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Weed biological control agents approved for California

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Biological control, or biocontrol, is a weed control method where the natural enemies of an invasive exotic weed are intentionally introduced in an effort to reduce its abundance. This is achieved by the introduction of new natural enemies (usually insects that are highly host-specific) from a plant's native range into the area invaded by the weed.

Prior to release of any beneficial exotic organism, several steps are performed: 1) exploration and discovery of potential biological control agents in the weed's area of origin, 2) evaluation of their environmental safety (through host specificity testing) and efficacy, and 3) review of environmental safety and permit approval by USDA-APHIS (Animal and Plant Health Inspection Service). For background on the process of developing biological control agents, see "Biocontrol 101: Classical biological control of weeds" in the Winter 2008 issue of *Cal-IPC News*, available at www.cal-ipc.org.

If a biocontrol agent is approved for release by both APHIS and CDFA, it can be released. Establishment and spread in the invaded range depends on how fast the agent multiplies. The ultimate objective is for the exotic natural enemies to become permanently established and to build up populations that reduce the weed population.

Patrick Moran of USDA examining water hyacinth plants in 2012 as part of the biocontrol release evaluation process for this aquatic weed. Photo by Chris Mehelis, USDA.

In pursuing biological control of a weed, it is understood that the weed will not be eradicated and that both the weed and biological control agents will permanently persist but at densities below economic or ecological threshold levels where the weed is no longer problematic. Because biocontrol agents and their target weeds interact with many environmental factors, the level of control may vary from year to year and site to site.

A total of 65 species of biological control agents have been imported into California and released against 36 species of weeds (see table). Of these, 54 bioagents successfully established in California. However, the impact of these control agents has been variable. Biological control was successfully achieved on musk thistle (*Carduus nutans*) in northern California, diffuse knapweed (*Centaurea diffusa*), squarrose knapweed (*Centaurea squarrosa*), rush skeletonweed, (*Chondrilla juncea*), Klamath weed (*Hypericum perforatum*), and purple loosestrife (*Lythrum salicaria*), as well as tansy ragwort (*Senecio jacobaea*), puncturevine (*Tribulus terrestris*), and to some degree yellow starthistle (*Centaurea solstitialis*) in ungrazed, undisturbed areas.

The table shows the agents released against each target. The agents in bold are the most effective and are therefore recommended for use by land managers. It should be noted that nine bioagents have been released fairly recently and it is too early to judge their efficacy. On the other hand, agents for eight weed species have failed to establish or were extirpated when their host plant was eliminated from release sites by other control methods.

Additional new biocontrol agents are being evaluated for Cape ivy (*Delairea odorata*), Dalmatian toadflax (*Linaria dalmatica*), gorse (*Ulex europaeus*), Russian knapweed (*Acroptilon repens*), Russian thistle (*Salsola tragus*), Scotch broom (*Cytisus scoparius*), French broom (*Genista monspessulana*), Scotch thistle (*Onopordum acanthium*), tamarisk (*Tamarix ramosissima*), water hyacinth (*Eichhornia crassipes*) and yellow starthistle (*Centaurea solstitialis*).

Insect agents that are established in the field may be available for distribution free of cost, for example as weed parts containing insects. Landowners and natural resource managers can contact their County Agricultural Commissioner's office for more information on availability of weed biocontrol agents in their area.

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Weeds targeted for classical biological control and associated biological control agents permitted for use in California.

Most effective agents shown in **bold**.

Weed species	Common name	Level of control	Approved biocontrol agents for California
Acroptilon repens	Russian knapweed	Unknown, too early	*Jaapiella ivannikovi* (Russian knapweed galling midge)
Alternanthera philoxeroides	alligatorweed	All extirpated	*Agasicles hygrophila* (alligator weed flea beetle) *Amynothrips andersoni* (alligator weed thrips) *Vogtia malloi* (alligator weed stem borer)
Arundo donax	giant reed	Unknown, too early	*Rhizaspidiotus donacis* (Arundo armored scale) *Tetramesa romana* (Arundo shoot gall wasp)
Carduus nutans	musk thistle	Good control in northern CA	***Rhinocyllus conicus* (thistle seed head weevil)**
Carduus pycnocephalus	Italian thistle	Little control	***Rhinocyllus conicus* (thistle seed head weevil)**
Centaurea diffusa	diffuse knapweed	Good control	***Bangasternus fausti* (broad-nosed seed head weevil)** ***Larinus minutus* (lesser knapweed flower weevil)** *Sphenoptera jugoslavica* (knapweed root-boring beetle) *Urophora affinis* (banded knapweed seed head gall fly) *Urophora quadrifasciata* (four-banded knapweed seed head gall fly)
Centaurea jacea ssp. *pratensis*	meadow knapweed	Uncertain	*Bangasternus fausti* (broad-nosed seed head weevil) ***Cyphocleonus achates* (knapweed root weevil)** ***Larinus minutus* (lesser knapweed flower weevil)** *Larinus obtusus* (blunt knapweed flower weevil) *Urophora affinis* (banded knapweed seed head gall fly)
Centaurea stoebe	spotted knapweed	Uncertain	*Agapeta zoegana* (yellow-winged knapweed root moth) *Cyphocleonus achates (*knapweed root weevil) ***Larinus minutus* (lesser knapweed flower weevil)** *Terellia virens* (green clearwing fly) *Urophora affinis* (banded knapweed seed head gall fly) *Urophora quadrifasciata* (four-banded knapweed seed head gall fly)
Centaurea squarrosa	squarrose knapweed	Good control	***Bangasternus fausti* (broad-nosed seed head weevil)** Cyphocleonus achates (knapweed root weevil) *Larinus minutus* (lesser knapweed flower weevil) *Sphenoptera jugoslavica* (knapweed root-boring beetle) Terellia virens (green clearwing fly) *Urophora affinis* (banded knapweed seed head gall fly) *Urophora quadrifasciata* (four-banded knapweed seed head gall fly)
Centaurea solstitialis[1]	yellow starthistle	Reduction observed in some undisturbed (non-grazed) habitats	*Bangasternus orientalis* (yellow starthistle bud weevil) *Chaetorellia australis* (yellow starthistle peacock fly) ***Eustenopus villosus* (yellow starthistle hairy weevil)** *Larinus curtus* (yellow starthistle flower weevil) *Puccinia jacea* var. *solstitialis* (yellow starthistle rust fungus) *Urophora jacaea* (yellow starthistle gall fly) *Urophora sirunaseva* (yellow starthistle gall fly)

...table continued page 12

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...Biocontrol table continued from page 12

Weed species	Common name	Level of control	Approved biocontrol agents for California
Centaurea calcitrapa	purple starthistle	All failed to establish	*Bangasternus fausti* (broad-nosed seed head weevil) *Larinus minutus* (lesser knapweed flower weevil) *Terellia virens* (green clearwing fly)
Centaurea iberica	Iberian starthistle	Failed to establish	*Bangasternus fausti* (broad-nosed seed head weevil)
Chondrilla juncea	rush skeletonweed	Good control	*Aceria chondrillae* (rush skeletonweed gall mite) *Cystiphora schmidti* (rush skeletonweed gall midge) *Puccinia chondrillina* (rush skeletonweed rust fungus)
Cirsium arvense	Canada thistle	? - Too early	*Altica carduorum* (Canada thistle flea beetle) ***Ceutorhynchus litura* (Canada thistle stem weevil)** *Urophora cardui* (Canada thistle gall fly)
Cirsium vulgare	bull thistle	Level of control uncertain	***Urophora stylata* (bull thistle seed head gall fly)**
Cytisus scoparius	Scotch broom	Little control	***Exapion fuscirostre* (Scotch broom seed weevil)** *Leucoptera spartifoliella* (Scotch broom twigminer)
Eichhornia crassipes	water hyacinth	Little control	*Megamelus scutellaris* (water hyacinth plant hopper) *Neochetina bruchi* (water hyacinth weevil) *Neochetina eichhorniae* (water hyacinth weevil) *Niphograpta albiguttalis* (water hyacinth moth)
Euphorbia esula	leafy spurge	? - Too early	***Aphthona lacertosa* (brown-legged leafy spurge flea beetle)** ***Aphthona nigriscutis* (black dot leafy spurge flea beetle)** *Oberea erythrocephala* (red-headed leafy spurge stem borer)
Euphorbia oblongata	oblong spurge	All failed to establish	*Hyles euphorbiae* (leafy spurge hawk moth) *Aphthona lacertosa* (brown-legged leafy spurge flea beetle)
Euphorbia terracina	carnation spurge	Failed to establish	*Aphthona lacertosa* (brown-legged leafy spurge flea beetle)
Halogeton glomeratus	halogeton	Failed to establish	*Coleophora parthenica* (Russian thistle stem-mining moth)
Hydrilla verticillata	hydrilla	All extirpated	*Bagous affinis* (Indian hydrilla tuber weevil) *Hydrellia pakistanae* (Indian hydrilla leaf-mining fly)
Hypericum canariensis	Canary Island hypericum	? - Too early	*Aplocera plagiata* (St. Johnswort inchworm)
Hypericum perforatum	St. Johnswort (klamathweed)	Good control	***Agrilus hyperici* (St. Johnswort root borer)** *Aplocera plagiata* (St. Johnswort inchworm) ***Chrysolina hyperici* (klamathweed beetle)** ***Chrysolina quadrigemina* (klamathweed beetle)** *Zeuxidiplosis giardi*
Linaria dalmatica[2]	Dalmatian toadflax	? - Too early	***Mecinus janthiniformis* (Dalmatian toadflax stem weevil)**
Lythrum salicaria	purple loosestrife	Good control north of Sacramento	***Galerucella calmariensis* (black-margined loosestrife beetle)** ***Galerucella pusilla* (golden loosestrife beetle)** *Hylobius transversovittatus* (loosestrife root weevil) *Nanophyes marmoratus* (loosestrife weed weevil)
Onopordum acanthium	Scotch thistle	Failed to establish	*Rhinocyllus conicus* (thistle seed head weevil)

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Weed species	Common name	Level of control	Approved biocontrol agents for California
Salsola tragus	Russian thistle	Little control	*Coleophora klimeschiella* (Russian thistle casebearer) *Coleophora parthenica (*Russian thistle stem-mining moth)
Salvia aethiopis	Mediterranean sage	Good control	***Phrydiuchus tau*** **(Mediterranean sage root weevil)**
Salvinia molesta	giant salvinia	Good control	***Cyrtobagous salviniae*** **(salvinia weevil)**
Senecio jacobaea	tansy ragwort	Good control	***Longitarsus jacobaeae*** **(tansy ragwort flea beetle)** *Botanophila seneciella* (ragwort seed head fly) *Tyria jacobaeae* (cinnabar moth)
Silybum marianum	milk thistle	Little control	*Rhinocyllus conicus* (thistle seed head weevil)
Tamarix parviflora[3] *Tamarix ramosissima*[3]	saltcedar	Level of control uncertain	***Diorhabda carinulata*** **(northern tamarisk beetle)** ***Diorhabda elongata*** **(Mediterranean tamarisk beetle)**
Tribulus terrestris	puncturevine	Good control	***Microlarinus lareynii*** **(puncturevine seed weevil)** ***Microlarinus lypriformis*** **(puncturevine stem weevil)**
Ulex europaeus	gorse	Little control	***Exapion ulicis*** **(gorse seed weevil)** *Tetranychus lintearius* (gorse spider mite)

[1]Note that the accidentally introduced species *Chaetorellia succinea* is more common than *C. australis*.

[2] Biocontrol agents for *L. dalmatica* are permitted only in Kern, Los Angeles, and Ventura counties.

[3] Biocontrol agents for *Tamarix* spp. are permitted only in central and northern California. Contact your local county agricultural commissioner's office to find out if you are in the area where these agents are permitted.

The Arundo wasp, *Tetramesa romana,* is approximately 6 mm long. Photo by USDA-ARS.

CDFA staff releasing the arundo wasp in Glenn County in 2010. (CDFA's weed biocontrol program has since been eliminated because of state budget cuts. Cal-IPC is sponsoring a bill to renew funding to the program, along with funding for Weed Management Areas. See page 3.) USDA is continuing arundo work at this site. Photo by Mike Pitcairn, CDFA.