yet."

For long-term suppression, though, the key was getting wheatgrass into the system. Pubescent wheatgrass was initially slow to establish but increased from 4% cover in 1997 to 40% cover or higher in 2000 in all Transline treatments.

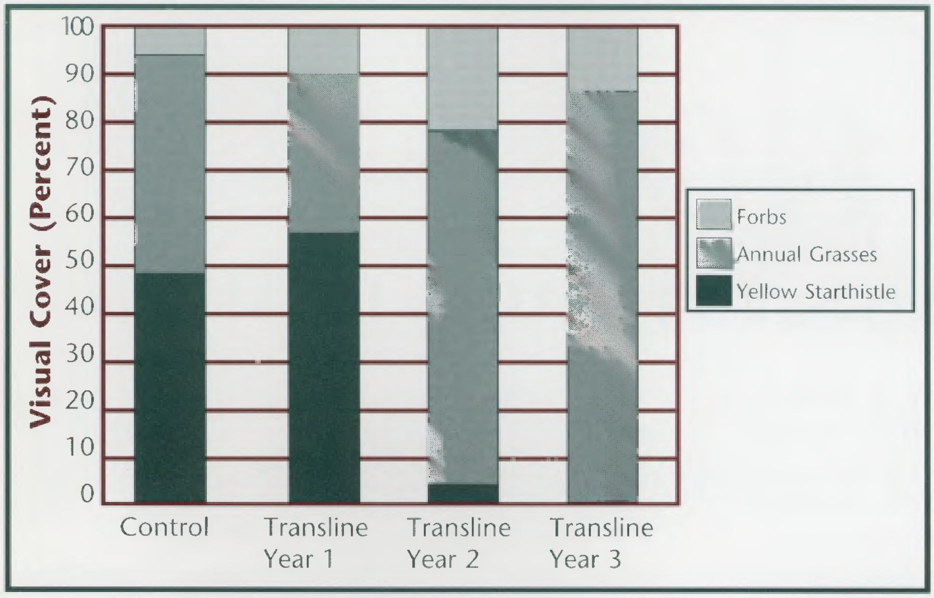
"With slow growing perennial grasses, we felt subsequent Transline applications after the seeding year might improve wheatgrass establishment. We did see a slight but significant increase with three years application compared to one or two years," Enloe remarks. "However, it may be more important in restoration projects where some extremely slow growing native perennial grasses may need an extra year without competition from yellow starthistle."

Where wheatgrass was established, yellow starthistle cover decreased to less than 5 % with one, two, or three previous Transline applications. The difference wheatgrass makes in the system is most easily seen between the one-year Transline plots versus the one-year Transline plus wheatgrass plots: over four years, the former have reverted to yellow starthistle dominance whereas the plots with wheatgrass have less than 5 % yellow starthistle cover.

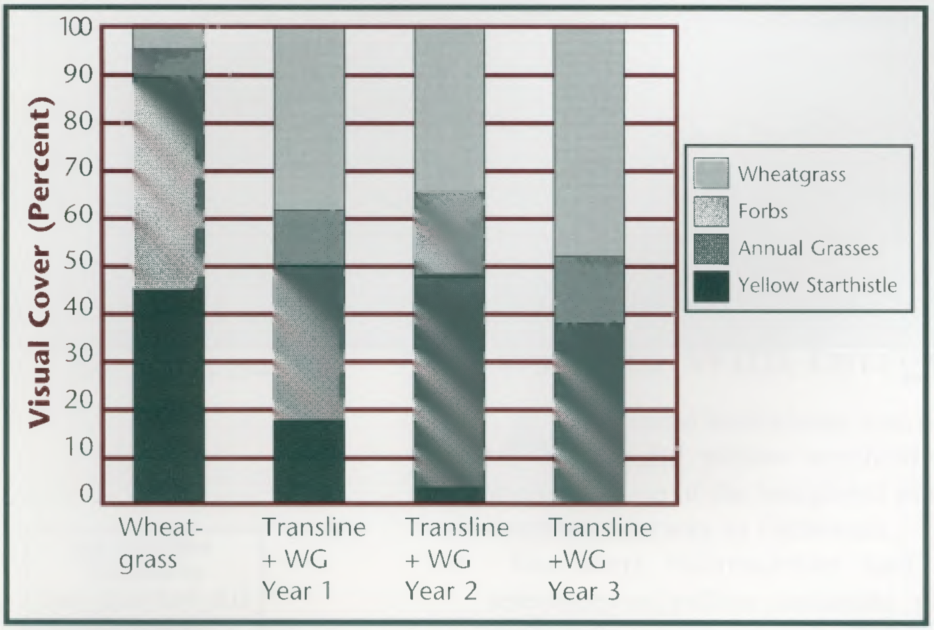
Over the four-year period, rose clover establishment was generally poor. Data from 1998 indicated rose clover establishment ranged from 4.5%-7.0% with no

*Trademark of Dow AgroSciences, LLC

Plant Community Response to Treatment



Plant Community Response to Treatment



significant differences between Transline-treated or untreated plots. Based upon poor stand establishment, rose clover provided essentially no competitive suppression of yellow starthistle.

In California's Mediterranean climate, annual grasses and forb abundance often fluctuate based upon rainfall patterns. However, yellow starthistle may strongly suppress both. "Over the four-year period we observed a big release of annuals such as mustards, cheatgrass, wild barley, and filaree in plots that only received Transline," Enloe states. "When you reduce yellow starthistle cover, annual grasses and especially forbs in the seedbank will respond positively. Over time yellow starthistle reinvades and forb cover declines. However, getting pubescent wheatgrass established in the system changes this dynamic. You don't get the strong forb release, but forb levels do remain similar to control plots. This could be positive or negative depending upon your objectives."

Although biocontrol was not a component of this study, Enloe says they have observed that two species of biocontrol insects, the false peacock fly *(Chaetorellia succinea)* and the hairy weevil *(Eustenopus villosus)* appear to be establishing very well across the study area. "There is long-term potential for these control agents, especially where yellow starthistle is suppressed by perennial grasses. Both biocontrol agents feed within seedheads and are capable of significantly reducing seed production."

Enloe says he is very encouraged by their results to date. Transline herbicide was effective for yellow starthistle control during wheatgrass establishment.

Additionally they achieved an 80% to 94% reduction in the yellow starthistle seedbank when Transline was applied for two or three years. These reductions in yellow starthistle density can allow a management shift to spot treatments or other strategies after two years. Pubescent wheatgrass is also proving itself worthy for use as a strong competitor with yellow starthistle. "Even with one year of Transline in 1997, pubescent wheatgrass has established well and is keeping yellow starthistle down four years later," Enloe says.

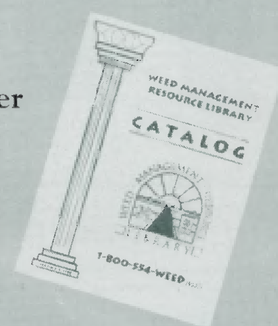
"Since we have found some success in pubescent wheatgrass establishment, we are currently evaluating the effects of grazing on the competitive interaction between yellow starthistle and pubescent wheatgrass. We need to understand how best to graze to maximize forage use and prevent yellow starthistle from regaining dominance. Finally, we will continue to monitor the role of biocontrol agents in the suppression of yellow starthistle in this integrated management system," Enloe concludes.

Weed Management Resource Library 1-800-554-WEED (9333)

The *Weed Management Resource Library* (WMRL) contains a wide variety of information resources to improve your noxious and invasive plant management. The Library provides you with quick, convenient access to as many resources as possible in one location.

Through the *Weed Management Resource Library*, you may obtain complete copies or additional information on every subject that appears in *TechLine*. All aspects of noxious weed and invasive plant management are presented.

Call the 800 number for your Catalog copy.



We want to answer your technical questions, so *TechLine* solicits your input and feedback. If you have a successful weed technique or program you would like to share with your colleagues— we welcome them. Please call us toll-free at the *Weed Management Resource Library* at 1-800-554-WEED (9333) with your suggestions, comments, and input.

There is no charge for using the Library. The Library serves as a network to place you in touch with other managers and experts. In this way, the Library serves as a central clearinghouse of weed management knowledge and expertise.

354-02-013 (05/2001 AgW)

TechLine
c/o Ag West Communications
P.O. Box 1910
Granby, CO 80446-1910