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Biological Control Options for Invasive Weeds in Nevada

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This publication provides a basis for evaluating the use of biological control agents of invasive weeds in Nevada. It includes a list of weeds with the currently available biological control agents that have shown promise in weed management programs. It also includes references for those interested in using livestock as a weed management agent.

Introduction

Noxious weed encroachment is a serious threat to the economic well-being and ecological balance of Nevada lands. A weed is normally declared as "noxious" by individual States. The state then decides the level of control or management required for each noxious weed by the owner of the property where it is found. In Nevada, this is codified under Chapter 555 of the Nevada Revised Statutes. A noxious designation is necessary for invasive, hard-to-control weeds that once established, come to dominate the infested lands, resulting in lost profits and greatly increased costs associated with management of these weeds. These exotic, invasive, weeds are plants that have demonstrated the ability to outcompete the complex of native plants occurring on lands that they invade. This results in extensive monocultures of the introduced weed species that gradually displace the more diverse plant and animal communities. These native plant and animal associations are not easily restored once lost to noxious weed invasions.

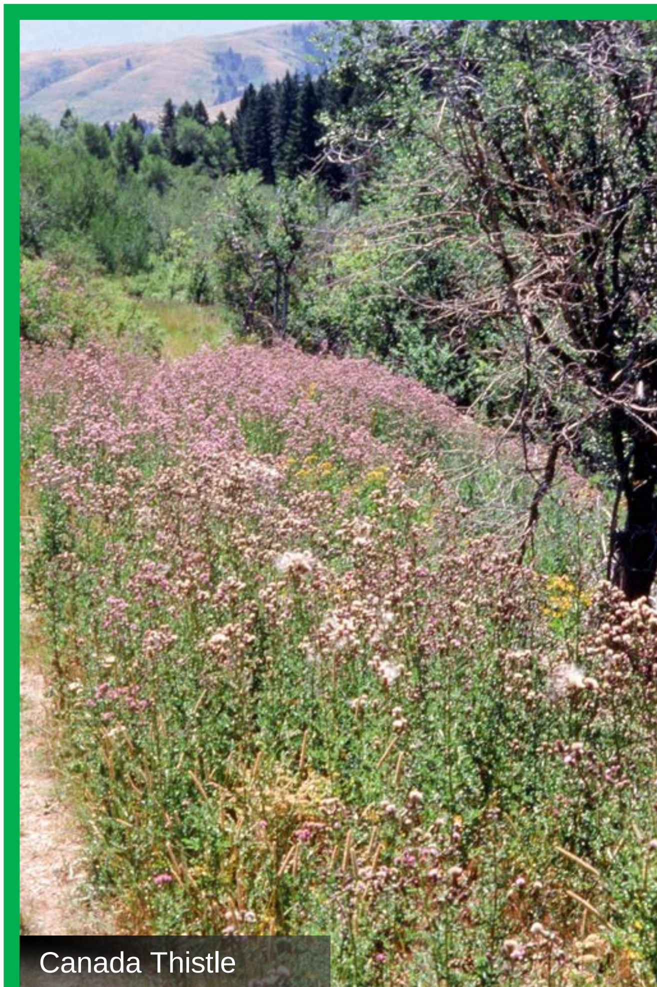

Yellow Starthistle

All of Nevada's most troublesome invasive plant species were introduced from Europe or Asia. They are widespread in various areas of the western United States because their native range had a similar environment, and the naturally occurring pests of these plants were not introduced into the U.S. at the same time as the weed. Some examples 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 local insects and disease complexes associated with the plants' native community limit the plants' density and spread in the native range. However, in a new ecosystem the weed is no longer challenged by these biological control agents and soon dominates large areas.

There are several tools being used to fight the spread of noxious weeds in the Great Basin and Nevada. Prevention is always the preferred method of control, but some unintentional spread of seeds or plant parts from waterways, vehicles and animal movements is inevitable. Chemical control has proved effective on some species but may not be economically or ecologically appropriate in every instance. Cultural practices such as repeated tillage may be used with some annual weeds but perennials are often spread or benefit by this disturbance. Biological control using insects or diseases specific to a particular weed species is a tool that has been utilized with some success in controlling the spread and impact of noxious weeds. The best approach is to utilize an integrated pest management (IPM) model whereby multiple control activities are used in a way that significantly reduces a noxious weed population at the lowest economic and environmental cost.

Understanding Biological Control

Biological control is the intentional introduction of a biological agent such as an insect that incrementally stresses the target weed species in order to help suppress weed populations without affecting other desirable plants growing in that location. When a noxious weed is stressed over time, it becomes less competitive with native plants. In a successful biological control program, the weedy species is not eradicated but the economic and ecological impact of that weed species is sharply reduced. After the successful establishment of a biological control agent such as an insect, a weed population will typically experience a dramatic decline in numbers. This is followed by a decline in the insect populations due to the reduction in the targeted weed numbers (food source). This allows the weed population to increase again, which is then followed by an increase in the insect population. This cycle continues over several years with a gradual, long-term reduction in the targeted weed species. It is not a short-term method of weed management, but when successful, provides a low-cost, noxious weed management option for landowners dealing with large-scale infestations. Biological control is not a first-line treatment for small patches or newly infested areas, because biological control agents usually take many years to become established and significantly suppress a weed population.



Canada Thistle

Biological control strategies should be considered when an invasive weed population has become economically or ecologically too large to be managed using traditional control methods. Large populations of a weed species are normally required for an introduced biological agent to reproduce and survive. The weed species is never eradicated because the bio-control agent requires a remnant plant population for reproduction and survival. If eradication of the target weed species is the goal, biological control agents are not usually an appropriate tool. A biological based weed management program when applied appropriately is, however, the best long-term option where invasive weeds have occupied extensive areas and are well established, and conventional control techniques are impractical due to economic or environmental limitations on the site. While there is some disagreement regarding the right combination(s) of agents for attack on a targeted plant, agents that attack several different parts of a plant simultaneously generally increase the effectiveness of the biological control program. As with any weed management program, the use of a biological control agent must be evaluated for costs and potential effectiveness at each location in which it will be applied.

There are several ways that weeds can be managed using biological control methods. Traditional biological control has focused on introducing an organism, usually an insect, to feed on a plant. However, in the past 10 years biological control has grown to include any management practice that uses a living organism to suppress a weed population. Livestock, disease-causing pathogens, mites and insects are all now being used as part of biological control strategies to suppress weeds. While the focus of this publication is on insects, which are the traditional biological control agents, it briefly discusses a new approach using livestock that has been effective in the United States and is growing in popularity.

Biological Control With Livestock Grazing

Some weeds can be reduced by selectively and intensively grazing the target weed with the proper species of livestock. When using livestock, several items must be considered before a management plan can be successfully implemented. As with any biological control agent, the use of livestock to manage weeds requires a long-term commitment to be successful. Selecting the proper species of livestock, training it to eat the target weed, and applying the grazing treatment at the appropriate time are the most critical parts of a successful management program. Although livestock are able to eat weeds that are not normally considered forage, they may not eat the weeds without proper training or exposure to the target weed. The timing or when the grazing treatment is applied is also critical to success. Proper timing will increase the effects of grazing, resulting in maximum damage to the targeted weed with minimal damage to desirable plants on the site. Grazing levels or intensity must be controlled for the same reason. In addition, steps should be taken to prevent viable weed seeds passing through the grazer's digestive system or those trapped in the coats of the livestock used to graze the infested areas from spreading to lands not infested by the target weeds when the livestock are moved. Animals should be isolated in holding pens for enough time (five to seven days) to ensure that viable seeds have all passed the digestive system before being moved to new grazing lands. Any weeds that grow in the holding areas should be killed to prevent additional spread.

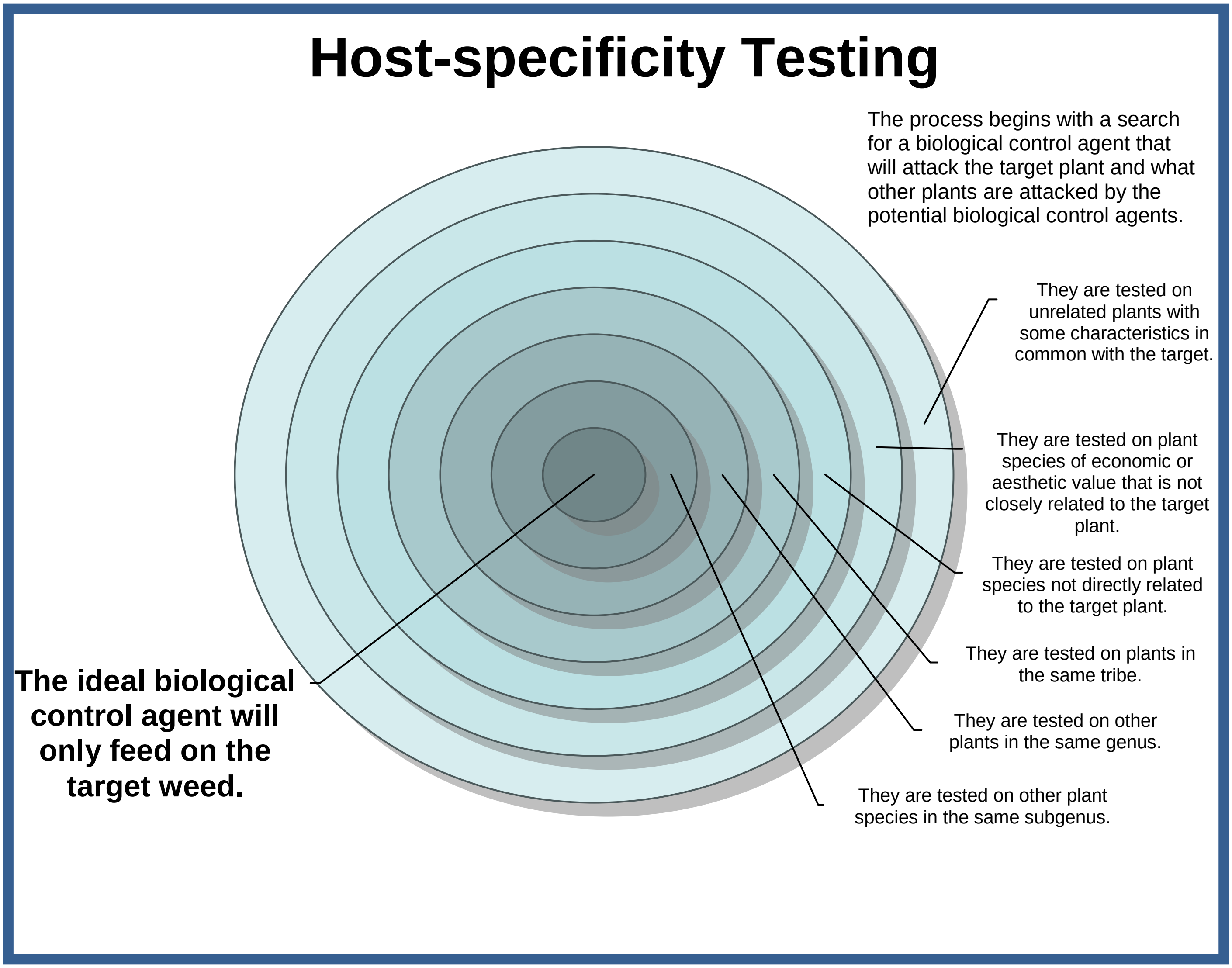
Urophora affinis a knapweed seed head gall fly on knapweed

These are just a few of the considerations necessary to implement a successful biological control program using livestock. Resources with comprehensive guidelines for using livestock to control weeds can be found in an Extension bulletin, 06-05, "Livestock Grazing Guidelines for Controlling Noxious Weeds in the Western United States," available from University of Nevada Cooperative Extension at http://www.unce.unr.edu/publications/files/ag/2006/eb0605.pdf and in the book "Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement" (Wilson, et. al. 2006). The book is available from the University of Idaho and the American Sheep Industry Association.

Traditional Biological Control Using Insects

In the United States, the procedure for determining acceptable control agents for release is quite rigorous and expensive, once a target weed species has been determined. Potential insects that may be effective biological control agents are identified and collected from the home ranges of the target weed. The insects or pathogens undergo extensive testing in the insect's native range to determine their effectiveness at controlling the target species and to ascertain their potential for harm to any other related or native plant species. These "starvation" tests demonstrate that the potential biological control agent will starve to death rather than feed on plant species other than the target. Any agents that fail these tests are eliminated before continued trials occur in the United States. Figure 1 shows the process that must

Figure 1. Required testing stages before an insect can be introduced as a biological control agent in the United States. A goal diagram showing the steps that each biological control agent must undergo before being released.



be undertaken before an exotic control agent can be introduced into the United States.

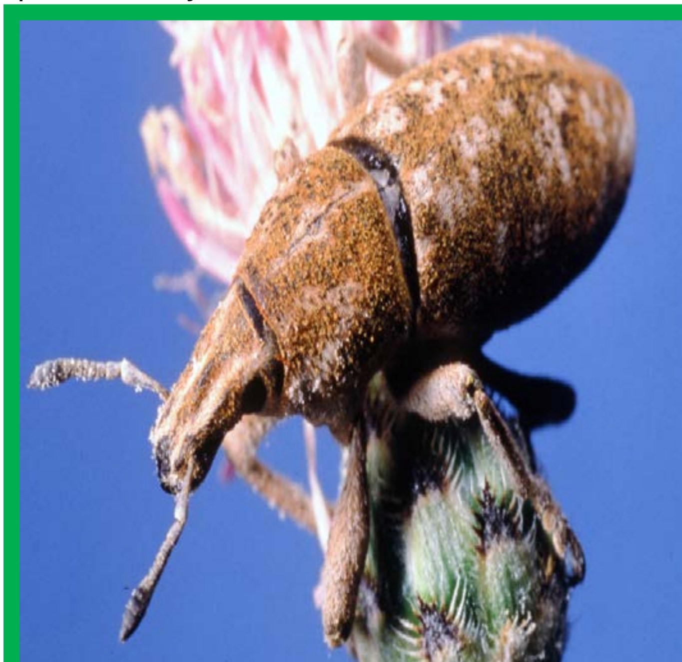
After passing “starvation” tests to ensure the agent will only feed on the target weed and not agricultural plants or closely related native species, the potential biological agent is imported into the United States for further testing. If the biological control agent is an insect, the number imported is usually quite small. The insect population must then be increased to sufficient numbers for experiments to be conducted in special isolation labs that reduce the risk of accidental escape.

The next stage of testing occurs in controlled greenhouse and laboratory settings. This testing stage ensures the following:

- that the agents respond the same way to the target weed growing outside of its normal environmental conditions found in the home country,
- that sufficient additional stress placed upon the target weed by the biological agent is effective,
- that the control agent reproduces or forms important social structures in the new environment,

- that the control agent can properly disperse,
- that the control agent can survive new predators in the new environment, and
- that the agent is released in specific environments where it can be effective.

Only when the biological control agent has successfully passed the test can the agent be released into the environment to fill its niche as part of the system.



Cyphocleonus achates a knapweed root boring beetle adult on knapweed

The time it takes from the point of release until the agent is sufficiently established to impact the target species can take years, or even decades, and in some cases the agent, may not be able to be released at all. There are many environmental factors that influence the action of a particular biological control agent and it is different for each species based on the genetic characteristics of the individual insects in the agent population. The most effective strategy is to identify and release more than one type of control agent that is used to attack different parts of a target weed. Multiple agents that damage roots, leaves and seeds of a target weed greatly increase stress levels on the target plant. This additional stress results in a greater chance of significant reductions of weed abundance and spread. This is critical as even successful biocontrol programs that have resulted in reductions in weed populations are hard pressed to keep up with the rate of spread of successful weed invaders. For example, there are over 14 insects that have been released in the United States for spotted knapweed control. However, the range of spotted knapweed is still increasing, but at a slower pace than before the insects were released.

Biological control agents have advantages and disadvantages when compared to other management methods. Once biological agents are successfully established, they are usually self-perpetuating in conjunction with the available food supply. Although the initial cost may be high, once established, the long-term control cost is minimal. In the summer of 2012, biological control agents available for spotted knapweed, the knapweed root weevil, *Cyphocleonus achates,* cost about $1 per individual insect, and the knapweed flower weevil, *Larinus obtusus,* cost about 33 cents per individual

Larinus minutus a knapweed flower head weevil on knapweed

insect. The recommended control plan is to release at least several hundred at an initial release site or to augment an existing, but declining insect population. Unlike herbicide applications, the cost is normally incurred only one time, and when spread over large areas, it may be much less expensive than other control methods.

Biological agents have the advantage of being able to locate their hosts, and it is highly unlikely that the target weed species will develop a resistance to the control agent, as may be the case with repeated chemical applications. The result is that these insects work for many years and can travel long ways to forage on the target weed. Control or management is achieved once the biological agents place sufficient stress on the target weed to limit the competitive advantage the weed originally displayed when introduced to the ecosystem. Once again, this process may take many years and works best if applied when sufficient populations of desirable plant species are present on the site to take advantage of the weakened state of the weed by expanding their populations. Biological control may be one of the only management techniques that can be applied to control noxious weeds in environmentally sensitive areas or on lands with limited economic value.

Leafy Spurge

One disadvantage of using biological control is the need to release a large population of insects in order to increase the likelihood that the agent can survive and reproduce. If environmental conditions are marginal, then subsequent releases may be necessary. Also, since the invasive weed and its control agent will eventually become part of the overall plant community, the target weed will never be completely eradicated with biological control agents alone. The objective is to reduce the density of the weed to a desired economic or biological threshold. Based on the experiences of past biological research around the country, the level of weed control will vary from zero to 90 percent. It is normally desirable to use other management techniques in conjunction with or after the biological control agents have reduced the plants to a small enough population that another type of management is feasible. Mechanical or chemical control can be used; however, this may destroy the biological control agents along with killing the target weeds. In that case, mechanical and/or chemical control may be applied along the edges of large infestations to prevent further spread in an infestation where biological control agents are established but have not yet reached a population size large enough to limit the spread of the weed.

Biological control is an evolving science due to the long-term nature related to the effectiveness of biological agents. It has been a useful tool in the effort to control invasive plant species in many parts of the United States, but additional knowledge is needed to understand the effectiveness of biological agents in Nevada. Most of the Nevada environment is quite different than the environment in surrounding states. Both the target plants and the biological agents may react differently in Nevada then in surrounding environments. As an example, the harsh environment inherent in Nevada might make it difficult to establish healthy insect populations here, or populations may crash during extreme drought or cold in Nevada.

How do I start a biological control project?

First, you need to be sure that your target weed is properly identified. If you are unsure of what species of plant you have, bring it to the nearest University of Nevada Cooperative Extension office to confirm the identity of the plant species. If the weed is identified as a noxious weed, the weed population is large or extensive, and other treatment methods are not feasible, contact your local United States Forest Service, Animal and Plant Health Inspection Service, Nevada Department of Agriculture, or Cooperative Weed Management Organization; or contact a neighboring state noxious weed program, to see if these agencies would be willing to do a site assessment and provide biological control agents. Many public agencies, particularly in our neighboring states, have biological control insectaries and are willing to share to continue to get agents established in the West and reduce the spread of infestations. Idaho has a very active biological control task force and Nevada Department of Agriculture works closely with them regarding information on biological control. Resources from the Idaho program can be found at: http://www.agri.idaho.gov/Categories/PlantsInsects/NoxiousWeeds/Bio_Control.php.

In order to abide by federal laws regarding the movement of organisms, all parties must have an Animal and Plant Health Inspection Service permit to receive, move or release agents within the U.S., meaning that individual landowners must also have a permit. Information regarding permits can be obtained at the following link: http://www.aphis.usda.gov/plant_health/permits/index.shtml.

After you have a permit to release, you will need to obtain appropriate insects. The Nevada Department of Agriculture Noxious Weed Program has a developing biological control program with the mission to help augment and monitor the use of biological control programs in Nevada. This program will help landowners obtain agents, implement a monitoring plan, and develop a long-term approach to weed management on their properties. The latest developments of this program can be found at: http://agri.nv.gov/Plant/Noxious_Weeds/Programs_Biological control/.

If you cannot find a local source, some insects are available for purchase. However, you need to make sure that your supplier has a valid permit to ship the insects to the state of Nevada. The Association of Natural Biological Control Producers keeps a registry of members who offer products at: http://anbp.org/index.php/members-products, which may be a useful resource for finding a place to purchase insects. Biological Control of Weeds, Inc. has many of the available agents for weeds that occur in Nevada and at the time of this publication has a permit to ship to Nevada. To reduce the chance of excessive insect death loss you must be available to release your insects as soon as they arrive. To further reduce stress on the biological control

Purple Loosestrife

agents and maximize the effectiveness of the release, make sure to follow the directions of the supplier.

Animal and Plant Health Inspection Service administers permits on a case-by-case basis and will not comment regarding insects that are currently permitted to be released in Nevada. However, we have compiled a list of weeds in the state that commercial producers currently are licensed to ship to Nevada (Table 1). These insects are listed in bold type in the table. Other listed insects are either not commercially available, are thought to be already widely distributed in Nevada or are not currently allowed to be released or moved. Sample your weed population and identify any insects you find. **If an agent is already on the property, it is not illegal for it to remain there. (i.e. if you have a restricted agent on your property you do not have to remove or try to kill it.) However, you cannot intentionally relocate it to another area, even if the same agent is already there**. If you discover biological control agents on your property, there may be steps you can take to increase the population and you can find specific advice by contacting the agencies listed above. This table does not reflect any legal status of the agents and should not be used to determine which insects are legal to release or move in Nevada. All of that information must come directly from APHIS in the form of a permit to move or release the agent.

Conclusion

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. Prevention and rapid treatment are the first steps in keeping new weeds from becoming broadly established across the state. Biological control techniques may be the most feasible management actions applicable to large, well-established weed infestations, but the uncertainty and cost associated with the introductions of new biocontrol agents often make them a choice of last resort. A scientific method of selection of the best potential biological agent for the Great Basin is needed. Research dollars are needed for the further development of biological agents on target plant pests specific to Nevada. The Nevada Department of Agriculture has started a program of release tracking, rearing, monitoring, redistribution and effectiveness, but this effort needs to be strengthened in Nevada. By implementing these steps, biological control agents can be improved as an additional effective tool in the effort to keep noxious plant species from dominating the landscapes of Nevada.

Acknowledgements:
The photos of biological control agents and weeds were used with permission from Noah Poritz, www.bio-control.com.

Table 1. List of weed species threatening Nevada and available potential biological control agents. Agents commercially available for shipment to Nevada in bold.

Target Plant Species	Potential Biological Control Agents
Canada thistle, *Cirsium arvense*, a native of Europe, Asia and Africa	Canada thistle stem weevil (*Ceutorhynchus litura*), a German weevil that feeds on the stem Canada thistle bud weevil (*Larinus planus*), a European weevil that feeds in the buds thistle stem gall fly (*Urophora cardui*), a central European fly that galls the stems
dalmation toadflax, *Linaria genistifolia* ssp. da*lmatia*, a native of the Mediterranean region	**stem boring weevil (*Mecinus janthinus*), a Yugoslavian weevil** **toadflax seed capsule weevil (*Gymnetron antirrhini*)** root-boring moth (*Eteobalea intermediella*), a Mediterranean root boring moth toadflax flower-feeding beetle (*Brachypterolus pulicarious*), a European ovary feeding beetle root-galling weevil (*Gymnetron linariae*), a German weevil
diffuse knapweed, *Centaurea diffusa*, a native of southern Europe to northcentral Ukraine	(Urophora affinis and U. quadrifasciata) knapweed gall flies, two different fly species that lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant. (Aceria centaureau), a mite that forces the plant to form galls on leaves (Agapeta zoegana) sulpur knapweed moth, a Yugoslavian moth that mines within the root (Bangasternus fausti) broad-nosed seed head weevil. A Greek weevil that feeds upon the seed head (Subanquina picridis), a Turkish nematode that bores into the leaves and stems (Larinus minutus) lesser knapweed flower weevil and (L.obstusus) the blunt knapweed flower weevil, a Greek seed head feeding weevils (Metzneria paucipunctella) spotted knapweed seed head moth, a yellow Swiss moth that feeds upon the seed (Pelochrista medullana) brown-winged root moth, a Romanian moth that feeds upon the root (Pterolonche inspersa) grey-winged root moth, a European moth that feeds upon the root (Puccina jaceae), a fungus that works on the leaves of the plant (Schlerotinia sclerotiorun), a fungus on the crown of the plant (Sphenoptera jogoslavica) bronze knapweed root-borer, a Greek beetle that feeds within the root (Terellia virens) green clearwing fly, an Austrian teph fly that feeds within the seed head (Aceria centaureae) knapweed blister mite, a Greek blister mite that produces leaf galls (Chaetorellia acrolophi) knapweed peacock fly, a Europeon fly that feeds upon the seed head
Eurasian watermilfoil, *Myriophyllum spicatum*	weevil (*Euhychiopsis lecontei*) and (*E. alberatanus*), feed on stem and leaves and 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 (*Paraponynx stratiotata*)

Note: University of Nevada Cooperative Extension does not recommend any biological control agent listed in this table for use on any of the listed weeds. The biocontrol agents featured in this publication are those currently available at the time of publication which may change in the future. Readers are cautioned to check with the appropriate state or federal agency before releasing any biological control agent on to their property.

Target Plant Species	Potential Biological Control Agents
leafy spurge, *Euphoria escula,* a native of western asia	**brown-legged leafy spurge flea beetle (*A. lacertosa*)** **leafy spurge tip gall midge (Spurgia esulae), an Italian fly that feeds upon the shoot tips** **black dot leafy spurge flea beetle (*A. nigriscutis*)** **red-headed leafy spurge stem borer (Oberea erythrocephala), a European beetle that feeds upon the stems and roots** minute spurge flea beetle (Aphthona abdominalis), black leafy spurge flea beetle (A. czwalinae), copper leafy spurge flea beetle (A. flava), brown dot leafy spurge flea beetle (A. cyparissiae), (*A. chinchihi*), (*A. venustula*), and (*A. seriata*) European or Asian flea beetles that feed upon the leaves and roots (*Chamaesphecia crassicornis*), (*C. empiformis*), (C. *tenthrediniformis*), (*C. astatiformis*), and Hungarian clearwing moth (*C. hungarica*), Yugoslavian moths that feed upon the roots (*Dasineura* sp. *nr capsulae*), an Italian fly that feeds upon the shoot tips leafy spurge hawkmoth (*Hyles euphorbiae*), a European moth that feeds upon the leaves and flowers (*Oxicesta geographica*), a Russian moth that feeds on the leaves and flowers (*Simyra dentinosa*), a moth that feeds on the leaves and flowers (*Oncochila simples*), an Italian bug that 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
Mediterranean sage, *Salvia aethiopis*	mediterranean sage weevil (*Phydeuchus tau*)
musk thistle, *Carduus nutans,* originated in southern Europe and western Asia	(*Cheilosia corydon*) thistle crown fly, fly from Italy with larvae that feed inside of a root crown (*Rhinocyllus conicus*) thistle head weevil, European weevil that feeds upon the seed heads (*Psylliodes chalcomera*) an Italian flea beetle that feeds upon the growing tips of buds and stems (*Trichosirocalus horridus*) thistle crown weevil, an Italian weevil that feeds upon the rosette shoot tip (*Puccinia carduorum*) musk thistle rust, a Turkish rust that reduces seed set
poison hemlock, *Conium maculatum,* a Eurasian and African plant	defoliating hemlock moth (*Agonopterix alstroemeriana*), a European moth that feeds all over the plant
puncturevine, *Tribulus terrestris,* introduced from Eurasia or Africa	puncturevine seed weevil (*Microlarinus lareynii*), an Italian weevil that feeds upon developing seeds
purple loosestrife, *Lythrum salicaria,* Native of Europe and north Africa	**golden loosestrife beetle** (*Galerucella calmariensis* and ***G. pusilla***), German beetles that feed upon the flower buds loosestrife root weevil (*Hylobius transversovittatus*), 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 reduce seed production

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Target Plant Species	Potential Biological Control Agents
rush skeletonweed, *Chondrilla juncea*, a native of eastern Europe and north Africa	skeletonweed gall midge (*Cystiphora schmidti*), Greek stem- and leaf-feeding gall midge skeletonweed gall mite (*Eriophyes chondrillae*), an Italian gall mite which feeds upon the axillary and terminal buds rush skeletonwood rust (*Puccinia chondrillina*), an Italian rust of the entire plant
russian knapweed, *Centaurea repens*, a native of the southern Ukraine, southeast Ruyssian, Iran, Kazakhstan and Mongolia	(*Subanquina picridis*) Russian knapweed gall, a Turkish nematode that bores into the leaves and stems (*Alternaria* sp.), a fungus of the leaves and stem (*Puccinia acroptili*), a fungus of the leaves (*Schlerotinia sclerotiorum*), a fungus on the crown of the plant
Russian thistle,*Salsola kali*	(*Coliaphora* sp.), the larvae feed on the plant
saltcedar,*Tamarix* spp., a native of Chine and eastern Asia	(*Diorhabda* spp.), Old world leaf beetles that defoliate the tree
scotch thistle, *Onopordum acanthium*, a Mediterannean 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
spotted knapweed, *Centaurea maculosa*, a native of central Europe	**(*Cyphocleonis achates*) knapweed moth weevil, larvae of an Asian weevil that feeds within the root crown** **(*Larinus minutus*) lesser knapweed flower weevil and the blunt knapweed flower weevil (*L.obstusus*) Greek weevils that feeds upon the seed head** (*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies. Two different Europeon fly species that lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant (*Agapeta zoegana*) sulpur knapweed moth, a Yugoslavian moth that mines within the root (*Metzneria paucipunctella*) spotted knapweed seed head moth, a yellow Swiss moth that feeds upon the seed (*Bangasternus fausti*) broad-nosed seed head weevil, a Greek weevil that feeds upon the seed head (*Chaetorellia acrolophi*) knapweed peacock fly, a Europeon fly that feeds upon the seed head (*Pelochrista medullana*) brown-winged root moth, a Romanian moth that feeds upon the root (*Pterolonche inspersa*) grey-winged root moth, a European moth that feeds upon the root (*Sphenoptera jogoslavica*) bronze knapweed root-borer, a Greek beetle that feeds within the root (*Terellia virens*) green clearwing fly, an Austrian teph fly that feeds within the seed head (*Aceria centaureae*) knapweed blister mite, a Greek blister mite that produces leaf galls (*Schlerotinia sclerotiorun*), a fungus on the crown of the plant

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Target Plant Species	Potential Biological Control Agents
squarrose knapweed, *Centaurea virgata* ssp. *squarrosa* , a native of central Asia and the Middle East	(*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies, two different Europeon fly species that lay their eggs inside of the flower bud, the plant then forms a gall around the egg to isolate it from the plant (*Pterolonche inspersa*), a European moth that feeds on the root (*Bangasternus fausti*) broad-nosed seed head weevil, a Greek weevil that feeds upon the seed head
St. Johnswort, *Hypericum perforation,* a native of western Europe, north Africa and southern Asia	**klamath weed beetles (*Chrysolina hyperici* and *C. quadrigemina*), multicolored European beetles that feed upon the leaves and flowers of the plant** St. Johnswort borer (*Agilus 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 larvae feed on the leaves
yellow starthistle, *Centaurea solstitalis,* a native of southern Europe	**yellow starthistle hairy weevil (Eustenopus villosus), a Greek weevil that feeds on early bud stages of the seed head** yellow starthistle bud weevil (*Bangasternus fausti*), A Greek seed head-feeding weevil yellow starthistle peacock fly (*Chaetorellia australis*), a Greek seed head-feeding fly yellow starthistle flower weevil (L*arinus curtus*), a Greek seed head feeding weevil yellow starthistle gall fly (*Urophora sirunaseva*), a Greek fly that feeds in the developing seeds knapweed blister mite (*Aceria centaureae*), a Greek blister mite that produces leaf galls
yellow toadflax, *Linaria vulgaris,* native to Eurasia	toadflax moth (Calophasia lanula) a European defoliating moth

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