Yellow Starthistle Management with Grazing, Mowing, and Competitive Plantings

Craig D. Thomsen, William A. Williams, and Marc P. Vayssieres
Dept. of Agronomy and Range Science, University of California, Davis, CA 95616

1. Using livestock to manage yellow starthistle in annual grasslands

Introduction

Livestock grazing has been recognized as a major driving force for noxious weed invasions in pastures and on rangeland (Parker 1949). Livestock alter botanical composition and contribute to weed proliferation by reducing plant cover, dispersing seed, concentrating nutrients, compacting soil, and selective grazing (Burcham 1957). Many weeds that occur on grazing land possess anti-herbivore traits such as spines, stiff awns, high silica and lignin content, or secondary compounds such as alkaloids and glandular exudates. Because animals selectively graze some plants and avoid others, species that have grazing deterrents are favored on grazing lands and often increase relative to those eaten by livestock.

Paradoxically, some noxious weeds that flourish on grazing lands have some stages of growth that are palatable to livestock, and with alterations in grazing management, can be suppressed by livestock. For example, medusahead (*Taeniatherum caput-medusae)* (Lusk et al. 1961), Klamath weed (*Hypericum perforatum*) (Murphy et al. 1954), spotted knapweed (*Centaurea maculosa*) (Kelsey and Mikalovich 1987), leafy spurge (*Euphorbia esula*) (Johnston and Peake 1960), tansy ragwort (*Senecio jacobaea*) (Mosher 1979) and yellow starthistle (*Centaurea solstitialis*) (Thomsen et al. 1993) have all been suppressed by livestock grazing.

Some invasive species are absent from grazing land because they are highly palatable to livestock. In maritime areas, the palatable sweet fennel (*Foeniculum vulgare*) can reach dominant status in ungrazed grasslands, but is usually entirely absent from adjacent grazed land.

Livestock can be a useful "tool" in weed management programs when the following conditions are met: 1) target plants are acceptable as forage, 2) grazing can be timed to inflict damage at vulnerable periods in the weed's life cycle, 3) water is available for livestock, and 4) livestock are controlled to minimize damage to non-target species and other ecosystem components.

A land manager can manipulate various factors in a grazing/weed management program: these include paddock size, location, and configuration, stocking rates, timing and frequency of grazing, and class of animal. Prior to the development of portable electric fences, many of these grazing management options were beyond the practical control of the manager, but the recent availability of the New Zealand style fencing technology has created a wide range of management opportunities.

It is easy to assume that grazing to manage yellow starthistle infestations is not an option, since it is stoutly spined in the flowering stage. Also, horses can develop "chewing mouth disease", a fatal nervous disorder, when they have eaten 86-200% of their body weight (Cordy 1978). This reinforces the impression that yellow starthistle is not a suitable forage. Although horses should not be allowed to graze yellow starthistle, it is an acceptable forage for ruminants (Thomsen et al. 1989). Cattle, sheep, and goats readily graze yellow starthistle before spines are present and will often still graze plants with spines, although much less intensively.

Methods

To test whether livestock could be used as a tool to control yellow starthistle by heavy defoliation at specific growth stages, we conducted controlled experiments over a three-year period with cattle, sheep, and goats at two heavily infested sites in northern California. We compared timing and frequency of defoliation at specific growth stages with the three different animal species. We used a randomized complete block experimental design with the following treatments: 1) repeated grazing of yellow starthistle during the rosette stage of growth (March to May), 2) repeated grazing of yellow starthistle during the bolting, pre-spiny stage (May to June), and 3) controls with no grazing. An intensive grazing management approach was used, i.e., high stocking rates with short grazing periods that were timed according to plant phenology and regrowth responses. We monitored results by comparing yellow starthistle flowerhead densities among treatments.

Results

Grazing periods timed to rosette stages (spring grazed) led to an increase in yellow starthistle's reproductive output (Table 1A), whereas those that were timed to yellow starthistle's bolting, pre-spiny stages (late-May, June) decreased yellow starthistle flowerhead densities, plant height and canopy size compared to ungrazed controls (Table 1B, 2). In spite of repeated defoliation, yellow starthistle was favored by early grazing because competition was reduced from associated plants, giving yellow starthistle greater access to light, water, and other nutrients. Even under drought conditions, yellow starthistle has a tremendous capacity to regrow, far exceeding other associated species. This resilience is partially due to its deep taproot, and is an important reason why yellow starthistle is so abundant on winter and spring grazed rangelands.

Table 1.

Densities of yellow starthistle flowerheads A) under sheep grazing (3x) initiated in the rosette stage July 1990, and B) under goat grazing (2x) in the bolting stage July 1991, UC Agronomy Farm.

Treatment	A – Sheep 1990	B – Goats 1991
	- - - - - - flowerheads/m^2* - - - - - -	
Grazed	266 a	27 a
Ungrazed	172 b	374 b

Means followed by different letters are significantly different ($p<0.05$). Based on rank transformation of the data. *Actual quadrant size = 0.1 square meter.

Table 2.

Yellow starthistle flowerhead densities under grazing (3x, U, 3x) by cattle at bolting and ungrazed treatments in 1989,1990, and 1991 (Colusa County).

Treatment	1989	1990	1991
		- - - - - - flowerheads/m^2* - - - - - -	
Grazed	82 a	23 a	192 a
Ungrazed	558 b	255 b	843 b

Means followed by different letters are significantly different ($p<0.05$). Based on rank transformation of the data. *Actual quadrant size = 0.1 square meter.

Grazing during late May and June when plants were in the bolting, pre-spiny stage was more effective than earlier grazing for several reasons: 1) plants were less likely to recover from defoliation due to higher ambient air temperature and decreasing soil moisture, 2) animals preferentially grazed the later-maturing yellow starthistle over the early-maturing dried annual vegetation because it was still green and more palatable, and 3) the late grazing allowed many associated resident plants to grow without spring defoliation and compete against yellow starthistle. Although there were three to four intensive grazings during this period, this grazing regime did not denude the site. Since many of the other resident annual plants had completed their life cycle, their seed replenished the seed bank and appreciable amounts of plant residue were left on the soil surface.

In addition to yellow starthistle response, we monitored the response of the resident spring flora. In the controls (where grazing was excluded) low-statured dicots were uncommon. Most notable was the suppression of lupine (*Lupinus bicolor*) at one site and meadowfoarn (*Limnanthes douglasii*) at another site. In grazed areas adjacent to the ungrazed treatments, these two native species were conspicuous components at their respective sites, whereas in the ungrazed controls they were nearly absent. The suppression of these low-statured species is consistent with results of other studies in which grazing has been excluded in California grasslands dominated by introduced annual species (Heady 1977). When taller-statured exotic annuals dominate a site and are left standing, their residues accumulate, and form dense thatch-like mulches that suppress many species with high light or heat requirements.

Conclusion

Livestock grazing in annual grasslands can either increase or decrease yellow starthistle stands, depending on when grazing occurs. Grazing that began in the bolting, pre-spiny stage (late May) and was repeated one to three times decreased canopy size, flowerhead and seed production, and lowered yellow starthistle densities compared to ungrazed controls. The number of grazings required depends on the amount of late-season rainfall and soil moisture levels. The type of animal appears to be less important than timing; the availability of ruminants, size of infestation, and other site factors will generally determine the suitability of one species over another. Although we used intensive grazing management during this study, we have observed similar reductions in yellow starthistle under more traditional, extensive management where grazing periods were similar. However, grazing does not eradicate yellow starthistle infestations and management with livestock requires that grazing is used on an annual basis. In addition to managing yellow starthistle, controlled livestock grazing is a useful management tool in grasslands dominated by exotic annuals because it reduces thatch levels, producing landscapes with greater floristic diversity (Edwards 1992; Ehrlich and Murphy 1989; Menke 1992).

2. Timed Mowing to Control Yellow Starthistle

Introduction

The results of the grazing research with yellow starthistle demonstrated that proper timing of defoliation is an important factor in managing yellow starthistle stands. Therefore, in 1991 we initiated a "pilot" study with mowing to examine the effect of a single defoliation during yellow starthistle's early flowering stage, a later stage of growth than is possible with grazing. In the two trial strips that were mowed, many plants did not recover and those that did had reduced reproductive output. We were encouraged by these preliminary results and continued this work with the research described below.

Methods

To test the effects of various mowing regimes on yellow starthistle response we conducted an experiment over a three year period at the U.C. Davis Agronomy Farm on a site heavily infested by yellow starthistle. The treatments were: 1) early mowing during vegetative stages (late April to early May), 2) a single late mowing during the early flowering stage (mid-June), 3) late mowing (mid-June) during the early flowering stage followed by a second mowing at flowering on regrowth (late July to early August), and 4) a control with no mowing. We mowed all plots prior to seed maturation. The plots were 9 x 9 meters, arranged in a randomized complete block design with four replications, and mowing was done with a flail mower mounted on a small tractor. The treatment effects were monitored by measuring flowerhead densities, as an indicator of potential seed production per unit area and seedling densities after germination.

Results

Analysis of the data revealed significant differences in flowerhead densities between treatments (Table 3). The lowest densities were in plots that received two late mowings, followed by plots that had received a single late mowing. Plots that received a single early mowing contained significantly higher flowerhead densities in the second year compared to the controls, indicating that early mowing can increase reproductive output.

Table 3.

Flowerhead densities (summer) under mowing treatments, UC Agronomy Farm, 1992, 1993, 1994

Treatment	1992	1993	1994
		- - - - - - flowerheads/m^2* - - - - - -	
Control	326 a	460 a	223 a
Early mowing	380 a	713 b	226 a
Late mowing (x1)	46 b	169 c	74 b
Late mowing (x2)	19 c	12 d	2 c

Numbers are per meter square. Treatments with the same letter are not significantly different at (p <0.05%). ANOVA and LSD computed on rank transformed data. *Actual quadrant size = 0.1 square meter.

Discussion and Conclusion

These results are consistent with the Lyrazing experiments, but much better control was achieved with two late-season mowings. The improved control with this treatment was due to several factors: mowing was more uniform, greater amounts of biomass were removed, and defoliation occurred at a later time than is possible with grazing. Defoliation is presumably more "costly" to the plants during later phenological stages because they have invested more of their below-ground resources in reproductive structures than plants still in the vegetative stage, and consequently are less able to recover. As with the grazing results, later mowing allowed the associated resident annuals to grow without disruption and complete their life cycles. This enabled them to replenish the seed bank and provide some competition against yellow starthistle during the growing season.

The timing of the early mowing regime more or less parallels what occurs in many situations throughout California. Landowners and highway crews frequently mow when annual grasses mature and become a fire hazard. Mowing is also done to remove with the dried reproductive structures of many annual grasses and forbs that become a nuisance by attaching to wool, fur, and clothing, or by causing injury to the eyes and ears of pets and livestock. Although it may temporarily alleviate these problems, early mowing can exacerbate yellow starthistle infestations by creating denser stands that become a greater problem later on.

3. Considerations for using competitive plants for managing yellow starthistle

Introduction

One principle of long-term weed control is that the ecological niche occupied by the target species should be filled by another species once the target plant is reduced. Without the establishment of competitive replacement species, reinvasion by the target weed or another undesirable species is likely. For example, in many grassland communities of northern California where yellow starthistle occurs, a "successful" single species control program might result in the increase of other undesirable late-maturing species such as medusahead (*Taeniatherum caput-medusae*), barbed goatgrass (*Aegilops triuncialis*), or wild lettuce (*Lactuca serriola*).

While it is conceivable to conduct a multispecies control program where two or more of these late-season weeds can be targeted, their reduction will leave a temporal and spatial "opportunity" for other species already present in the seed bank, or perhaps for some new invasive species. Whether additional efforts such as the use of competitive plantings to try and fill open niches in grassland communities or elsewhere is warranted remains an open question and can only be determined by site-by-site decision making and future research. Even where competitive plantings are appropriate, constraints such as inadequate budgets, size of the problem, and biological reality, i.e., presence of other exotics that prevent establishment of desirable species, may force us to accept something less than an ideal plant community.

In general, the use of competitive plantings is not appropriate for managing yellow starthistle in remnant native plant communities, especially in dryland areas where herbaceous species predominate. Some of the reasons are: 1) Local natives that might be desirable to use in plantings do not occupy the same niche as yellow starthistle and are not competitive. Sheley and Larson (1994) have shown that part of yellow starthistle's success as a weed derives from its ability to avoid competition due to rapid root growth and its deep rooting habit. 2) Assuming a local species is truly competitive, it is likely to displace desirable species as well. Managing for a diversity of all on-site native species may be the preferred management objective for many sites rather than attempting to establishing competitive plants. 3) Obtaining sufficient on-site native material to seed large areas by collecting and increasing seed may require years. 4) Even if there is sufficient material, establishing herbaceous plants from seed is difficult because there are usually other weeds present that will also compete with the seeded plant, especially during establishment stage. Plug or container planting with adjunct weed control is one way to address this, but for economic reasons this is usually possible only on a small scale. 5) The terrain in most wildland situations is not conducive to creating "seed-safe" sites or planting with seeding equipment, nor is disturbance desirable. 6) Reducing a major intruder such as yellow starthistle, may be enough to allow native species that were held back to once again be expressed, leading to quasi-restoration. Although a potential niche is open, additional vegetation management with planting may not be desirable.

The use of competitive replacement plants through seeding is best suited to arable lands where seedbeds can be properly prepared, pre- and post-plant weed control can be done, uniform seeding is possible, and supplementary water can be applied during critical establishment stages in case of drought. The choice of species should reflect the site conditions, management required to establish and maintain the plantings, and future use of the site. Before investing in large-scale seeding, some initial on-site small-scale plantings may be the best means to evaluate which plants are suited for the site and whether they are truly competitive against yellow starthistle under the prevailing land use. Compatible mixes that include plants with vigorous cool-season growth that shade yellow starthistle seedlings and rosettes, and species with deep root systems that deplete soil moisture merit consideration. Several years may be needed to determine which species or mix of plants is most appropriate. It is best to avoid thinking in "magic bullet" terms, i.e., one species does it all (or even a mixture) and expect that some form of ongoing management will be a necessary part of any program.

In choosing plants, be careful to select species that will not spread and become weeds outside of their intended area of use. Since yellow starthistle is so undesirable, and most land where yellow starthistle grows also supports other exotic species, this may seem like a moot point. But, it is clear that many plants that have been intentionally introduced for erosion control, range improvement, or ornamental purposes have moved beyond their intended boundaries and are now major weeds. Among the grasses are: European beach grass (*Ammophila arenaria*), giant reed (*Arundo donax*), Andean pampas grass (*Cortaderia jubata*), pampas grass (*Cortaderia selloana*), Bermuda grass (*Cynodon dactylon*), veldt grass (*Ehrharta calycina*), tall fescue (*Festuca arundinacea*), Italian ryegrass (*Lolium multiflorum*), fountain grass (*Pennisetum setaceum*), harding grass (*Phalaris aquatica*), and smilo (*Piptatherum miliaceum*). There is even a larger array of non-grasses that fall under this category (CalEPPC 1996). It is not surprising that many of these species have become weeds since they were often selected for characteristics such as seedling vigor, long growing periods, robust growth, deep roots, reseeding potential, and drought tolerance, i.e., characteristics that help them survive in a difficult world, but also help contribute to their weediness.

Perennial grasses are among the best herbaceous candidates as competitors, if they have overlapping growth periods and deep root systems that deplete soil moisture, but there is no completed field research in California that we are aware of that has addressed this adequately. Current research with native grasses and forbs by Cynthia Brown at UC Davis will shed some light on this question. She is testing the "ecological combining ability" of selected mixtures and invasibility of well-established seeded stands, but another growing season is needed before conclusions can be fully drawn about resistance to yellow starthistle invasion by the planted mixtures.

John Anderson of Hedgerow Farms in Winters, CA is producing some extraordinary large-scale native grass stands in converted farmland and along roadsides that contain very little yellow starthistle; but, the reduction of yellow starthistle is probably more a result of herbicide applications than a competitive effect from the grasses. Looking at some of these stands gives the impression that invasion would at least be slowed down, but elsewhere we have seen yellow starthistle invading remnant stands of purple needlegrass (*Nassella pulchra*), three-awn (*Aristida ternipes* ssp. *hamulosa*), and creeping wildrye (*Leyinus triticoides*), indicating that native grass stands are prone to invasion and by themselves will not keep out yellow starthistle.

Results from research in Oregon with a variety of perennial grasses were not especially encouraging (Johnson and Borman 1992). Seedings frequently failed, and the limited site-specific plantings that were successful required the use of broad-leaf herbicides. Callihan, et al. (1987) tested 11 species of native and non-native grasses in Idaho. The non-native intermediate wheatgrass *Elytrigia intennedia* spp. *intermedia* was the most successful species, but was of little value without herbicide applications.

I have visually monitored an impressive stand of introduced wheatgrasses, cultivars; "Luna" pubescent and "Jose" intermediate *Elytrigia* spp. that were seeded in 1989 by the City of Davis at one of their flood control/ wildlife ponds. The grasses are robust with some inflorescences' over 5' tall and they provide good cover for wildlife.

There is very little, if any, yellow starthistle within the plantings, but some of the implanted borders are heavily infested. It appears that one or both of these wheatgrass cultivars are having a strong competitive effect on yellow starthistle as well as other species, i.e., coyote brush (*Baccharis pilularis*) and an undetermined rose (*Rosa* sp.). They are also spreading beyond the areas originally planted indicating that one or possibly both could become weeds elsewhere. It is noteworthy that wheatgrasses, because of their wildlife value and "staying power" have been seeded over millions of acres in the western United States and Canada (Bawtree 1992). One of their uses in the Great Basin is to allegedly replace cheatgrass (*Bromus tectorum*). Yet, in assessing the potential for designating land to wilderness status by BLM, the presence of crested wheatgrass was considered a greater negative factor than the presence of weeds (Asher and Harmon 1995). Regarding the use of non-native perennial grasses, a weed scientist suggested to me that they are the "functional equivalents" of natives, making their use acceptable. Anyone care to expand on that?

In current research (Thomsen et al. 1996) with competitive plantings we are testing the use of subterranean clover (*Trifolium subterraneum*) in combination with timed mowing in an agricultural setting. Subterranean clover (subclover) is a useful cover crop in vineyards and orchards, is an excellent forage, and fixes atmospheric nitrogen. It is adapted to Mediterranean climates, is self-regenerating, tolerates defoliation, and in spite of widespread use has not shown any tendency towards weediness, i.e., subclovers are not invasive and their persistence is dependent on properly timed defoliation, periodic applications of phosphorus or sulfur, and drought-free growing seasons. We selected it as a potential competitor based on information obtained previously from a variety trial done on the same site. Adapted varieties that were properly managed (mowed in late winter) were vigorous and produced a dense winter and spring canopy that deprived yellow starthistle of space and light.

Experimental plots were seeded with subclovers, fertilized with phosphorus and sulphur 0-20-0-12, and mowed during January to stimulate the clover and again in late May to target the yellow starthistle. Unseeded plots received no mowing until late May. Our preliminary results are presented in Table 4. First year results are not presented because there were additional mowings in January and June, so they are not directly comparable. Second and third year results appear very promising, but we are unsure if subclovers will persist at the densities necessary to maintain competitive pressure. Nevertheless, the cumulative effects from three years of timed mowing, even in the unseeded mowed plots, have led to considerable reductions in yellow starthistle compared to the unseeded, unmowed controls. No yellow starthistle survived in the seeded plots this year and very little remained in the unseeded, single-mowed plot. An additional year of data will give us more confidence in overall trends at this site, particularly as they pertain to the decline in the yellow starthistle seed bank.

Table 4.

Yellow starthistle flowerhead densities under combinations of seeding with subterranean clover and mowing, BIRC Field Station, Winters, CA.

Treatment	1995	1996
	- - - - - - flowerheads/m^2* - - - - - -	
Seeded and Mowing (2x)	0.20 a	0.0 a
Mowing (1x)	43 b	6 b
Control	420 c	171 c

Means followed by different letters are significantly different. Based on log transformed data. *Actual quadrant size = 0.1 square meter.

Conclusion

Yellow starthistle has a remarkable set of adaptive traits that gives it an enormous advantage over most herbaceous species in California. It has both competitive characteristics (rosettes, large reproductive output, rapid germination and seedling development, long germination period, high productivity, quick regrowth following defoliation), and traits that allow it to avoid interspecific competition (summer-maturing, deep-rooting habit). Other adaptive attributes include tolerance to extreme (arid and saline) environments (Larson et al. 1992), spines that deter grazing in reproductive stages, and roots that have been shown to deplete large quantities of late-spring and summer soil moisture, and at greater depths than other species (Cynthia Brown and John Gerlach, oral communication). A potential competitor would have to match some of these traits to interfere with and suppress yellow starthistle growth. That is a lot to ask of another herbaceous plant or even a group of plants, with the additional stipulation that they don't become weedy. In general, it is more effective to suppress yellow starthistle with herbicides, mowing, fire, manual removal, etc. rather than with competitive plants. Any program involving the use of competitive replacement plants should anticipate this and incorporate appropriate pre- and post-plant weed management methods.

An ecologically based weed management program should consider the entire community. So, before introducing plants, inventories should be done to determine whether desirable species might be adversely affected by establishing a competitor. Management practices such as prescribed burning, mowing, or controlled grazing that encourage desirable (or less offensive) onsite species without planting may be the most realistic and appropriate objective for many large-scale yellow starthistle infestations.

Natural areas appear to be the least suited sites for competitive plantings because of the inherent problems mentioned previously. Arable lands including roadsides, converted farmland, borders of agricultural fields, pastures, vineyard "middles", orchard floors, and other disturbed areas with seedbanks that are already dominated by exotic species are sites most appropriate for plantings. In addition to controlling yellow starthistle, improved vegetation management on these sites can create wildlife and beneficial insect habitat, decrease soil erosion, improve water quality, provide forage, and enhance soil structure and fertility. The research opportunities are enormous.

Acknowledgement

Thanks to Robert L. Bugg of the University of California Sustainable Agriculture Research and Education Program for reviewing this manuscript and for his helpful comments.

Literature Cited

Asher, J.E. and D.W. Harmon 1995. Invasive exotic plants are destroying the naturalness of U.S. wilderness areas. Inter. J. of Wilderness 1(2):35-37.

Bawtree, A.H. 1992. Crested wheatgrass seedings and knapweed in British Columbia. Knapweed 6(2):2-3. Wash. State U. Coop. Ext.

Brown, Cynthia, 1996. Oral communication. UC Davis graduate group, Ecology.

Burcham, L. T. 1957. California rangeland. Sacramento:Calif. Dept. of Forestry. 291 p.

California Exotic Plant Pest Council, 1996. Exotic Pest Plants of greatest ecological concern in California as of August 1996.

Callihan, R.H., J.B. Johnson, and E. L. Michalson 1987. Yellow starthistle cooperative agreement #58-9AHZ-1-574, U. of Idaho, Dept. Plant, Soil, and Entomological Sciences.

Cordy, D.R. 1978. Centaurea species and equine nigropallidal encephalomalacia. In Keeler, R.F., K.R. Van Kampen and L.F. James (eds.) Effects of Poisonous Plants on Livestock. Academic Press, pp. 327-336.

Dyksterhaus, E. J. 1949. Condition and management of rangeland based on quantitative ecology. J. of Range Manage. 2(3):104-115.

Edwards, S.W. 1992. Observations on the prehistory and ecology of grazing in California. Fremontia 20(l):3-11.

Ehrlich and Murphy 1989. Conservation biology of California's remnant native grasslands. In: Huenneke, L.F. and Mooney, H (eds.) Grassland structure and function: California annual grassland. pp.47-58. Kluwer Academic Publishers.

Gerlach, John 1996. Oral communication. UC Davis graduate group, Ecology.

Heady, H.F. 1977. Valley grassland. In M.G. Barbour and J. Major (eds.) Terrestrial Vegetation of California. John Wiley and Sons.

Johnson, P.E. and M.M. Borman 1992. Yellow starthistle control research in Southwestern Oregon. Knapweed 6(2):3-4. Wash. State U. Coop. Ext.

Johnson, A. and R.W. Peake 1960. Effect of selective grazing by sheep on the control of leafy spurge *(Euphorbia esula* L.). J. of Range Manage. 13:192-195.

Kelsey, R.G. and R. D. Mikalovich 1987. Nutrient comoposition of spotted knapweed *(Centaurea nzaculosa).* J. of Range Manaze. 40(3):277-281.

Larson, L., G. Kienmec and M. McInnis 1992. Effects of water and salt stress on yellow starthistle germination and root growth. Knapweed 6(2):3.

Lusk, W. C., M. B. Jones, P. J. Torrell, and C. M. McKell 1961. Medusahead palatabiltiy. J. of Range Manage. 14248-241.

Menke, J.W. 1992. Grazing and fire management for native perennial grass restoration in California grasslands. Fremontia 20 (2):2-25.

Mosher, W. 1979. Use of sheep in control of tansy ragwort. In: (ed.) P.R. Cheeke, Symposium on Pyrrolyzidine *(Senecio)* Alkaloids: Toxicity, Metabolism and Poisonous Plant Control Measures. Oregon State U. pp. 157-159,

Murphy, A.H., R.M. Love, and L.J. Berry 1954. Improving Klamath weed ranges. Calif. Agric. Exp. Sta. Circ. 437. 15 pp.

Parker, K.W. 1949. Control of noxious range plants in a range management program. J. of Range Manage. 2(3):128-132.

Sheley, R.L. and L.L Larson 1994. Comparative growth and interference between cheatgrass and yellow starthistle seedlings. J. Range Manage. 47(6):470-474.

Thomsen, C.D., W. A. Williams. M.R. George. W.B. McHenry. F.L.. Bell, and R.S. Knight 1989. Managing yellow starthistle on rangeland. Calif. Agric. 43(5):4-6.

Thomsen, C.D., W. A. Williams, M. P. Vayssi&es, F.L. Bell. and M. R. George 1993. Controlled grazing on annual grassland decreases yellow starthistle. Calif. Agric. 47(6):36-40.

Thomsen, C.D., W. A. Williams, W. Olkowski, and D.W. Pratt 1996. Grazing, mowing and clover plantings control yellow starthistle. IPM Practitioner 18(2):1-4.