Cells with green color…..	Indicates review question not directed to but answer of interest

MN NWAC Risk Assessment Worksheet (04-2011)	Common Name	*Latin Name*
	Yellow and Dalmatian Toadflax	*Linaria vulgaris* Miller / *Linaria dalmatica* (L.) P. Mill.
Reviewer	**Affiliation/Organization**	**Date (mm/dd/yyyy)**
Becker	**University of Minnesota**	**05/25/2011**

Box	Question	Answer	Outcome
1	Is the plant species or genotype non-native?	Yes both USDA PLANTS database Review by Saner et al. 1995 (yellow toadflax, steppes of SE Europe, SW Asia) Review by Vujnovic and Wein 1997 (Dalmatian toadflax, 'Dalmatian coast' of former Yugoslavia, SE Europe and Mediterranean area)	Go to box 3
3	Is the plant species, or a related species, documented as being a problem elsewhere?	Yes. Both considered invasive, particularly in grazing lands in western U.S. and Canada Review by Saner et al. 1995 (yellow toadflax) Review by Vujnovic and Wein 1997 (Dalmatian toadflax)	Go to box 6
6	A. Is the plant, or a close relative, currently established in Minnesota?	Yes Dalmatian isolated Yellow widely distributed	Go to box 7
7	A. Does the plant reproduce by asexual/vegetative means?	Yes. Can spread by spreading horizontal roots	Go to 7B.
	B. Are the asexual propagules effectively dispersed to new areas?	Yes. Fragmented root segments.	Go to 7I.

Box	Question	Answer	Outcome
	C. Does the plant produce large amounts of viable, cold-hardy seeds?	Dalmatian, reported 500,000 seeds/plant Review by Vujnovic and Wein 1997 (Dalmatian toadflax) Yellow, easily 210,000/m^{-2}. 5000 to 10,000/plant. Review by Saner et al. 1995 (yellow toadflax)	
	E. Is this species self-fertile?	Rare	
	G. Can the species hybridize with native species (or other introduced species) and produce viable seed and fertile offspring in the absence of human intervention?	Not with native but do with each other (Ward et al, 2009)	
	I. Do natural controls exist, species native to Minnesota, that are documented to effectively prevent the spread of the plant in question?	No.	Go to Box 8
8	A. Does the plant have toxic qualities, or other detrimental qualities, that pose a significant risk to livestock, wildlife, or people?	No. yellow can be mildly toxic to livestock (Saner et al. 1995), more a palatability issue than toxicity though.	Go to 8B
	B. Does, or could, the plant cause significant financial losses associated with decreased yields, reduced crop quality, or increased production costs?	Yes, reduce productivity in grazing areas Review by Saner et al. 1995 (yellow toadflax) Review by Vujnovic and Wein 1997 (Dalmatian toadflax)	Go to 9

Box	Question	Answer	Outcome
	C. Can the plant aggressively displace native species through competition (including allelopathic effects)?	Yes. No mention found of allelopathy.	Go to Box 9
	F. Does the plant have the potential to introduce or harbor another pest or serve as an alternate host?	Yes, Dalmatian toadflax for cucumber mosaic virus Pariera Dinkins et.al, 2007 None reported for yellow toadflax	If Yes, go to box 9.
9	A. Is the plant currently being used or produced and/or sold in Minnesota or native to Minnesota?	No	Go to 10
10	A. Is the plant currently established in Minnesota?	Yes to both but Dalmatian less common. Dalmatian upland, drier areas, yellow toadflax wetter areas.	Go to 10B
	B. Does the plant pose a serious human health threat?	No.	Go to 10C
	C. Can the plant be reliably eradicated (entire plant) or controlled (top growth only to prevent pollen dispersal and seed production as appropriate) on a statewide basis using existing practices and available resources?	No yellow toadflax, Risk Assessment directs to list as restricted noxious weed but I recommend to list in the 'species of concern' nonexistent category. Yes for Dalmatian because not widely established in MN yet, list as prohibited/eradicated noxious weed. - Both can be controlled with big guns herbicides with collateral damage that may not be acceptable if widely distributed. Mowing not effective, severe tillage sequential schedule yes, but limited to non-erosive areas or small patches. - Biocontrol in Canada and US (Van Hezewijk et al., 1997)	If yes, list as a prohibited noxious weed. If no, list as a restricted noxious weed.
11	Should the plant species be allowed in Minnesota via a species-specific management plan; designate as specially regulated?	no	

Box	Question	Answer	Outcome
Final Results of Risk Assessment			
	Review Entity	**Comments**	**Outcome**
	NWAC Listing Subcommittee		List as a possible Prohibited Eradicate Species
	NWAC Full-group		List Dalmatian Toadflax as a Prohibited Eradicate List. Do not list Yellow Toadflax
	MDA Commissioner	Approved listing of Dalmatian Toadflax as a Prohibited-Eradicate Noxious Weed No listing for Yellow Toadflax	**Dalmatian Toadflax listed as a Prohibited - Eradicate Noxious Weed**
		File Number: MDARA00004TFLAX_11_30_2011	

References:
(List any literature, websites, and other publications)

Grieshop, M.J. Nowierski, R.M. 2002. Selected factors affecting seedling recruitment of Dalmatian toadflax. Journal of range management.. 55(6) p. 612-619.

Lym, R.G. 2002. Dalmatian Toadflax and Yellow Toadflax *(Linaria genistifolia* spp. *dalmatica* and *Linaria vulgaris)* Identification and Control. NDSU. W-1239. December 2002.

Pariera Dinkins, C.L. Brumfield, S.K. Peterson, R.K.D. Grey, W.E. Sing, S.E. 2007. Dalmatian toadflax (*Linaria dalmatica*): new host for cucumber mosaic virus
Weed technology. 21(1) p. 41-44.

Saner M.A., Clements, D.R., Hall, M.R., Doohan, D.J. and Cropmton, C.W. 1995. The biology of Canadian weeds. 105. *Linaria vulgaris* (L.) Mill Canadian journal of plant science. 75(2) p. 525-537.

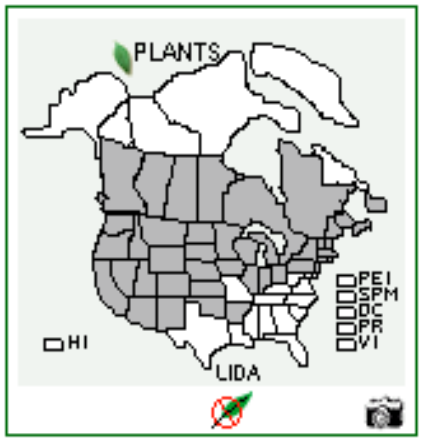
Vujnovic, K. Wein, R.W. 1997. The biology of Canadian weeds. 106. *Linaria dalmatica* (L.) Mill. Canadian journal of plant science. 77(3) p. 483-491.

Van Hezewijk, Brian H. Bourchier, Robert S. DeClerck-Floate, Rosemarie A. 2010. Regional-scale impact of the weed biocontrol agent *Mecinus janthinus* on Dalmatian toadflax (*Linaria dalmatica*) . Biological control : theory and application in pest management. 55(3) p. 197-202.

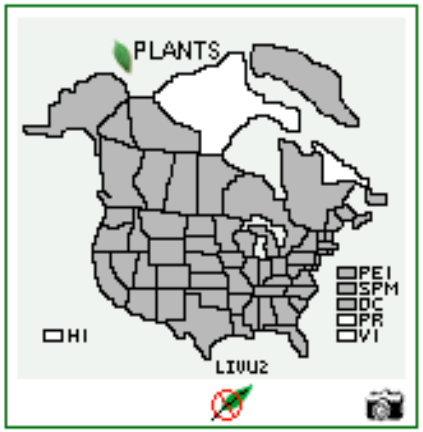
Ward, Sarah M. Fleischmann, Caren E. Turner, Marie F. Sing, Sharlene E. 2009. Hybridization between Invasive Populations of Dalmatian Toadflax (*Linaria dalmatica*) and Yellow Toadflax *(Linaria vulgaris*) Invasive plant science and management. 2(4) p. 369-378.

Appendices

PLANTS distribution maps.



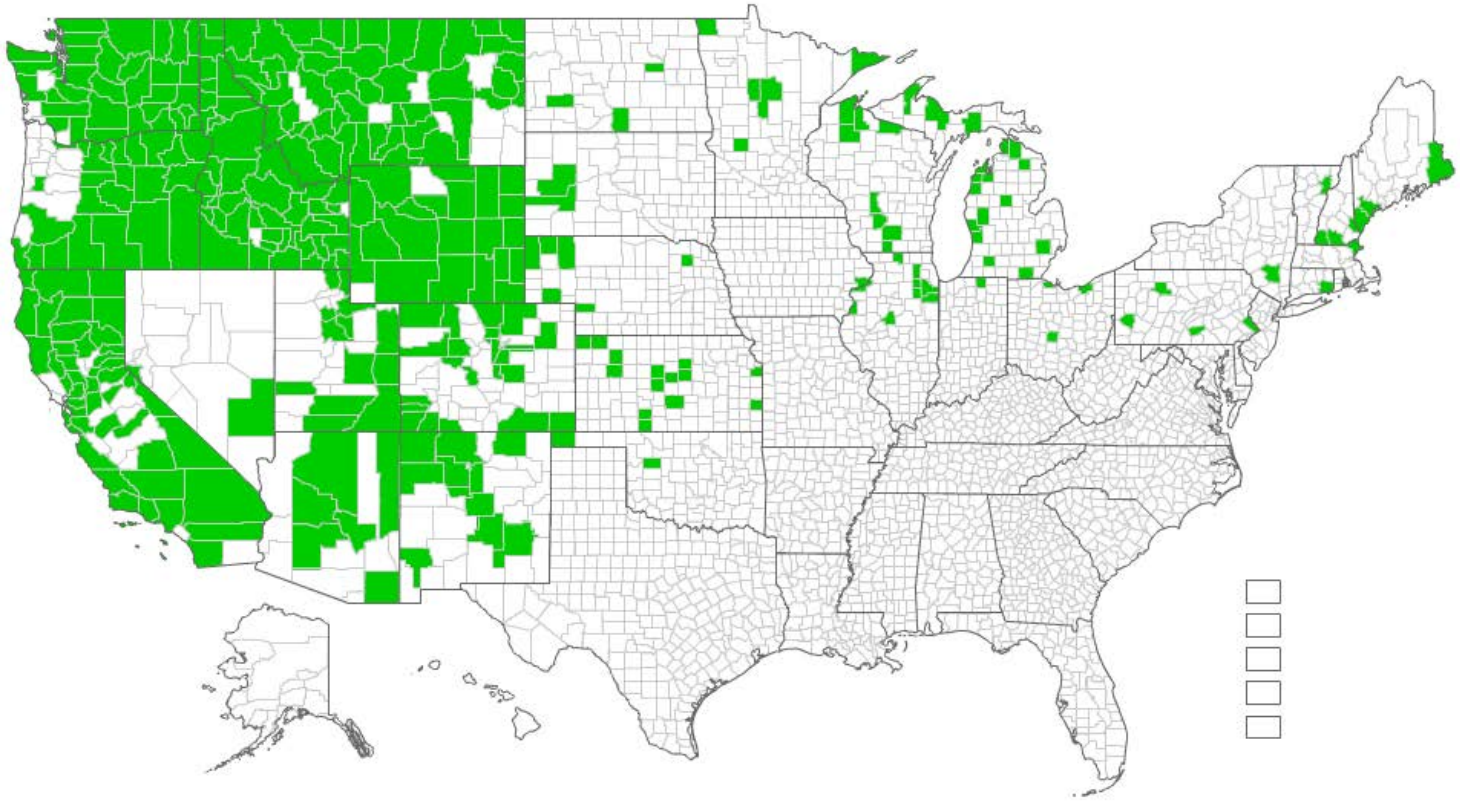
Linaria dalmatica
Dalmatian toadflax



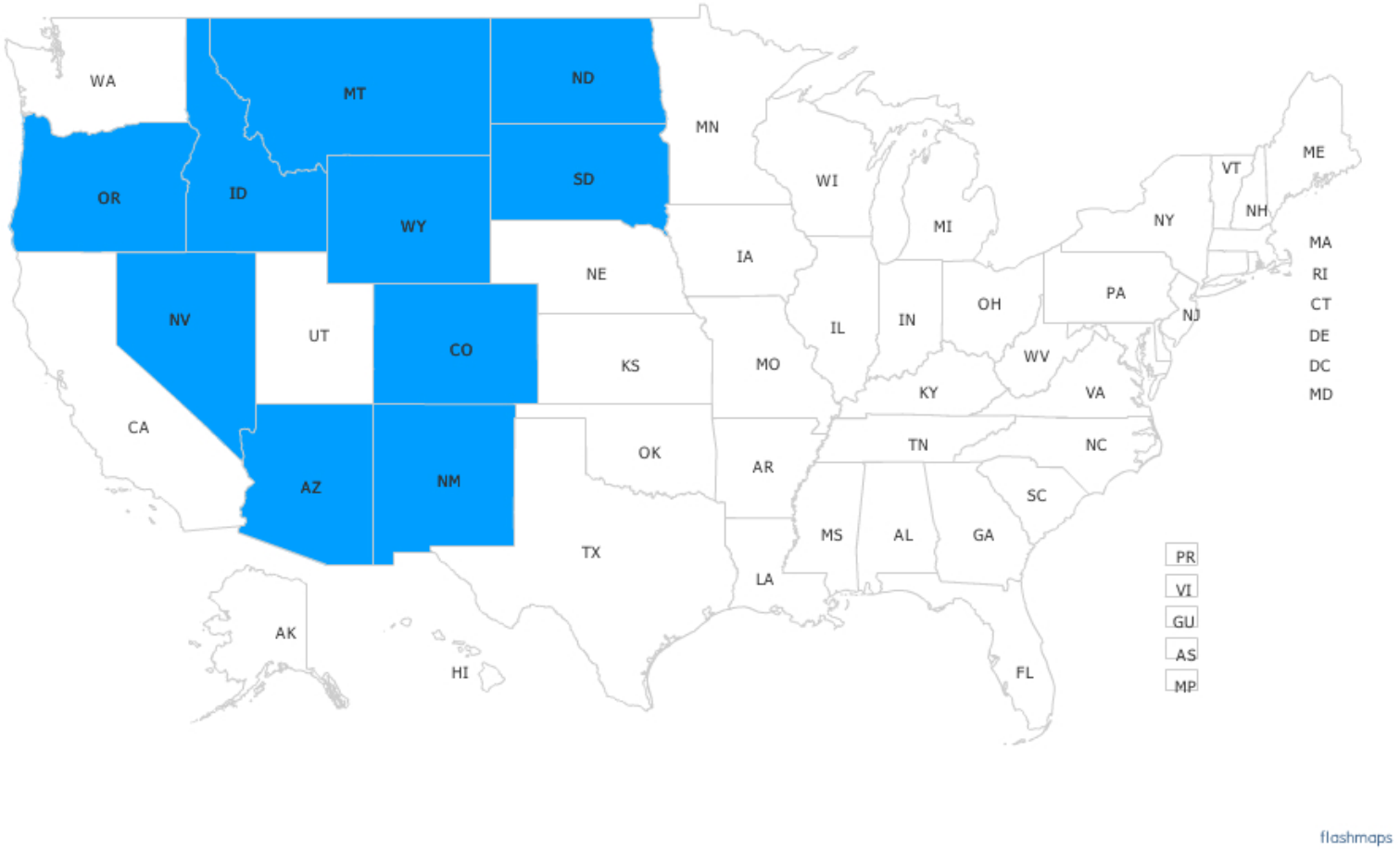
Linaria vulgaris
butter and eggs

EDDMapS Distribution:

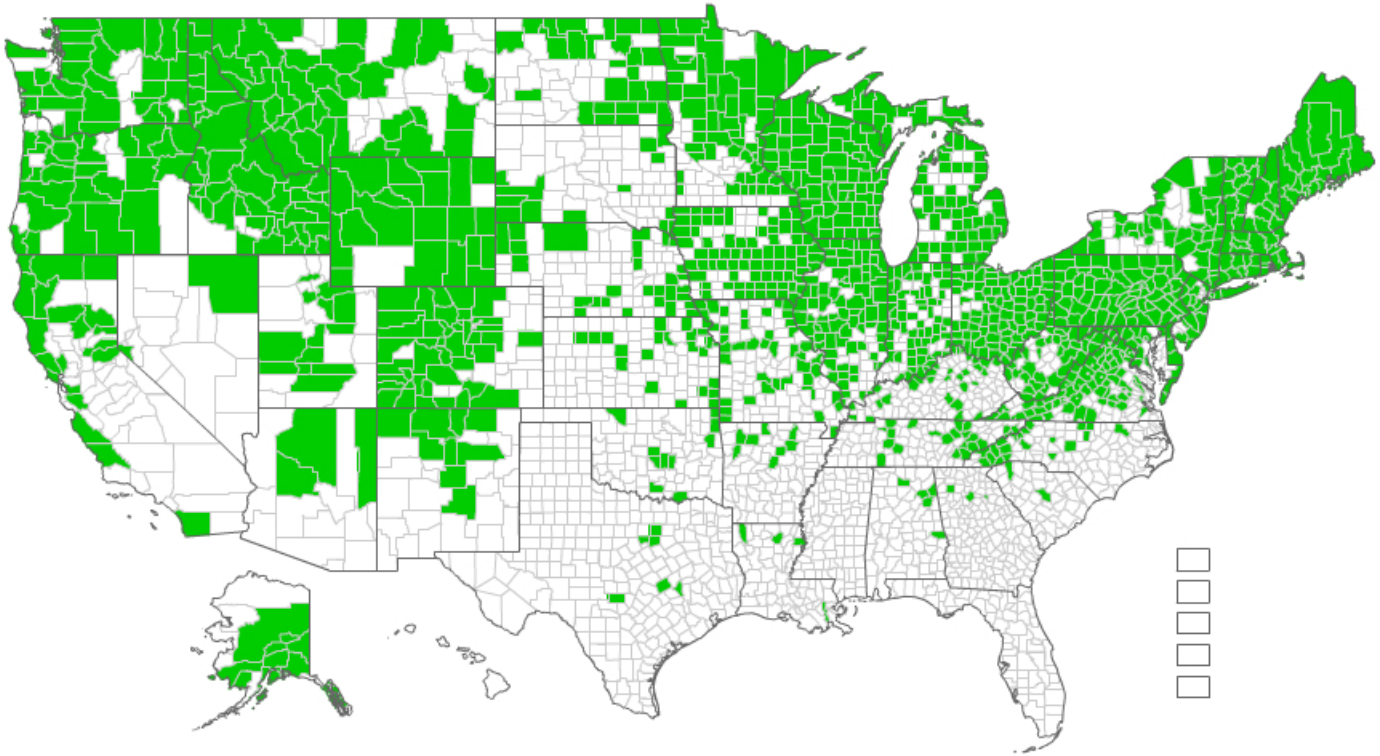
This map is incomplete and is based only on current site and county level reports made by experts and records obtained from USDA Plants Database. For more information, visit www.eddmaps.org



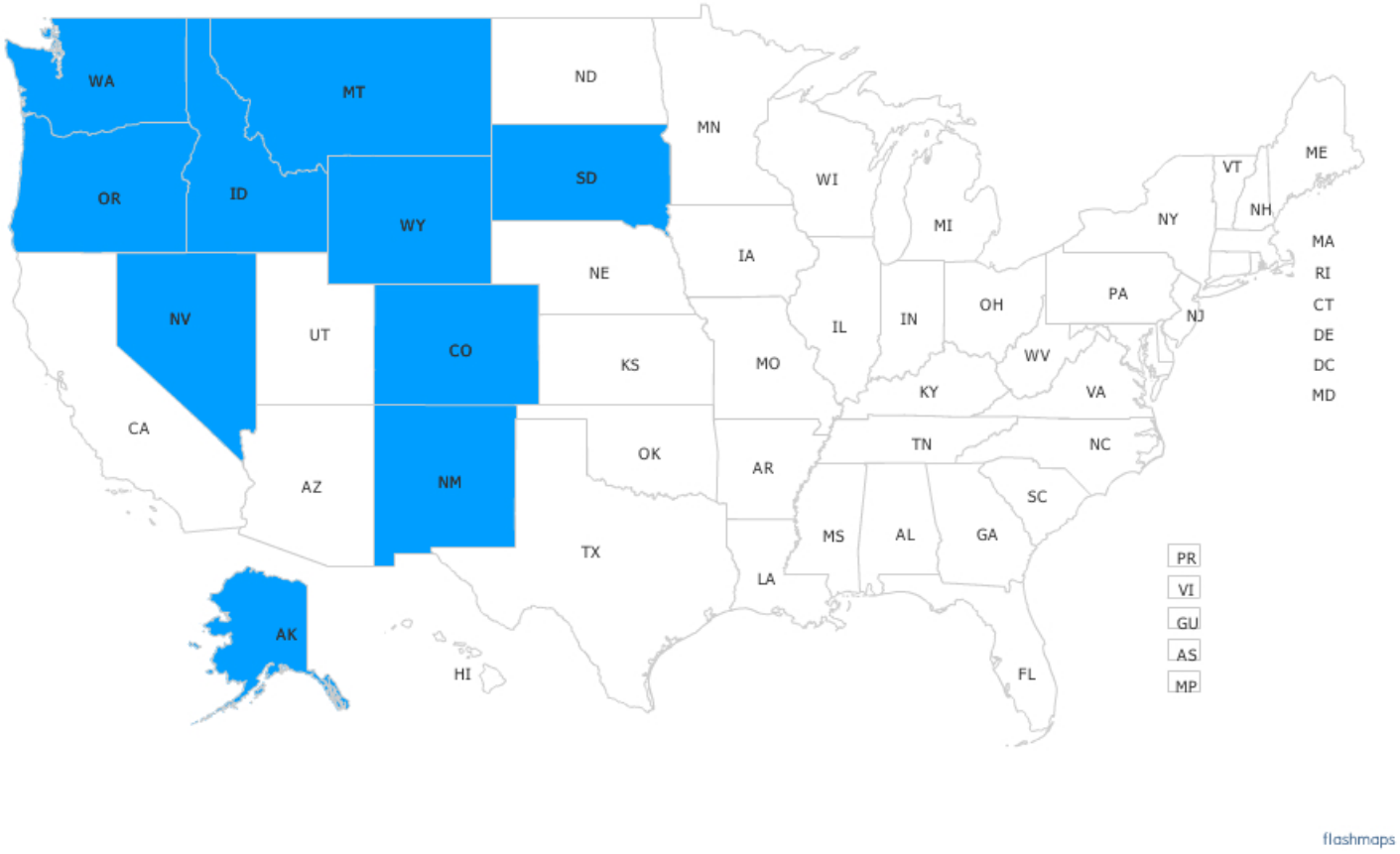
Dalmatian toadflax Regulated Map



Yellow toadflax EDDMaps



Yellow toadflax Regulated Map



Additional Literature

Date: May 19, 2011 7:55:28 AM CDT
Ovid Technologies, Inc. Email Service

Search for: Linaria dalmatica/
Results: 32

1. Do you know these infamous weeds?
McKinney, Mary Jerup, Amy
Barnyards & backyards. 2010 Fall. 6(4) p. 15.
AN: IND44458706.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44458706

2.Regional-scale impact of the weed biocontrol agent Mecinus janthinus on Dalmatian toadflax (Linaria dalmatica)
Van Hezewijk, Brian H. Bourchier, Robert S. DeClerck-Floate, Rosemarie A.
Biological control : theory and application in pest management. 2010 Dec. 55(3) p. 197-202.
AN: IND44442264.
Dalmatian toadflax (Linaria dalmatica (L.) Mill.) is an important invasive plant on rangelands throughout western North America. In 1991, the stem-mining weevil, Mecinus janthinus Germar, was introduced into Canada from Europe as a classical biological control agent to reduce toadflax densities and improve rangelands, particularly in British Columbia. To determine if the program was a success at a regional level, this paper answers three key questions: (1) has M. janthinus spread throughout the study area, (2) is M. janthinus causing a decline in toadflax plant size or density at the regional scale, and (3) has the distribution of toadflax plants changed following M. janthinus introduction? These questions are answered by combining historical survey data and mensurative experimental data on plant and weevil densities across a 40,000 km2 area in southern British Columbia. The results show that through a combination of intentional redistribution and natural dispersal weevils have spread throughout the study area. Stem densities at naturally colonized sites and historical release sites were equally low. Across weevil populations between 3 and 10 years old, weevil densities peaked in the eighth year, and there was a negative relationship between weevil density and stem length. Between 2000 and 2007, toadflax patches were found to both decrease in density and become more fragmented over time, with 15% of patches disappearing completely. These findings show that M. janthinus has had a significant negative impact on both the density and distribution of Dalmatian toadflax throughout a large part of its range in British Columbia.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44442264

3. Root plasticity of native and invasive Great Basin species in response to soil nitrogen heterogeneity
James, J.J. Mangold, J.M. Sheley, R.L. Svejcar, T.
Plant ecology. 2009 June. 202(2) p. 211-220.
AN: IND44203218.
Soil nutrients are heterogeneously distributed in natural systems. While many species respond to this heterogeneity through root system plasticity, little is known about how the magnitude of these responses may vary between native and invasive species. We quantified root morphological and physiological plasticity of co-occurring native and invasive Great Basin species in response to soil nitrogen heterogeneity and determined if trade-offs exist between these foraging responses and species relative growth rate or root system biomass. The nine study species included three perennial bunchgrasses, three perennial forbs, and three invasive perennial forbs. The plants were grown in large pots outdoors. Once a week for 4 weeks equal amounts of p#eNH p#eNO were distributed in the soil either evenly through the soil profile,

in four patches, or in two patches. All species acquired more N in patches compared to when N was applied evenly through the soil profile. None of the species increased root length density in enriched patches compared to control patches but all species increased root N uptake rate in enriched patches. There was a positive relationship between N uptake rate, relative growth rate, and root system biomass. Path analysis indicated that these positive interrelationships among traits could provide one explanation of how invasive forbs were able to capture 2 and 15-fold more N from enriched patches compared to the native grasses and forbs, respectively. Results from this pot study suggest that plant traits related to nutrient capture in heterogeneous soil environments may be positively correlated which could potentially promote size-asymmetric competition belowground and facilitate the spread of invasive species. However, field experiments with plants seedlings with green leaf phenotype. Journal of Environmental Horticulture 24:133-136.
asymmetric competition belowground and facilitate the spread of invasive species. However, field experiments with plants in different neighbor environments ultimately are needed to determine if these positive relationships among traits influence competitive ability and invader success.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44203218

4. Elevated CO effects on semi-arid grassland plants in relation to water availability and competition
Dijkstra, Feike A. Blumenthal, Dana Morgan, Jack A. LeCain, Daniel R. Follett, Ronald F.
Functional ecology. 2010 Oct. 24(5) p. 1152-1161.
AN: IND44424713.
1. It has been suggested that much of the elevated CO effect on plant productivity and N cycling in semi-arid grasslands is related to a CO-induced increase in soil moisture, but the relative importance of moisture-mediated and direct effects of CO remain unclear. 2. We grew five grassland species common to the semi-arid grasslands of northern Colorado, USA, as monocultures and as mixtures of all five species in pots. We examined the effects of atmospheric CO concentration (ambient vs. 780 p.p.m.) and soil moisture (15 vs. 20% m/m) on plant biomass and plant N uptake. Our objective was to separate CO effects not related to water from water-mediated CO effects by frequently watering the pots, thereby eliminating most of the elevated CO effects on soil moisture, and including a water treatment similar in magnitude to the water-savings effect of CO. 3. Biomass of the C grasses Hesperostipa comata and Pascopyrum smithii increased under elevated CO, biomass of the C grass Bouteloua gracilis increased with increased soil moisture, while biomass of the forbs Artemisia frigida and Linaria dalmatica had no or mixed responses. Increased plant N uptake contributed to the increase in plant biomass with increased soil moisture while the increase in plant biomass with CO enrichment was mostly a result of increased N use efficiency (NUE). Species-specific responses to elevated CO and increased soil moisture differed between monocultures and mixtures. Both under elevated CO and with increased soil moisture, certain species gained N in mixtures at the expense of species that lost N, but elevated CO led to a different set of winners and losers than did increased water. 4. Elevated CO can directly increase plant productivity of semi-arid grasslands through increased NUE, while a CO-induced increase in soil moisture stimulating net N mineralization could further enhance plant productivity through increased N uptake. Our results further indicate that the largest positive and negative effects of elevated CO and increased soil moisture on plant productivity occur with interspecific competition. Responses of this grassland community to elevated CO and water may be both contingent upon and accentuated by competition.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44424713

5.Microbially mediated CH consumption and NO emission is affected by elevated CO, soil water content, and composition of semi-arid grassland species
Dijkstra, Feike A. Morgan, Jack A. LeCain, Daniel R. Follett, Ronald F.
Plant and soil. 2010 Apr. 329(1-2) p. 269-281.
AN: IND44339168.

Elevated CO affects plant productivity, but also water availability and plant species composition in semi-arid grasslands, thereby potentially causing complex effects on CH consumption and NO emission. We studied the effects of atmospheric CO concentration (400 vs 780 oL Lp#), water content (15 vs 20% gravimetric soil moisture), and composition of semi-arid grassland species (perennial grasses Bouteloua gracilis, Hesperostipa comata, and Pascopyrum smithii; sub-shrub Artemisia frigida; invasive forb Linaria dalmatica grown in monoculture and all five species together) on CH consumption and NO emission in a full factorial greenhouse experiment. We used a unique method where we measured microbial effects on CH consumption and NO emission in isolation from effects of gas diffusivity. Microbially mediated CH consumption was significantly higher under elevated CO (by 20%), but was not affected by soil water content or plant species composition. Microbially mediated NO emission was not significantly affected by elevated CO, but was significantly higher with high water content (by 67%) and differed significantly among species. Treatment effects on CH consumption and NO emission often could not be explained simply by differences in soil moisture, suggesting that treatment-induced changes in other soil and microbial properties played a role in causing these effects.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44339168

6. Iridoid Glycoside Variation in the Invasive Plant Dalmatian Toadflax, Linaria dalmatica (Plantaginaceae), and Sequestration by the Biological Control Agent, Calophasia lunula
Jamieson, Mary A. Bowers, M. Deane
AN: IND44327178.
Invasive plant species can have significant ecological and economic impacts. Although numerous hypotheses highlight the importance of the chemical defenses of invasive plant species, the chemical ecology of many invasive plants has not yet been investigated. In this study, we provide the first quantitative investigation of variation in iridoid glycoside concentrations of the invasive plant Dalmatian toadflax (Linaria dalmatica). We examined variation in chemical defenses at three levels: (1) variation within and among populations; (2) variation due to phenology and/or seasonal differences; and (3) variation among plant parts (leaves, flowers, and stems). Further, we examined two biological control agents introduced to control L. dalmatica for the ability to sequester iridoid glycosides from this invasive plant. Results indicate that L. dalmatica plants can contain high concentrations of iridoid glycosides (up to 17.4% dry weight of leaves; mean = 6.28pl0.5 SE). We found significant variation in iridoid glycoside concentrations both within and among plant populations, over the course of the growing season, and among plant parts. We also found that one biological control agent, Calophasia lunula (Lepidoptera: Noctuidae), was capable of sequestering antirrhinoside, an iridoid glycoside found in L. dalmatica, at levels ranging from 2.7 to 7.5% dry weight. A second biological control agent, Mecinus janthinus (Coleoptera: Curculionidae), a stem-mining weevil, did not sequester iridoid glycosides. The demonstrated variation in L. dalmatica chemical defenses may have implications for understanding variation in the degree of invasiveness of different populations as well as variation in the efficacy of biological control efforts.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44327178

7. Hybridization between Invasive Populations of Dalmatian Toadflax (Linaria dalmatica) and Yellow Toadflax (Linaria vulgaris)
Ward, Sarah M. Fleischmann, Caren E. Turner, Marie F. Sing, Sharlene E.
Invasive plant science and management. 2009 Oct. 2(4) p. 369-378.
AN: IND44305847.
Although there is evidence that interspecific hybridization can initiate invasion by nonnative plants, there are few documented examples of novel hybridization events between introduced plant species already exhibiting invasive behavior. We conducted morphometric and molecular analyses of toadflax plants with intermediate morphology found at two sites in Montana, which were co-invaded by yellow toadflax and Dalmatian toadflax. Field-collected putative hybrid plants had intermediate morphometric scores (mean 0.47, on a scale of 0.0 = indistinguishable from Dalmatian toadflax to 1.0 =

indistinguishable from yellow toadflax) for a suite of phenotypic traits that differentiate the parent species (leaf lengthwidth ratio, growth form, seed morphology, inflorescence type, and ventral petal shape). Inter-simple sequence repeat (ISSR) analysis of a subset of these putative hybrids revealed combinations of species-diagnostic bands, confirming the presence of DNA from both parent species. Controlled interspecific hand-pollinations generated viable first generation (F1) hybrid plants that also had intermediate morphometric scores (mean 0.46) and a mix of species-diagnostic ISSR bands from both parents. The hand-generated F1 hybrids crossed readily with both parent species to produce viable first generation backcrossed (BC1) plants. Our results confirm that hybridization is occurring between invasive populations of yellow toadflax and Dalmatian toadflax, and that the hybrid progeny are viable and fertile. This example of hybridization between alien congeners is of concern as the parent taxa are already known to be highly invasive. Further research is needed to assess the invasive potential of hybrid toadflax populations, and the likelihood of introgressive trait transfer between the parent species.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44305847
8. Some Wyoming invasive weed areas are biological warfare battegrounds.
Ziehl, Travis
Barnyards & backyards. 2009 Summer. 5(3) p. 7-9.
AN: IND44229081.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44229081

9. 7,8-Benzoflavone: a phytotoxin from root exudates of invasive Russian knapweed [Retraction: 2009 Jan., v.70, issue 1, p. 156.]
Stermitz, F.R. Bais, H.P. Foderaro, T.A. Vivanco, J.M.
Phytochemistry. 2003 Sept. 64(2) p. 493-497.
AN: IND43862533.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43862533
Journal of chemical ecology. 2010 Jan. 36(1) p. 70-79.) abundances in Connecticut, USA. Environmental Entomology 39:1911-1921.

10. Increased snow facilitates plant invasion in mixedgrass prairie
Blumenthal, D. Chimner, R.A. Welker, J.M. Morgan, J.A.
New phytologist. 2008 July. 179(2) p. 440-448.
AN: IND44076437.
Although global change is known to influence plant invasion, little is known about interactions between altered precipitation and invasion. In the North American mixedgrass prairie, invasive species are often abundant in wet and nitrogen (N)-rich areas, suggesting that predicted changes in precipitation and N deposition could exacerbate invasion. Here, this possibility was tested by seeding six invasive species into experimental plots of mixedgrass prairie treated with
a factorial combination of increased snow, summer irrigation, and N addition. Without added snow, seeded invasive species were rarely observed. Snow addition increased average above-ground biomass of Centaurea diffusa from 0.026 to 66 g mpo, of Gypsophila paniculata from 0.1 to 7.3 g mpo, and of Linaria dalmatica from 5 to 101 g mpo. Given added snow, summer irrigation increased the density of G. paniculata, and N addition increased the density and biomass of L. dalmatica. Plant density responses mirrored those of plant biomass, indicating that increases in biomass resulted, in part, from increases in recruitment. In contrast to seeded invasive species, resident species did not respond to snow addition. These results suggest that increases in snowfall or variability of snowfall may exacerbate forb invasion in the mixedgrass
prairie. Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44076437

11. Selected factors affecting seedling recruitment of dalmatian toadflax
Grieshop, M.J. Nowierski, R.M.
Journal of range management. Nov 2002. 55(6) p. 612-619.
AN: IND23320394.
Seedling recruitment of Dalmatian toadflax, (Linaria genistifolia ssp. dalmatica (L.) Maire and Petitmengin (Scrophulariaceae)), was examined in a 2-year field study in Montana using overseeding and plant/insect exclusion methods, to determine whether it was more limited by seed availability or interspecific plant competition. Overseeding test plots with toadflax seed had no effect on seedling recruitment. Exclusion of plant competition (via herbicide application and pruning) significantly increased total, and cumulative seedling recruitment of Dalmatian toadflax on the last sampling date in 3 of 4, and 2 of 4 cases examined, respectively. Insect exclusion (via insecticide application) significantly increased total seedling recruitment of Dalmatian toadflax on the last sampling date in only 1 of 4 cases examined, and had no effect on cumulative seedling recruitment of Dalmatian toadflax on the last sampling date. We conclude that seedling recruitment in Dalmatian toadflax was more strongly influenced by plant competition than herbivory in our study. Hence, microsite limitation (i.e., competition for safe sites for germination) rather than seed limitation appears to play a more important role in toadflax seedling recruitment. In light of this, current biological control agents that impact seed
production will likely have minimal capabilities of influencing toadflax density. Thus, a premium should be placed on establishing biological control agents that are able to cause significant damage to the stem and root system of Dalmatian toadflax, and in maintaining a healthy plant community that, through interspecific competition, will negatively affect toadflax seedling recruitment.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND23320394

12. Large-scale Aerial Images Capture Details of Invasive Plant Populations
Blumenthal, D. Booth, D.T. Cox, S.E. Ferrier, C.E.
Rangeland ecology & management. 2007 Sept. 60(5) p. 523-528.
AN: IND44024718.
Satellite and high-altitude aerial remote sensing have been used to measure dense infestations of invasive weeds over very large areas but have limited resolution and cannot be used to detect sparsely distributed weeds. Ground-based methods have provided detailed measurements of invasive weeds but can measure only limited areas. Here we test a novel approach that uses a lightweight airplane, flying at 72 km/h and 100-m altitude, to rapidly collect high-resolution images
over relatively large areas. We obtained 1987 images, each representing 48.5 m2 of mixed-grass prairie with 2-mm resolution (ground sample distance). From these images we were able to reliably measure small patches and even individual plants of the invasive forb Dalmatian toadflax (Linaria dalmatica [L.] P. Mill.). Ground-based measurements of aboveground toadflax biomass were highly correlated (R2>0.93) with point-intercept and visual-estimate cover measurements from aerial images. The time required to analyze images ranged from 4 to 45 seconds for presence/absence data and from 1 to 6 minutes for cover data. Toadflax was present in 795 of 1987 images but exceeded1% cover in only 99 images. Given the observed variation among images in toadflax cover, at least 400 images were needed to precisely estimate the mean toadflax cover of 0.2%. These results suggest that such high-resolution aerial
imagery could be used to obtain detailed measurements of many invasive weed populations. It may be most useful for identifying incipient weed infestations and expanding the scale at which population-level attributes of weed populations can be effectively measured.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44024718

13. Integrated management of yellow and dalmatian toadflax.
Quarles, W.
The IPM practitioner : the newsletter of integrated pest management. 2007 May-June. 29(5-6) p. 1-7.
AN: IND44053169.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?

T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND44053169

14. Host-plant preference of Brachypterolus pulicarius, an inadvertently introduced biological control insect of toadflaxes.
MacKinnon, D.K. Hufbauer, R.A. Norton, A.P.
Entomologia experimentalis et applicata. 2005 Sept. 116(3) p. 183-189.
AN: IND43740593.
Brachypterolus pulicarius (L.) (Coleoptera: Kateridae) is an inadvertently introduced biological control agent that can reduce seed set in two North American invasive species, yellow (Linaria vulgaris P. Mill.) (Scrophulariaceae) and Dalmatian toadflax (Linaria genistifolia (L.) P. Mill. ssp. dalmatica). The beetles are more common on yellow toadflax than on Dalmatian toadflax. To understand their distribution on the two host plants, we investigated whether they prefer one host to the
other and whether individuals aggregate toward conspecifics. In field and laboratory experiments where beetles were presented with a choice of both toadflax species, B. pulicarius sampled from both host plants preferred yellow toadflax. However, in the laboratory experiment, beetles collected from Dalmatian toadflax showed a weaker preference for yellow toadflax than beetles collected from yellow toadflax. In the field experiment, all beetle populations sampled showed
similar preferences. When given a choice between yellow toadflax plants with and without trapped adult B. pulicarius, beetles preferred plants with conspecifics, suggesting aggregation toward beetle pheromones or host-plant volatiles induced by beetle activity. These results do not support the current practice of redistributing North American B. pulicarius onto Dalmatian toadflax because of their preference for yellow toadflax.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43740593

15. Dalmatian toadflax (Linaria dalmatica): new host for cucumber mosaic virus
Pariera Dinkins, C.L. Brumfield, S.K. Peterson, R.K.D. Grey, W.E. Sing, S.E.
Weed technology. 2007 Jan. 21(1) p. 41-44.
AN: IND43949496.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43949496

16. External rostral characters for differentiation of sexes in the biological control agent Mecinus janthinus (Coleoptera: Curculionidae) [Erratum: 2007 Oct., v. 139, no. 5, p. 756.].
Schat, M. Sing, S.E. Peterson, R.K.D.
Canadian entomologist. 2007 May-June. 139(3) p. 354-357.
AN: IND43924073.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43924073

17. Postrelease Evaluation of Mecinus Janthinus Host Specificity, A Biological Control Agent for Invasive Toadflax (Linaria spp)
Breiter, N.C. Seastedt, T.R.
Weed science. 2007 Mar. 55(2) p. 164-168.
AN: IND43895850.
Toadflax invasion into natural areas has prompted interest in weed management via biological control. The most promising biological control agent currently available for the control of Dalmatian toadflax is Mecinus janthinus, a stem-

boring weevil that has been shown to significantly reduce toadflax populations. Some land managers, however, are reluctant to release approved weed biological control agents based on concerns about possible nontarget impacts. Few postrelease examinations of biocontrol impact and host specificity have been performed, despite the call for such information. This study examined the host specificity of Mecinus janthinus, postrelease, in relation to Colorado sites to provide information to managers about its relative safety as a weed biological control agent. This study employed three components: (1)

greenhouse choice and no-choice experiments; (2) no-choice caged field experiments; and (3) release-site evaluation of nontarget use of native plant species where this weevil has been released and has established. Both
greenhouse and field experiments failed to demonstrate nontarget use of native plant species by M. janthinus in the region where it was studied, even in no-choice starvation tests. We found no evidence of nontarget herbivory on native plants growing at toadflax sites where M. janthinus was well established. These results support the continued use of M. janthinus as a low-risk biological control agent for the management of toadflax in the Rocky Mountain Front Range.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43895850

18. Predicting the occurrence of nonindigenous species using environmental and remotely sensed data.
Rew, L.J. Maxwell, B.D. Aspinall, R.
Weed science. 2005 Mar-Apr. 53(2) p. 236-241.
AN: IND43704897.
To manage or control nonindigenous species (NIS), we need to know where they are located in the landscape. However, many natural areas are large, making it unfeasible to inventory the entire area and necessitating surveys to be performed on smaller areas. Provided appropriate survey methods are used, probability of occurrence predictions and maps can be generated for the species and area of interest. The probability maps can then be used to direct further sampling for new
populations or patches and to select populations to monitor for the degree of invasiveness and effect of management. NIS occurrence (presence or absence) data were collected during 2001 to 2003 using transects stratified by proximity to rights-of-way in the northern range of Yellowstone National Park. In this study, we evaluate the use of environmental and remotely sensed (LANDSAT Enhanced Thematic Mapper +) data, separately and combined, for developing probability maps
of three target NIS occurrence. Canada thistle, dalmatian toadflax, and timothy were chosen for this study because of their different dispersal mechanisms and frequencies, 5, 3, and 23%, respectively, in the surveyed area. Data were analyzed using generalized linear regression with logit link, and the best models were selected using Akaike's Information Criterion. Probability of occurrence maps were generated for each target species, and the accuracies of the predictions were assessed with validation data excluded from the model fitting. Frequencies of occurrence of the validation data were calculated and compared with predicted probabilities. Agreement between the observed and predicted probabilities was reasonably accurate and consistent for timothy and dalmatian toadflax but less so for Canada thistle.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43704897

19. Evaluating host use of an accidentally introduced herbivore on two invasive toadflaxes
MacKinnon, D.K. Hufbauer, R.A. Norton, A.P.
Biological control : theory and application in pest management. 2007 May. 41(2) p. 184-189.
AN: IND43905227.
The distribution of phytophagous insects is influenced by their preference for and performance on their host plants. Biological control agents of invasive plants that prefer and perform better on their target hosts are more likely to be both effective and safe.Brachypterolus pulicarius is an herbivore used in North America to combat two invasive plants, yellow toadflax and Dalmatian toadflax (Linaria vulgaris and Linaria dalmatica). Adult beetles prefer yellow toadflax over Dalmatian
toadflax, and when beetles are redistributed onto Dalmatian toadflax, populations do not consistently establish. This leads to the hypothesis that beetle larvae will perform best on yellow toadflax. A reciprocal transfer experiment was conducted to test this hypothesis. Development rate, pupal mass and percent survival were measured to assess larval performance. Development time was influenced by an interaction between the source host and the test host, a pattern suggesting that it
is important to consider both the collection host and redistribution host when releasing this beetle for the control of toadflax. Pupal mass of larvae reared on yellow toadflax was, on average, 13% greater than that of larvae reared on Dalmatian toadflax, supporting the hypothesis. Survival rate was not significantly influenced by source host, test host, or their interaction, suggesting that survival rates will be similar no matter the combination of collection host and redistribution host. These results, along with the preference that adult beetles show for yellow toadflax, do not support the redistribution of B.

pulicarius onto Dalmatian toadflax in North America.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43905227

20. Temperature and host-plant effects on development and population growth of Mecinus janthinus (Coleoptera: Curculionidae), a biological control agent for invasive Linaria spp
McClay, A.S. Hughes, R.B.
Biological control : theory and application in pest management. 2007 Mar. 40(3) p. 405-410.
AN: IND43883286.
Mecinus janthinus Germar is a European stem-mining weevil that has been established in North America as a biological control agent against the invasive European weeds Linaria vulgaris P. Mill. and Linaria dalmatica (L.) P. Mill. (Scrophulariaceae). Establishment success and impact of the weevil have varied widely among sites. We investigated the hypothesis that some of this variation may be due to a lack of sufficient time for M. janthinus to develop to the adult (overwintering) stage in less favorable climates. Development time of M. janthinus was measured in L. vulgaris and L. dalmatica at four constant temperatures, and logistic regression was used to derive a model for the effect of temperature on development. Development rates were simulated using historic climate data for a site in central Alberta (where establishment was marginal on L. vulgaris) and one in southern British Columbia (where outbreaks occurred, resulting in heavy damage to L. dalmatica). The model showed that, on average, the British Columbia site had 50 more days available for the weevil to lay eggs that could reach the adult stage in time for overwintering than did the Alberta site. This may explain the more rapid population buildup at the British Columbia site. This model could be used to predict the climatic suitability of other areas for establishment of M. janthinus. An unexplained result was the very low survival rate of eggs laid in L. dalmatica under the same experimental conditions.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=agra6&AN=IND43883286

21. Differential physiological responses of Dalmatian toadflax, Linaria dalmatica L. Miller, to injury from two insect biological control agents: implications for decision-making in biological control.
Peterson, R.K.D. Sing, S.E. Weaver, D.K.
Environmental entomology. 2005 Aug. 34(4) p. 899-905.
AN: IND43752360.
Successful biological control of invasive weeds with specialist herbivorous insects is predicated on the assumption that the injury stresses the weeds sufficiently to cause reductions in individual fitness. Because plant gas exchange directly impacts growth and fitness, characterizing how injury affects these primary processes may provide a key indicator of physiological impairment-which then may lead to reductions in fitness. The objective of this study was to use physiological methods to evaluate how the invasive weed, Linaria dalmatica L. Miller (Dalmatian toadflax), is affected by two introduced biological control agents within different injury guilds: the stem-boring weevil, Mecinus janthinus Germar, and the defoliating moth, Calophasia lunula Hufnagel. All studies with M. janthinus were conducted under field conditions at two sites in Montana in 2003 and 2004. For C. lunula evaluations, a total of five greenhouse studies in 2003 and 2004 were used. One field study in 2003 and two studies in 2004 also were conducted. Variables measured included net CO2 exchange rate, stomatal conductance, and transpiration rate. Results from both field sites revealed that the primary physiology of Dalmatian toadflax was deleteriously affected by M. janthinus larval injury. There were no significant differences among treatments for any of the gas exchange variables measured in all eight experiments with C. lunula. Our results indicate that insect herbivores in two distinct injury guilds differentially affect Dalmatian toadflax physiology. Based on the primary physiological parameters evaluated in this study, M. janthinus had more impact on Dalmatian toadflax than C. lunula. With such information, improved risk-benefit decisions can be made about whether to release exotic biological control agents.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?

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22. Overwintering mortality of and host attack by the stem-boring weevil, Mecinus janthinus Germar, on Dalmatian toadflax (Linaria dalmatica (L.) Mill.) in western Canada.
De Clerck-Floate, R. Miller, V.
Biological control : theory and applications in pest management. May 2002. 24(1) p. 65-74.
AN: IND23297586.
Populations of the weevil Mecinus janthinus Germar (Coleoptera: Curculionidae) were monitored at 13 sites in western Canada during the period 1994-1999 to assess the role of overwintering mortality on the establishment of this biocontrol agent introduced against the weed Dalmatian toadflax, Linaria dalmatica (L.) Mill. (Scrophulariaceae). Results indicated that M. janthinus is intolerant of freezing, as evidenced by adult mortalities of 75-100% occurring in about 30% of the site-years examined and whenever winter temperatures reached less than or equal to -28 degrees C. Exposure to low sub-zero winter temperatures explained 70% of the variation in adult mortality for sites in British Columbia. An 8-fold increase in adult mortality occurred in winter 1997/98 at one Alberta site monitored soon after temperatures dropped to less than or equal to -30 degrees C. Some inconsistencies in the relationship between winter temperatures and adult mortality at the Alberta site may be explained by the presence of insulating snow cover during the coldest temperatures of winters 1993/94 and 1996/97 and unseasonably cold temperatures during the spring of 1995. Despite the high periodic mortalities suffered by M. janthinus at most sites, the incidence and intensity of weevil attack on its host generally increased with time, thus demonstrating the resiliency of weevil populations.

Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
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23. Selected factors affecting seedling recruitment of dalmatian toadflax.
Grieshop, M.J. Nowierski, R.M.
Journal of range management. Nov 2002. 55(6) p. 612-619.
AN: IND23320394.
Seedling recruitment of Dalmatian toadflax, (Linaria genistifolia ssp. dalmatica (L.) Maire and Petitmengin (Scrophulariaceae)), was examined in a 2-year field study in Montana using overseeding and plant/insect exclusion methods, to determine whether it was more limited by seed availability or interspecific plant competition. Overseeding test plots with toadflax seed had no effect on seedling recruitment. Exclusion of plant competition (via herbicide application and pruning) significantly increased total, and cumulative seedling recruitment of Dalmatian toadflax on the last sampling date in 3 of 4, and 2 of 4 cases examined, respectively. Insect exclusion (via insecticide application) significantly increased total seedling recruitment of Dalmatian toadflax on the last sampling date in only 1 of 4 cases examined, and had no effect on cumulative seedling recruitment of Dalmatian toadflax on the last sampling date. We conclude that seedling recruitment in Dalmatian toadflax was more strongly influenced by plant competition than herbivory in our study. Hence, microsite limitation (i.e., competition for "safe sites for germination") rather than seed limitation appears to play a more important role in toadflax seedling recruitment. In light of this, current biological control agents that impact seed production will likely have minimal capabilities of influencing toadflax density. Thus, a premium should be placed on establishing biological control agents that are able to cause significant damage to the stem and root system of Dalmatian toadflax, and in maintaining a healthy plant community that, through interspecific competition, will negatively affect toadflax seedling recruitment.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
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Saner, M.A. Jeanneret, P. Muller-Scharer, H.
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28. 5-O-allosylantirrinoside from Linaria species.
Ilieva, E. Handjieva, N. Spassov, S. Popov, S.
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AN: IND20358852.
From the aerial parts of five Linaria species (L. genistifolia, L. dalmatica, L. simplex, L. pelisseriana and L. vulgaris) a novel iridoid glycoside, 5-O-allosylantirrinoside, along with the known antirrinoside, linarioside and 5-O-glucosylantirrinoside have been isolated.
Link to the Ovid Full Text or citation: http://ovidsp.ovid.com/ovidweb.cgi?
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