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Biological Control of Invasive Range Weeds in Nevada

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OUTLAW WEEDS!

Nevada Project WEEDS

University of Nevada, Reno
Cooperative Extension

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BIOLOGICAL CONTROL of INVASIVE RANGE WEEDS in NEVADA

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INTRODUCTION

Noxious weed encroachment is a serious threat to the ecological balance of Nevada's rangeland resource. Exotic, invasive, noxious weeds are plants that have the ability to outcompete a complex of native range plants. This results in extensive monocultures of the introduced species gradually displacing the diverse plant and animal communities native to the Great Basin. Replaced are the various plant associations and communities that support a diversity of animal species especially adapted to the Great Basin environment. The native plant and animal associations are not easily restored once disturbed.

All of our invasive plant species were introduced from Europe or Asia. They became widespread in various areas of the western United States because their native range had a similar environment. Some examples of this include: squarrose knapweed, native to southeastern Europe and Central Asia; yellow starthistle, native to southern Eurasia and the Mediterranean Basin; and saltcedar, native to central and southwestern Asia. In each of these examples, the plant is not a problem in its home range because of the natural suppression and stresses not introduced to this country along with the plant.

There are several tools being used to fight the spread of exotic noxious weeds in the Great Basin. Chemical control has proved effective on some species but may not be economically or ecologically effective in every instance. Cultural practices may be used with some annuals but perennials are often spread or benefited by disturbance. Prevention is always the preferred method of control but unintentional spread of seeds or plant parts on vehicles and animal movements is inevitable. Finally, biological control is a tool that has great promise of controlling the spread and impact of noxious weeds to our native rangelands.

UNDERSTANDING BIOLOGICAL CONTROL

Biological control is the intentional introduction of agents that incrementally stress the target species. When the noxious weed is stressed, it is less competitive with native plant communities. It must be remembered that biological control is not a tool to be used without other control measures. When the invasive weed population has become economically or ecologically uncontrollable with simpler measures, biocontrol should be considered.

> ***Noxious weed encroachment is a serious threat to the ecological balance of Nevada's rangeland resource.***

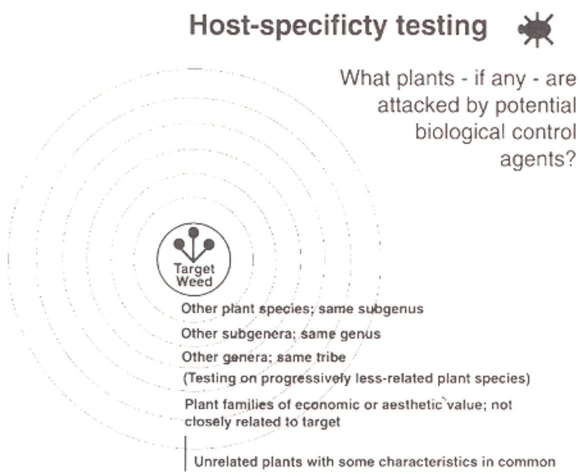
Large areas of weed species infestations are required for the biological agent to reproduce and survive. The target invasive plant species is never eradicated. Biological control agents leave a population of the invasive weed species where the control agent reproduces. Therefore, if eradication of the target species is the goal, biological control agents are not an appropriate tool. It is generally agreed by researchers that for

> ***All of our invasive plant species were introduced from Europe or Asia.***

most invasive plant species between seven and ten biological agents, each of which add stress to the target plant species, is necessary before sufficient stress is placed on a species so that it is no longer able to outcompete most other vegetation.

In the United States, the procedure for determining appropriate control agents is quite rigorous and expensive. Initially, public demand, or the well being of a particular industry, determines appropriate target weed species. At this point, other management tools have been deemed ineffective or uneconomical. Potential biological control agents are identified in the home ranges of the target weed. They undergo extensive testing overseas to determine their effectiveness at controlling the target species and to ascertain their potential for harm to an economically or environmentally important native species. These "starvation" tests prove that the potential biological control agent will starve to death rather than feed on plant species other than the target. Failure to pass this test eliminates the insect from importation into the United States. Figure 1 shows the process that must be undertaken before an exotic control agent can be introduced into this country.

Figure 1.



After passing "starvation" tests, the potential biological agent is imported into the United States for further testing. If the biological agent is an insect, usually the number imported is quite small. The agent must first be multiplied into sufficient numbers for experiments to be conducted.

Several crucial questions are then asked and tested. Will the insects react the same to the plant outside of its own environmental conditions? Will there be additional stress placed upon the target weed by the biological agent? Will the control agent reproduce or form important social structures in the new environment? How will the agent be dispersed? Will the agent populations survive predators in the new environment? In what specific environments is the biological agent effective? Only when these questions are answered positively, will the agent be released into the environment to fill its niche as part of the system.

The time it takes from the point of release until the agent is sufficiently established to impact the target species could take years, or even decades. There are many environmental factors that influence the action of a particular biological control agent. Also, frequently, more than one control agent is required to adequately stress widespread infestations of a particular plant species. For example, there are currently 14 control agents for spotted knapweed cleared for release now in the United States. Even

Establishment of biological agents takes a substantial period of time.

with that number of biological agents the range of encroachment by spotted knapweed is still increasing, but at a slower pace.

Biological control agents have numerous advantages and disadvantages when compared to other management methods. Once biological agents are in place, they are usually self-perpetuating in conjunction with the available food supply. Therefore, once established the long-term control cost is minimal. Biological agents have a searching ability to locate their hosts and it is unlikely that the target species will develop a resistance to the control agent. Control can be quite effective once biological agents place sufficient stress to limit the competitive vigor of the target organism. Finally, chemical use may not be permitted in many places. Biological control can be one of the tools used to control noxious weeds in environmentally sensitive areas.

Some disadvantages of using biological control include the need for a large infestation before the control agent can survive and reproduce. Also, since the invasive weed and its control agent have become part of the overall plant community, the target species will never be completely eradicated. The object is to reduce the density of the weed to some economic or biological threshold. A measure of control, between 0%-90%, can be expected according to the experiences of past biocontrol research around the country.

BIOLOGICAL CONTROL AGENTS

Table 1 is a list of invasive weed species that threaten Nevada, the biological agents which have been approved for release in the U.S., and those which have been introduced into Nevada by the spring of 1996:

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
musk thistle , nodding thistle (*Carduus nutans*) originated in southern Europe and western Asia	(*Cheilosia corydon*) thistle crown fly, A fly from Italy whose larvae feeds inside of the root crown	1990	1996 WP[1] Co.
	(*Rhinocyllus conicus*) thistle head weevil. A European weevil which feeds upon the seed heads	1969	1994 Wa Co. 1996 La Co.
	(*Psylliodes chalcomera*) Italian flea beetle feeds upon the growing tips of buds and stems	quarantine	
	(*Trichosirocalus horridus*) thistle crown weevil. An Italian weevil which feeds upon the rosette shoot tip	1974	
	(*Puccinia carduorum*) musk thistle rust. Turkish rust which reduces seed set	1987	
spotted knapweed (*Centaurea maculosa*) native of central Europe	(*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies. Two different European fly species which lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant	1973 and 1988	1995 WP Co. 1995 WP Co.
	(*Agapeta zoegana*) sulphur knapweed moth, a Yugoslavian moth that mines within the root.	1984	1995 WP Co.
	(*Cyphocleonis achates*) knapweed root weevil, larvae of an Asian weevil that feeds within the root crown	1988	1996 WP Co.
	(*Metzneria paucipunctella*) spotted knapweed seed head moth, a yellow Swiss moth that feeds upon the seed	1976	
	(*Bangasternus fausti*) broad-nosed seed head weevil. A		

[1] County abbreviations: WP – White Pine County, Wa - Washoe County, La – Lander County, El – Elko County, Hu – Humbolt County, Li – Lincoln County, Cl – Clark County, and Ly – Lyon County.

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
	Greek weevil that feeds upon the seed head		
	(*Chaetorellia acrolophi*) knapweed peacock fly, a European fly that feeds upon the seed head	1990	
	(*Larinus minutus*) lesser knapweed flower weevil and the blunt knapweed flower weevil (*L. obtusus*) Greek weevils that feeds upon the seed head	1993 1992	
	(*Pelochrista medullana*) brown-winged root moth, a Romanian moth that feeds upon the root	1984	
	(*Pterolonche inspersa*) grey-winged root moth, a European moth that feeds upon the root	1986	
	(*Sphenoptera jogoslavica*) bronze knapweed root-borer, a Greek beetle that feeds within the root	1981	
	(*Terellia virens*) green clearwing fly, an Austrian teph fly that feeds within the seed head	1993	
	(*Aceria centaureae*) knapweed blister mite, a Greek blister mite which produces leaf galls	not released	
	(*Sclerotinia sclerotiorum*) a fungus on the crown of the plant	native	
russian knapweed, Turkestan thistle (*Centaurea repens*) native to the southern Ukraine, southeast Ruyssian, Iran, Kazakhstan & Mongolia	(*Subanquina picridis*) Russian knapweed gall, a Turkish nematode that bores into the leaves and stems	1984	
	(*Alternaria* sp.) a fungus of the leaves and stem	unknown	
	(*Puccinia acroptili*) a fungus of the leaves	unknown	
	(*Sclerotinia sclerotiorum*) a fungus on the crown of the plant	native	
squarrose knapweed (*Centaurea virgata* ssp *squarrosa*) native to central Asia and the Middle East	(*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies, Two different fly species which lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant.	1988	
	(*Pterolonche inspersa*) a European moth that feeds on the root	1990	
	(*Bangasternus fausti*) broad-nosed seed head weevil. A Greek weevil that feeds upon the seed head	1993	
diffuse knapweed, tumble knapweed (*Centaurea diffusa*) native from southern Europe to northcentral Ukraine.	(*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies, Two different fly species which lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant.	1973 and 1988	1993 Wa Co. 1993 Wa Co.
	(*Aceria centaureau*) a mite that forces the plant to form galls on the leaves	quarantine	
	(*Agapeta zoegana*) sulphur knapweed moth, a Yugoslavian moth that mines within the root.	1984	1993 Wa Co.
	(*Bangasternus fausti*) broad-nosed seed head weevil. A Greek weevil thatfeeds upon the seed head	1990	
	(*Subanquina picridis*) a Turkish nematode that bores into the leaves and stems	1984	
	(*Larinus minutus*) lesser knapweed flower weevil and the blunt knapweed flower weevil (*L. obtusus*) Greek seed head feeding weevils	1992	
	(*Metzneria paucipunctella*) spotted knapweed seed head moth, a yellow Swiss moth that feeds upon the seed	1975	
	(*Pelochrista medullana*) brown-winged root moth, a Romanian moth that feeds upon the root	1984	
	(*Pterolonche inspersa*) grey-winged root moth, a European moth that feeds upon the root	1986	
	(*Puccinia jaceae*) a fungus that works on the leaves of the plant	unknown	
	(*Sclerotinia sclerotiorum*) a fungus on the crown of the		

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
	plant	native	
	(*Sphenoptera jogoslavica*) bronze knapweed root-borer, a Greek beetle that feeds within the root	1981	1995 Wa Co.
	(*Terellia virens*) green clearwing fly, an Austrian teph fly that feeds within the seed head	1993	
	(*Aceria centaureae*) knapweed blister mite, a Greek blister mite which produces leaf galls	not released	
	(*Chaetorellia acrolophi*) knapweed peacock fly, a European fly that feeds upon the seed head	1993	
yellow starthistle, St. Barnaby's thistle (*Centaurea solstitalis*) native of southern Europe	yellow starthistle bud weevil (*Bangasternus orientalis*) a Greek seed head feeding weevil	1985	None
	yellow starthistle peacock fly (*Chaetorellia australis*) a Greek seed head fly	1988	
	yellow starthistle hairy weevil (*Eustenopus villosus*)) a Greek weevil that feeds on early bud stages of the seed head	1990	
	yellow starthistle flower weevil (*Larinus curtus*)) a Greek seed head feeding weevil	1992	
	yellow starthistle gall fly (*Urophora sirunaseva*) a Greek fly which feeds in the developing seeds	1984	
	knapweed blister mite (*Aceria centaureae*) a Greek blister mite which produces leaf galls	not released	
rush skeletonweed (*Chondrilla juncea*)* Native of qestern Europe and north Africa	skeletonweed gall midge (*Cystiphora schmidti*) A Greek stem and leaf feeding gall midge	1975	
	skeletonweed gall mite (*Eriophyes chondrillae*) An Italian gall mite which feeds upon the axillary and terminal buds	1977	
	rush skeletonweed rust (*Puccinia chondrillina*) An Italian rust of the entire plant	1976	
leafy spurge (*Euphoria escula*) a native of western asia	minute spurge flea beetle (*Aphthona abdominalis*)	1993	
	brown dot leafy spurge flea beetle (*A. Cyparissiae*)	1987	1991 El Co.
	black leafy spurge flea beetle (*A. Czwalinae*)	1987	
	brown-legged leafy spurge flea beetle (*A. Lacertosa*)	1992	1994 Hu Co.
	copper leafy spurge flea beetle (*A. Flava*)	1993	
	black dot leafy spurge flea beetle (*A. Nigriscutis*)	1989	
	(*A. chinchihi*), (*A. venustula*), and (*A. seriata*) Different European or Asian flea beetles that feed upon the leaves and roots.	not released, not released & quarantine	
	(*Chamaesphecia crassicornis*), (*C. empiformis*, (*C. tenthrediniformis*), (*C. astatiformis*), and Hungarian clearwing moth (*C. hungarica*) Yugoslavian moths that feed upon the roots	quarantine, quarantine, unknown, 1975 & 1993 1991	
	(*Dasineura* sp. *nr. capsulae*) an Italian fly that feeds upon the shoot tips	1966	
	leafy spurge hawkmoth (*Hyles euphorbiae*) a European moth that feeds upon the leaves and flowers	1982	
	red-headed leafy spurge stem borer (*Oberea erythrocephala*) a European beetle that feeds upon the stems and roots	quarantine	
	(*Oxicesta geographica*) a Russian moth that feeds in the leaves and flowers	quarantine	
	(*Simyra dentinosa*) a moth that feeds in the leaves and flowers	1986	1994 El Co.
	leafy spurge tip gall midge (*Spurgia esulae*) an Italian fly that feeds upon the shoot tips	not released not released	

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
	(*Oncochila simples*) an Italian bug causes defoliation (*Pegomya curticornis*) an Austrian fly that forms galls which cause wilting and death of shoots (*Pegomya euphorbiae*) a Yugoslavian fly that burrows into the stems	not released	
sulfur cinquefoil (*Potentilla recta*) is from the Mediterranean region*	None	None	None
common crupina (*Crupina vulgaris*)* a Mediterranian plant	None	None	None
scotch thistle (*Onopordum acanthium*) a Mediterranian thistle	(*Trichosirocalus horridus*) weevil (*Larinus latus*) a seed head weevil (*Tephritis postica*) a seed head fly (*Lixus cardui*) a stem-boring weevil (*Tettigometra* sp.) planthoppers	1995 experimental experimental experimental experimental	None
houndstongue (*Cynoglossum officinale*)*	None	None	None
hoary cress/whitetop (*Cardaria* ssp.)	None	None	None
perennial pepperweed, tall whitetop (*Lepidium latifolium*)	None	None	None
St. Johnswort, goatweed (*Hypericum perforatum*) native to western Europe, north Africa, and southern Asia	klamath weed beetles (*Chrysolina hyperici* and *C. quadrigemina*) multicolored European beetles that feeds upon the leaves and flowers of the plant. St. Johnswort borer (*Agrilus hyperici*) a French beetle that feeds upon the roots St. Johnswort inchworm (*Aplocera plagiata*) a French moth that feeds on the roots and flowers klamath weed midge (*Zeuxidiplosis giardi*) a French fly whose larve feed on the leaves	1945 & 1946 1945 & 1946 1950 1989 1950	1955 Wa Co. 1955 Wa Co. 1965 Wa Co.
purple lythrum, purple loosestrife (*Lythrum salicaria*) Native of Europe and north Africa	golden loosestrife beetle (*Galerucella calmariensis* and *G. pusilla*) German beetles that feeds upon the flower buds loosestrife root weevil (*Hylobius transversovittatus*) a German weevil that live within the roots and feed upon the foliage blunt loosestrife seed weevil (*Nanophyes brevis*) and the loosestrife seed weevil (*N. marmoratus*) European weevils that reduces seed production	1992 & 1992 1992 quarantine & 1994	None
Eurasian watermilfoil (*Myriophyllum spicatum*)	weevil (*Euhychiopsis lecontei*) and (*E. albertanus*) Feed on stem and leaves. May be native to North America moth (*Acentria nivea*) reduces apical meristem development milfoil midge (*Cricotopus myriophilli*) caddisfly (*Triaenodes tarda*) cuts leaflets weevil (*Phytobius leucogaster*) European moth (*Parapoynx stratiotata*)	1927? unknown	None
medusahead rye (*Taeniatherum caput-medusae*)	None	None	None
dalmation toadflax (*Linaria genistifolia* ssp. *dalmatica*) native of the Mediterranian	toadflax moth (*Calophasia lunula*) a European defoliating moth stem boring weevil (*Mecinus janthinus*) a Yugoslavian	1968 pending	1978 Li Co.

* No documented infestions of this plant species within Nevada, but potentially a problem plant species.

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
region	weevil root-boring moth (*Eteobalea intermediella*) a Mediterranean root boring moth toadflax flower-feeding beetle (*Brachypterolus pulicarius*) a European ovary feeding beetle root-galling weevil (*Gymnetron linariae*) German weevil	pending 1919 not released	
yellow toadflax (*Linaria vulgaris*) native to Eurasia	toadflax flower-feeding beetle (*Brachypterolus pulicarius*) a European ovary feeding beetle toadflax capsule weevil (*Gymnaetron antirrhini*) and (*G. netum*) Eurasian seed capsule feeding weevils toadflax moth (*Calophasia lunula*) a European defoliating moth root-boring moth (*Eteobalea serratella*) Yugoslavian root-boring moth root-galling weevil (*Gymnetron linariae*) German weevil	1919 1909 1968 not released not released	None
saltcedar, tamarisk (*Tamarix ramosissima*) a native of Chine and eastern Asia	(*Diorhabda elongata*)	1996	1996
downey brome (*Bromus tectorum*), a native of Eurasia	None	None	None

There are additional biological agents that have been released in Nevada on weed pests which are not considered "invasive" (capable of dominating plant biodiversity) in the Great Basin. Table 2 lists those weed pests and the biological agents that have been released on them.

Table 2. Other weed species of interest and some available potential biological control agents

Target Plant Species	Potential Biological Control Agents	Year introduced into the U.S.	Year introduced into Nevada
puncturevine (*Tribulus terrestris*) introduced from Eurasia or African	puncturevine seed weevil (*Microlarinus lareynii*) an Italian weevil which feeds upon developing seeds puncturevine stem weevil (Microlarinus lypriformis) an Italian weevil which mines the stems and roots	1961 1961	1961 Cl Co. 1963 Li Co.
poison hemlock (*Conium maculatum*) a Eurasian and African plant	defoliating hemlock moth (*Agonopterix alstroemeriana*) a European moth that feeds all over the plant	1973	unknown
Russian thistle (*Salsola kali*)	(*Coliaphora* sp.) the larvae feed on the plant		1970 Wa & Ly Co.
Canada thistle (*Cirsium arvense*) a native of Europe, Asia and Africa	Canada thistle stem weevil (*Ceutorhynchus litura*) a German weevil Canada thistle bud weevil (*Larinus planus*) a European weevil thistle stem gall fly (*Urophora cardui*) a central European fly	1972 unknown 1977	 1977 El Co.

Biological control is an evolving science. In order for it to be a useful tool in the effort to control invasive plant species additional knowledge is needed of the target plant and biological agents within Nevada. Because the Great Basin environment is frequently quite different than the environment of much of the surrounding states, frequently both the target plant and the biological agents react differently in those states environments.

To help make biological control efforts more effective within Nevada, there are a few things that still need understood. Scientists, state regulatory agencies, biological professionals, land management agencies, and the general public need to understand the opportunities and limitations of biological weed control projects. Other control efforts need strengthening in order to minimize the need for eventual movement to biological control as a last resort. A scientific method of selecting the best potential biological agents for the Great Basin needs to be developed. Research dollars need to be committed for development of biological agents on target plant pests peculiar to Nevada. Again, Nevada's high desert environment is different so systems used in other states may not work in our Great Basin. In addition, a system of release tracking, rearing, monitoring, redistribution, and effectiveness has started with the Division of Agriculture, but needs strengthening, within this state.

By implementing these steps, biological control agents can be an effective additional tool in the effort to keep invasive plant species from dominating the rangeland landscapes of Nevada.

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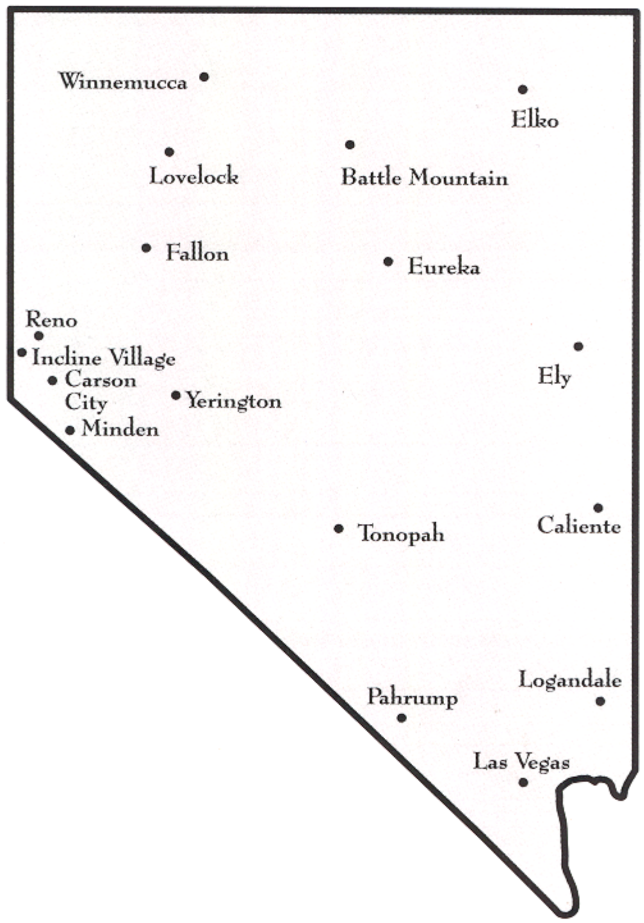

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