Implementing Effective Noxious Range Weed Control On Rangelands

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After decades of declining interest in range weed control, public concern has demanded that something be done. The nature of the problem has forged coalitions of strange bed fellows. Ranchers face declining forage production, wildlife mangers see junipers replacing browse species, weed control districts scream that reinfestation of noxious weeds occurs from public rangeland watersheds, and nature conservancy groups decry loss of biological diversity to alien weeds. This has culminated in proposed national legislation directing public land management agencies to control noxious weeds on federal lands and to provide adequate funding for such an effort.

Our purpose is to provide a brief historical perspective on range weed control in the context of present weed inventory, biological and herbicidal control technologies, and regulatory policies.

Noxious Weeds. The proposed federal legislation is specifically aimed toward those weeds that have been legally designated by state and/or the federal government as *noxious* (Tables 1 and 2). These weeds have characteristics that make them a threat to agronomic agriculture, grazing lands, and the environment in general if they are allowed to be introduced or spread without control. The legal connotation of being a *noxious* weed bans importation, transportation, and contamination in commercial seed lots by these species.

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The Federal list of *noxious* weeds has some species that are presently a serious pest on United States rangelands such as the grass *Curpina vulgaris* which occurs in the Pacific Northwest. The perennial species of Russian thistle, *Salsola vermiculata*, occurs in California where it provides valuable forage on rangelands, but is an alternate host for viral diseases that spread to crops. There are serious range weeds that are not yet introduced to the United States that are missing from the list. For example, *Stipa campensis* is an annual needlegrass found in southwestern Asia that is too tough and awned to serve as forage for camels. It probably is adapted to southern Great Basin ranges. From the species that are included and are absent, range managers have apparently not had a major role in developing the Federal *noxious* weed list.

We use the Nevada *noxious* weed list to provide species considered legally *noxious* by a western state, where agriculture is largely range livestock production. Each state has a slightly to markedly different list of *noxious* weeds. Some National Forests cross state boundaries and the conflicting lists can create problems.

Historic Range Weed Control. It is worth while to look at the history of range weed control to obtain a perspective on how the principles of range weed control evolved. The development of phenoxy herbicides after World War II had great application in vegetation management on rangelands. Most of the applications involved control of woody species that had increased on grazing lands. A major example was the use of 2,4-D to control excessively dense stands of sagebrush (*Artemisia tridentata*) to release perennial grasses from competition. Big sagebrush is neither a

Table 1. Adapted from the Federal list of noxious weeds as maintained by USDA-Animal and Plant Health Inspection Service. The list has the major categories: 1) aquatic, 2) terrestrial, and 3) parasitic species. The portion of the terrestrial category that would appear most likely to influence rangeland environments is reported in the table.

Scientific name	Common name
Avena sterilis	sterile oat
Crupina vulgaris	common crupina
Digitaria abyssinica	African couchgrass
D. velutina	annual couchgrass
Euphorbia prunifolia	painted euphorbia
Galega officinalis	goatsrue
Imperata brasiliensis	Brazilian satintail
Ischaemum rugosum	murainograss
Leptochloa chinensis	Asian sprangletop
Opuntia aurantiaca	jointed prickly pear
Pennisetum clandestinum	Kikuyugrass
P. macrourum	African feathergrass
P. polystachion	missiongrass
Prosopis (There are 25 species on the list)	
Salsola vermiculata	wormleaf salsola
Urochloa panicoides	liverseed grass

Table 2. Weeds that are legally classified as *noxious* in the state of Nevada. Each state has a list of weeds considered *noxious*. The more wide spread and troublesome weeds may occur on most of the state lists. A weed declared *noxious* in a particular state may or may not have the same legal designation in a neighboring state. The state lists are in addition to the Federal *noxious* weed list.

Scientific name	Common name
Rorippa austriaca	Austrian fieldcress
Sphaerophysa salsula	Austrian peaweed
Alhagi camelorum	Camelthorn
Hypericum perforatum	Klamath weed
Conium maculatum	Poison hemlock
Cicuta spp.	Hemlock
Solanum carolinense	Carolina horse nettle
S. elaeagnifolium	White horse nettle
Centaurea diffusa	Diffuse knapweed
C. repens	Russian knapweed
C. iberica	Iberian star thistle
C. calcitrapa	Purple star thistle
C. solstiltialis	Yellow star thistle
Euphorbia esula	Leafy spurge
Glycyrrhiza lepidota	Licorice
Salvia aethiopis	Mediterranean sage
Taeniatherum caput-meduase subsp.*asperum*	Medusahead
Tribulus terrestris	Puncture vine
Cirsium arvense	Canada thistle
Carduus nutans	Musk thistle
Onopordum acanthium	Scotch thistle
Sonchus arvensis	Sow thistle
Linara dalmatica	Dalmatian toadflax
Cardaria draba	Hoary cress
Lepidium latifolium	Perennial pepperweed
Sorghum spp.	Perennial species

noxious nor a self invasive species outside of areas where it is adapted, but it is a long-lived, woody perennial that can increase in population density and suppresses perennial herbaceous species. Range managers soon learned there was no use in controlling big sagebrush unless there were sufficient perennial grasses in the under story to preempt the environmental potential released by reducing the brush. You had to be able to step from remnant perennial grass bunch to bunch for the brush control to be effective in increasing desirable forage production.

The first generation herbicides such as 2,4-D were used for attempted control of such *noxious* range weeds as Canada thistle (*Cirsium arvense*). Canada thistle shares many of the characteristics of perennial *noxious* weeds in having creeping rootstocks that give rise to multiple stems, producing dense colonies that virtually smother through competition, all other vegetation. Canada thistle also is an excellent seed producer and is a phenotypically and genotypical highly variable. It required careful timing and repeated applications of 2,4-D to suppress weeds like Canada thistle, with eradication being seldom achieved.

Attempted control of the introduced poisonous plant halogeton (*Halogeton glomeratus*) with applications of 2,4-D did much to further elucidate the basic principals of range weed control. Halogeton is a fleshy annual that when young is susceptible to applications of 2,4-D. Halogeton produces huge amounts of black seeds, but they have very short lives in seedbanks. Initially it appeared that control of one or two generations of a given infestation would result in eradication. Halogeton is not a particularly competitive species and is readily suppressed by establishment of perennial plants. The rapid spread of halogeton across the Intermountain Area during the 1940s was a symptom of the underlying degradation of many salt desert rangelands from past abusive grazing.

Principles of range weed control that grew out of the halogeton control program were: 1) you have to have an adapted species to replace the weed once it is controlled, and 2) you have to understand the seed ecology of the weed being controlled. At the time it was not recognized the brown form of halogeton seeds had delayed germination and persisted in seedbanks for many years. In the more mesic big sagebrush zone several million acres were seeded to crested wheatgrass (*Agropyron desertorum*) to biologically suppress halogeton. In the salt desert zone an adapted perennial species to replace halogeton was not available. The native shrubs around halogeton infestations were susceptible to applications of 2,4-D. The unintentional killing of native shrubs enlarged the area where halogeton was adapted and the brown seeds provided seedlings to occupy the sites.

A second generation of herbicides represented by such compounds as atrazine were developed for use in herbicidal fallow techniques for the control of such herbaceous range weeds as cheatgrass (*Bromus tectorum*), to permit the establishment of perennial herbaceous or woody species. Cheatgrass is an example of a highly invasive species that is not a *noxious* weed.

Biological Control. The use of introduced organisms that suppress populations of a specific weed has had notable success on rangelands. The control of Klamath weed (*Hypericum perforatum*), a poisonous perennial herb, is an example of biological control with an introduced insect. Another, more recent example is the control of tansey ragwort (*Senecio jacobaea*), a poisonous biennial, using insects introduced from Europe. Biological control does not lead to eradication, but rather long term, sustainable suppression of weed populations. Research on the biological control of range weeds is underway for several other species using plant pathogens as well as insects (Table 3).

The failure to find a biological control organism for halogeton illustrates some of the problems with the

Table 3. Examples of the types of biological control agents, target species, and status of biological control programs for selected range weeds. Data compiled by the USDA-ARS, biological weed control laboratories in Albany, California and Bozeman, Montana.

Biological control agent	Type	Developmental status	Date released in USA	Plant part attacked
		Diffuse knapweed Centaurea diffusa		
Aceria centaureae	mite	quarantine study		galls leaves
Bangasternus fausti	weevil	established	1990	seed head
Larinus minutus	weevil	established	1992	" "
Metzneria paucipunctella	moth	established	1975	" "
Pelochrista medullana	moth	released	1984	root
Pterolonche inspersa	moth	released	1986	"
Puccinia jaceae	fungus	released	-	leaves
Sclerotiorum scerotiorum	fungus	native	-	crown
Sphenoptera jugoslavica	beetle	established	1981	roots
Urophora affinis	teph. fly	established	1973	seed head
U. quadrifasciat[1]	teph. fly	established	1988	" "
		Spotted knapweed *Centaurea maculosa*		
Agapeta zoegana	moth	established	1984	roots
Bangasternus fausti	weevil	established	1990	seed head
Chaetorellia acrolophi	fly	established	1993	" "
Cyphocleonus achates	weevil	established	1988	roots
Larinus minutus	weevil	established	1992	seed head
Metzneria paucipunctella	moth	established	1976	" "
Pelochrista medullana	moth	released	1984	root
Pterolonche inspersa	moth	released	1986	"
Sclerotinia sclerotiorum	fungus	native	-	crown
Terellia virens	teph. fly	established	1993	seed head
Urophora affinis	teph. fly	established	1973	" "
U. quadrifasciata[1]	teph. fly	established	1988[1]	" "
		Squarrose knapweed *Centaurea virgata* spp. *squarrosa*		
Pterolonche inspersa	moth	released	1990	root
Urophora affinis	teph. fly	established	1988	seed head
U. quadrifasciata	teph. fly	established	1988	" "
		Russian knapweed *Acroptilon repens*		
Alternaria sp.	fungus			leaves
Puccinia acroptili		fungus		"
Sclerotinia sclerotiorum	fungus	native		crown
Subanguina picridis	nematode	established	1984	leaves,stems
		Leafy spruge *Euphoria escula*		
Aphthona abdominalis	flea beetle	released	1993	roots, leaves
A. cyparissiae	flea beetle	established	1987	" "
A. czwalinae	flea beetle	established	1987	" "
A. lacertosa	flea beetle	released	1992	" "
A. seriata	flea beetle	quarantine study		" "
Chamaesphecia crassicornis	moth	quarantine study		roots
C. empiformis	moth	released		"
C. hungarica	moth	released	1993	"
Dasineura sp. nr. capsulae	fly	permit approved	1991	shoot tips
Hyles euphorbiae	moth	established	1966	leaves/flowers
Oberea erythrocephala	beetle	established	1982	stems/roots
Oxicesta geographica	moth	quarantine study		leaves/flowers
Simyra dentinosa	moth	quarantine study		" "
Spurgia esulae	fly	established	1986	shoot tip
		Klamath weed *Hypericum perforatum*		
Agrilus hyperici	beetle	established	1950	roots
Aplocera plagiata	moth	established	1989	leaves/flowers
Chrysolina hyperici	beetle	established	1945	" "
C. quadrigemina	beetle	established	1946	" "
Zeuxidiplosis giardi	fly	established	1950	leaves

(***Table 3 continued on page 161***)

(Table 3. Continued).

Biological control agent	Type	Developmental status	Date released in USA	Plant part attacked
		Canada thistle *Cirsium arvense*		
Ceutorhynchus litura	weevil	established	1972	stems/roots
Urophora cardui	teph. fly	established	1986	stems
		Musk thistle *Carduus nutans*		
Cheilosia corydon	fly	released	1990	stems/roots
Psylliodes chalcomera	flea beetle	quarantine study		leaves
Rhinocyllus conicus	weevil	established	1969	seed head/stems
Trichosirocalus horridus	weevil	established	1974	rosette shoot tip
		Yellow Star Thistle *Centaurea solstitialis*		
Bangasternus orientalis	weevil	established	1985	seed head
Chaetorellia australis	teph. fly	established	1988	" "
Eustenopus villosus	weevil	established	1990	" "
Larinus curtus	weevil	established	1992	" "
Urophora sirunaseva	teph. fly	established	1984	" "
		Tansy ragwort *Sevecio jacobaea*		
Hylemyia seneciella	fly	established	1966	seed head
Longitarsus jocobaeae	flea beetle	established	1969	leaves, roots
Tyria jacobaeae	moth	established	1959	leaves, flowers
		Mediterranean sage *Salvia aethiopis*		
Phrydiuchus spilmani	weevil	released	1969	root crown
Phrydiuchus tau	weevil	established	1971	" "
		Bull thistle, *Cirsium vulgare*		
Urophora stylata	teph. fly	established	1983	seed head
		Scotch Broom, *Cytisi scoparius*		
Apion fuscirostre	weevil	established	1964	seeds
Leucoptera spartifoliella	moth	established	1960	twigs
		Gorse, *Ulex europaeus*		
Apion ulicis	weevil	established	1953	seeds
Tetranychus lintearius	spider mite	released	1994	shoots

[1] Migrated south from release in Canada at earlier date.

method. Halogeton is a member of the goosefoot family that contains valuable crop species (i.e. sugar beets) and numerous important native range species (i.e. saltbushes, *Atriplex*). Obviously any imported parasitic insect has to be highly specific. Biological control scientists had difficulty getting access during the Cold War to Central Asia where halogeton is native. When they were able to collect in the native habitat they found it to be a infrequent species that did not have a lot of natural enemies. Some species are more amenable to biological control than others.

Range managers can obtain information on biological control agents through their local weed control district or extension agent. The biological control agent can be obtained from public and in some cases private sources. Many Land Grant universities have extension specialist in biological control. Public land management agencies have conducted training programs on the availability and use of biological agents. The USDA agency, Animal and Plant Health Inspection Service (APHIS), has information available on biological control agents through their offices in each state. USDA, Agriculture Research Service, maintains biological weed control laboratories in Albany, California, Bozeman, Montana, and Temple, Texas. Information on target weeds and biological control agents can be obtained from these laboratories.

Land managers using biological control agents should recognize that management practices such as grazing timing and intensity, herbicide application, prescribed burning, and fertilization may interact with the control organism and can have adverse affects. Excessive utilization of meadows, especially at the wrong season, can disrupt *Rhinocyllus conicus* on musk thistle (*Carduus nutans*) and result in the weevils moving to less disturbed areas.

Initiation Of Noxious Weed Suppression Programs

Inventory. A necessary first step in developing *noxious* weed suppression programs on rangelands is the development of precise data bases on the nature and extent of existing infestations. Their are a lot of partial data bases for *noxious* weeds already developed. In each state the state

Fig. 1A. *Dense stand of leafy spurge* (Euphorbia escula) *in Montana in 1991 at the time of the release of the biological control insect* Aphthona nigriscutis. *(Photograph from Biological Control of Weeds research unit, USDA-ARS Bozeman, MT)*

Fig. 1B. *Same location in 1994 with leafy spurge hardly evident on the site.*

department of agriculture is usually charged with the regulatory aspects of *noxious* weed programs. California has a rather comprehensive state wide inventory system for *noxious* and potentially *noxious* weeds, but it is based on presence or absence within townships. Obviously the local range manager needs a more detailed mapping system. Many land management agencies have, or are in the process of developing comprehensive Geographical Information Systems (GIS). The distribution of *noxious* weeds needs to be integrated with these systems. In order to accomplish accurate delineation of weed infestations land managers have to be able to recognize *noxious* and potentially *noxious* weeds. There is going to have to be an educational program within management agencies and among resource users.

Quarantine and Sanitation. Avoiding infestations of *noxious* weeds is perhaps the most overlooked tool in weed control. On rangelands this has recently become an issue in wilderness areas in terms of transporting weed free hay for pack animals. There is an example in eastern Oregon of a huge infestation of yellow star thistle (*Centaurea solstitialis*) that reportedly developed from an introduction of road construction equipment on a project designed to protect riparian habitat. Track laying tractors often transport soil and potentially weed vegetative

Fig. 2. Aphthona flava *feeding on leafy spurge* (Euphorbia escula). *(Photograph from Biological Control of Weeds research unit, USDA, ARS, Bozeman, MT.*

propagules and/or seeds from one job to the next. Specifying in contracts that construction equipment must be cleaned before transportation to the job site may prevent major problems. Land managers should always be cognizant of potential *noxious* weed contamination of seed used in revegetation projects. Read the seed tags and have seed lots tested by Association of Official Seed Analysts laboratories before planting. Livestock movement from infested ranges is a contributing factor to the spread of weed infestations.

Range managers should always remember that quality range management is the first line of defense against the introduction of *noxious* weeds. Weeds are colonizing species that usually rely on some form of disturbance for initial establishment. Maintaining diverse communities dominated by perennial species is the key to weed prevention on most ranges.

Spot Infestation. The suppression/eradication of spot infestations before they have a chance to spread is the most economical and probably biologically least disruptive to suppress *noxious* weed infestations once they occur. This has to be a site and species-specific decision and one that requires careful planning and thought. Always consider the first principle of range weed control: If you control the weed you have to be able to substitute a desirable perennial species to preempt the environmental potential released through the weed suppression. If you leave a void in the community it will be reoccupied by the weed or another weed species. The second principle of range weed control, the nature of seedbanks, also has to enter the thought process in determining if eradication or suppression should be the object of control programs for spot infestations. Will seedbanks keep feeding seedlings into the plant community for 0, 1, 10, or 20 years?

Landscape Infestations. Range managers who face *noxious* weed infestations on the landscape, as opposed to spot infestations, face a very difficult problem, but the same basic approach of integrated weed suppression is applicable. Inventory on a range site basis is a necessary first step. Integration of all available management options of biological control, biological suppression through grazing management and natural and artificial desirable vegetation seedling recruitment, and fire management has to be employed. On specific sites herbicidal, mechanical or even hand applied weed control will be appropriate.

Noxious Weed Control As Viewed By The Public

Virtually every knowledgeable biologist realizes that the consequences of uncontrolled spread of *noxious* weeds on rangelands is a gross reduction in biological diversity. Agricultural interests have long considered *noxious* weed infestations on rangelands as potential sources of infestation for croplands. It certainly behooves range managers to make an effort to educate the general public on the importance of the control *of noxious* weeds, and to make sure the suppression program for these weeds on rangelands is applied in an environmentally sound, biologically and economically effective manner.