

New developments in weed biological control for the northern US: 2011-2012 update



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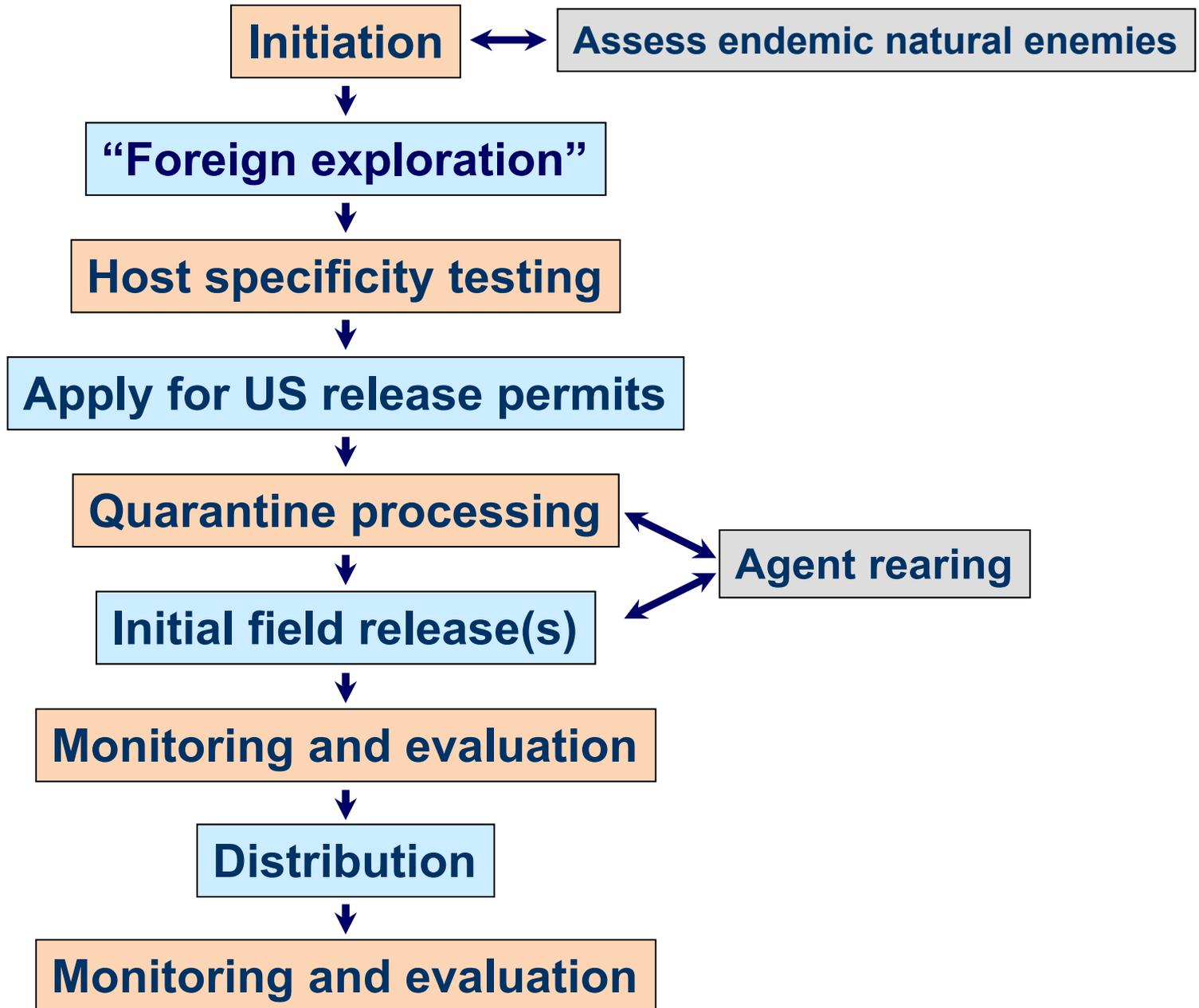




Weed biocontrol = classical biological control (CBC)

- ▶ **Release in one part of the world – *where the organism has become an exotic pest* – of natural enemies collected in another part of the world – *where the pest is native***
- ▶ **Intentional introduction of exotic biocontrol agents for permanent establishment and long-term exotic pest control**

Classical biological control: the process

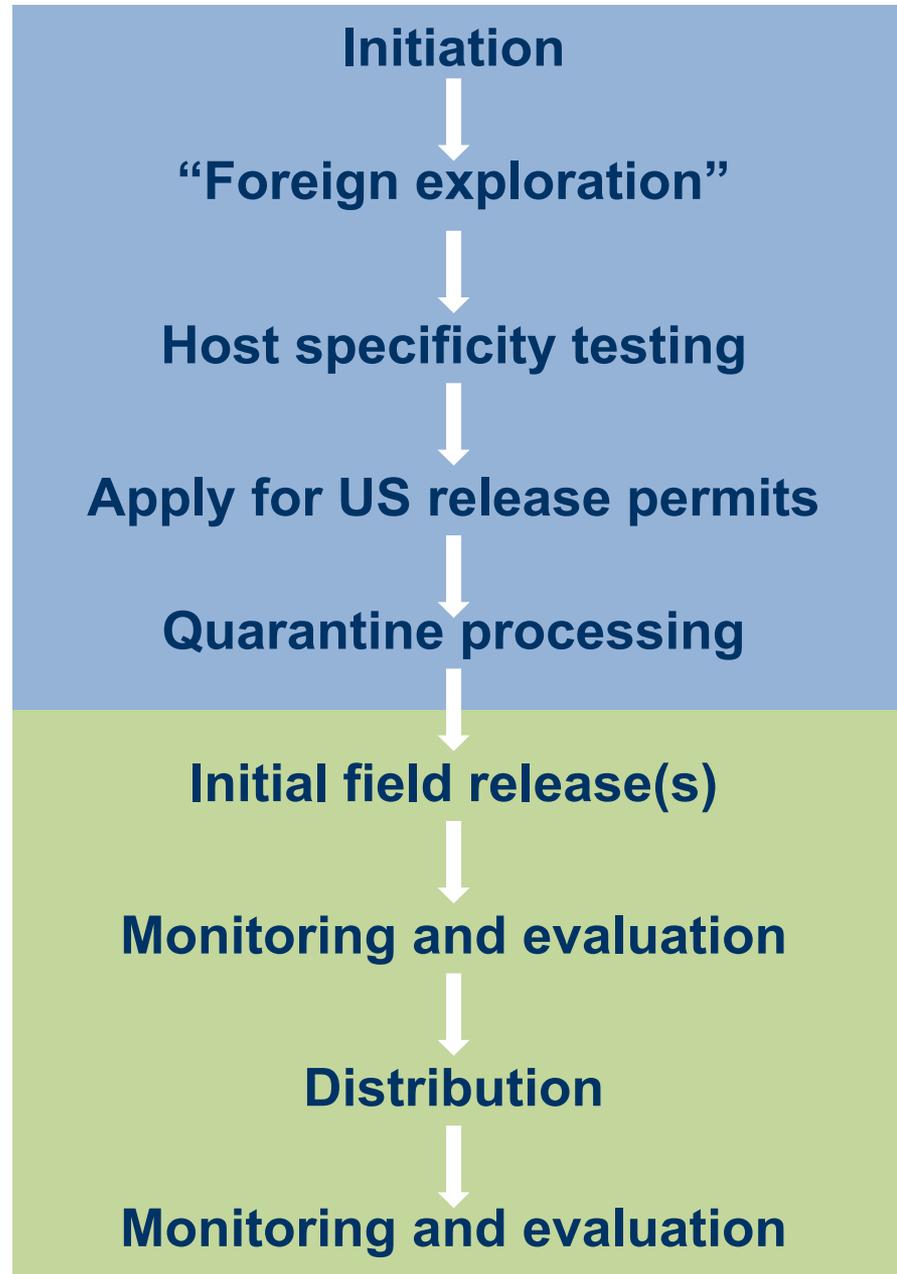


Classical biological control: the process

Pre-release research and development

- most of the costs
- much of the time

Implementation: putting agents in the field



Foreign exploration

- establish local contacts
- make travel arrangements
- conduct field surveys in native range of pest
- collect and identify natural enemies
 - × from target pest
 - × from relatives of target pest, if applicable
- assess type and severity of damage in field
- conduct preliminary assessment of biology and host specificity



Host specificity testing

Host specificity: the degree to which a potential biocontrol agent is restricted in the number of plant hosts utilized

Host range: the variety of hosts utilized by a biocontrol agent

- × many hosts = **broad host range** = polyphagous
- × fewer hosts = **narrow host range** = oligophagous
- × one/few hosts = **very narrow host range** = monophagous or stenophagous

Goal: estimate host range → estimate the relative risks that a BC agent poses to nontarget plants (natives, crops)

Host specificity testing

– Employs a test plant list:

- × crop/ornamental plants
- × related plants from native range
- × selected native plants
- × ‘listed’ native plants whenever possible
- × target weed = control
- × experiments in lab or field; no-choice and choice tests

– Test plant list based on:

- × ‘phylogenetic approach’: relatedness to target weed
- × ease of propagation and culture
- × availability of seeds, etc.

– Major evidence considered in permitting for US release (utilization of listed (T/E) or crop plant(s) a deal breaker)

– In practice, released agents highly host-specific (uses weed, few closely-related plants only)

Application for US release permits (USDA-APHIS-PPQ)

Researcher(s) submit a petition for US release to USDA



Petition evaluated by weed biocontrol

'Technical Advisory Group' (TAG) – *not* a decision-making entity

- US federal agencies (FWS), state agencies, Canada, Mexico
- **Mainly considers host specificity data**



PPQ publishes 'request' for field release in Federal Register:
public comment period



PPQ prepares biological assessment, addresses public comments; also, consultations with FWS



PPQ 'approves' release; issues permit for US



State Dept. of Ag. issues permit for state release

Weed biocontrol agents – pre-release research and development



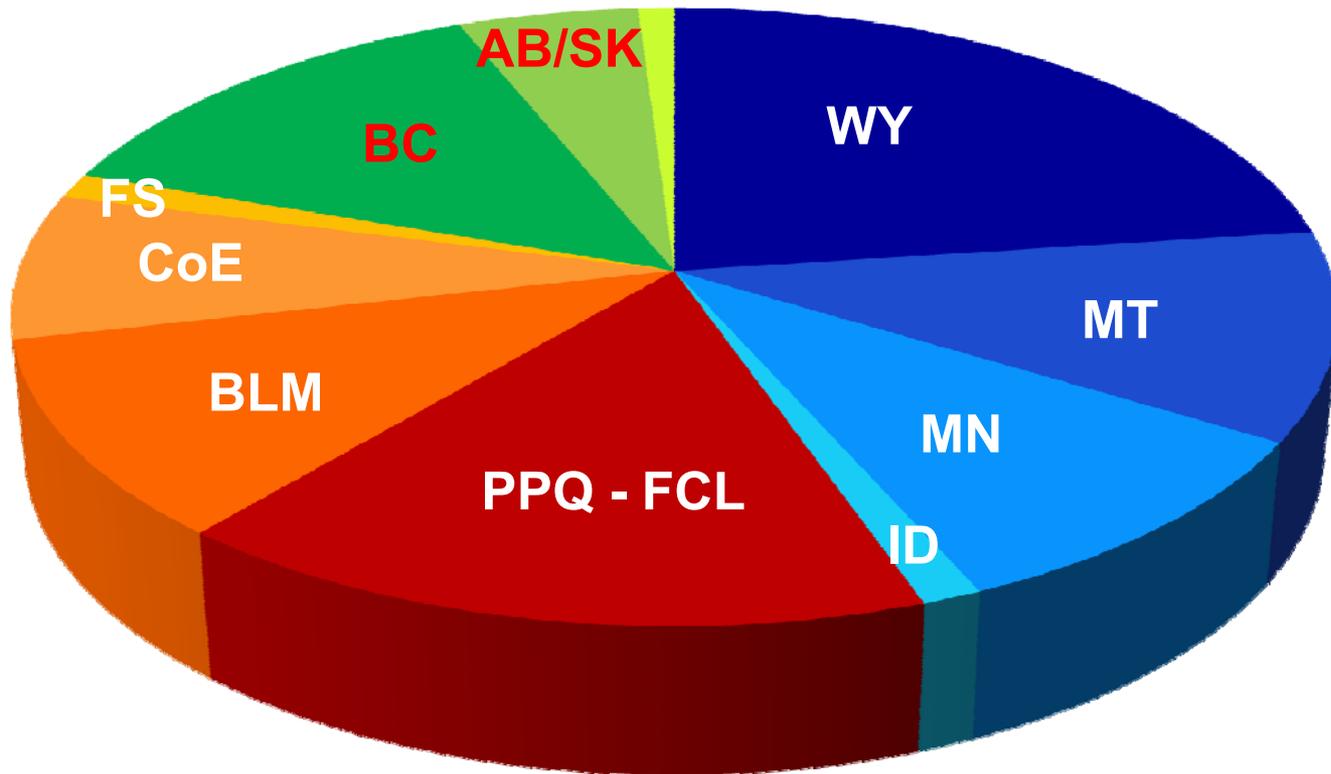
**CABI Bioscience Switzerland Centre
(Delémont):** works throughout Europe and Asia

also...



USDA ARS foreign biological control laboratories:
France, Australia, South America, China

CABI consortia funding (2011): North America



Total: \$US 1,106,450 (US 79%, CAN 21%)



PPQ: active weed biocontrol projects (2011)

Field release of BC agents:

Russian knapweed, *Acroptilon repens* (Asteraceae)

Tropical soda apple, *Solanum viarum* (Solanaceae)

Yellow toadflax, *Linaria vulgaris* (Scrophulariaceae)

~~Saltcedars, *Tamarix* spp. (Tamaricaceae)~~

Pre-release R&D:

Canada thistle, *Cirsium arvense* (Asteraceae)

Dyer's woad, *Isatis tinctoria* (Brassicaceae)

Field bindweed, *Convolvulus arvensis* (Convolvulaceae)

Garlic mustard, *Alliaria petiolata* (Brassicaceae)

Hawkweeds, *Pilosella* spp. (= *Hieracium* spp.) (Asteraceae)

Hoary cress, *Cardaria draba* (Brassicaceae)

Hound's-tongue, *Cynoglossum officinale* (Boraginaceae)

Mile-a-minute (bittervine), *Mikania micrantha* (Asteraceae)

Perennial pepperweed, *Lepidium latifolium* (Brassicaceae)

PPQ: 'mature' weed biocontrol projects (2011)

- Dalmatian toadflax, *Linaria dalmatica* (Scrophulariaceae)
- Diffuse knapweed, *Centaurea diffusa* (Asteraceae)
- Giant salvinia, *Salvinia molesta* (Salviniaceae)
- Leafy spurge, *Euphorbia esula* (Euphorbiaceae)
- Purple loosestrife, *Lythrum salicaria* (Lythraceae)
- Spotted knapweed, *Centaurea maculosa* (Asteraceae)



Noxious weeds – North Dakota

Absinth wormwood, *Artemisia absinthium* (Asteraceae)

Canada thistle, *Cirsium arvense* (Asteraceae)

Dalmatian toadflax, *Linaria dalmatica* (Plantaginaceae)

Diffuse knapweed, *Centaurea diffusa* (Asteraceae)

Leafy spurge, *Euphorbia esula* (Euphorbiaceae)

Musk thistle, *Carduus nutans* (Asteraceae)

Purple loosestrife, *Lythrum salicaria* (Lythraceae)

Russian knapweed, *Acroptilon repens* (Asteraceae)

Saltcedars, *Tamarix* spp. (Tamaricaceae)

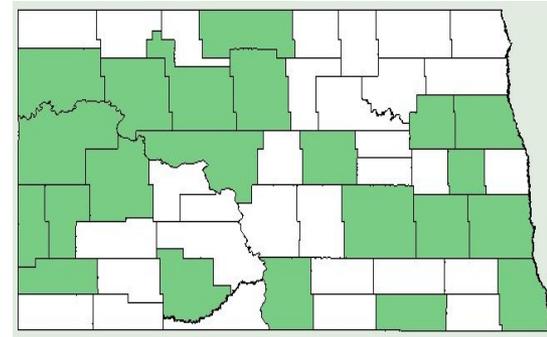
Spotted knapweed, *Centaurea stoebe* = *maculosa* (Asteraceae)

Yellow toadflax, *Linaria vulgaris* (Plantaginaceae)





Russian knapweed, *Acroptilon repens* (Asteraceae)

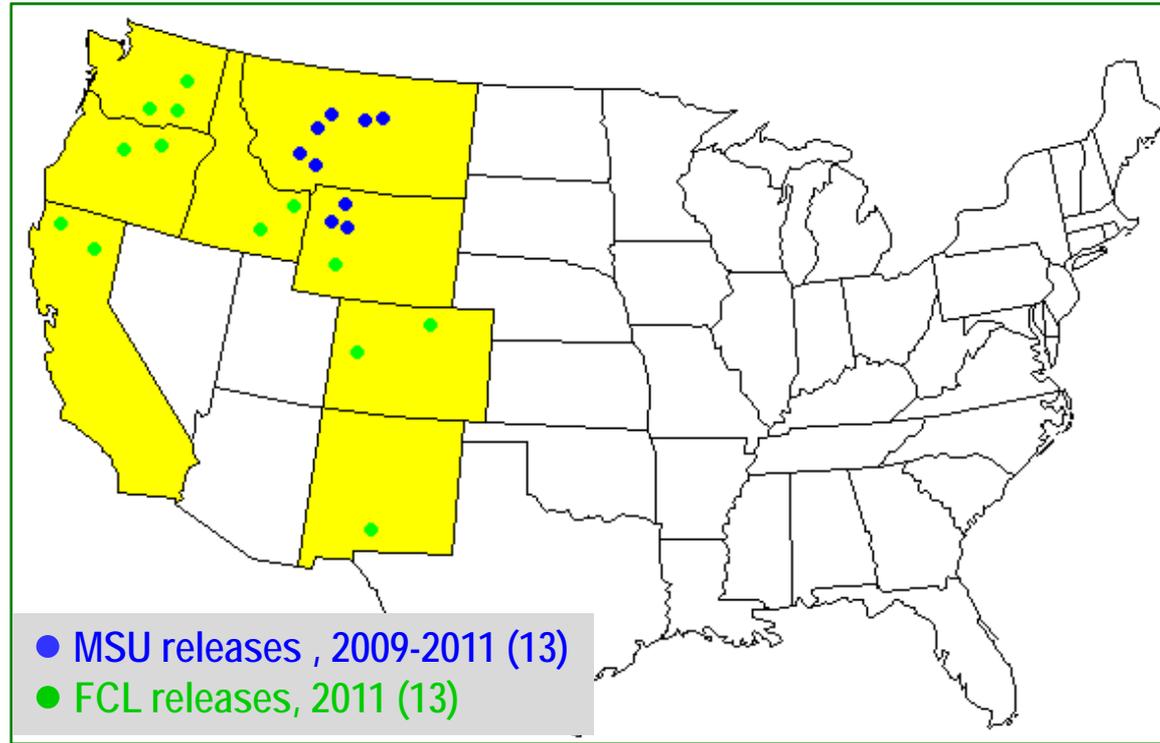


Bud gall midge, *Jaapiella ivannikovi* (Diptera: Cecidomyiidae)

- approved for US field release in 2009 (Uzbekistan)
- multiple generations per year
- reduces shoot growth, flowering, seed production
- CPHST FCL greenhouse rearing program initiated in 2011; galls for field release 2011-2012
- released in eight US states (2009-2011), Alberta; established in CO, MT, WY (collaborative project PPQ and MSU)



Russian knapweed, *Acroptilon repens* (Asteraceae)



Russian knapweed, *Acroptilon repens* (Asteraceae)

Gall wasp, *Aulacidea acroptilonica* (Uzbekistan)

- approved for US release in 2008
- difficult to collect and rear in quarantine; no US releases yet
- reduces seed production; relationship with *Jaapiella*?
- scale up US colonies in 2011 and 2012 – field release(s)?

Bud gall mite, *Aceria* sp. near *acroptiloni* (Iran)

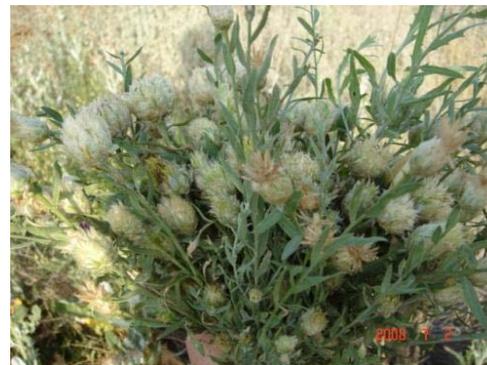
- attacks young shoots, flower buds; greater whole-plant impacts (stunting)?
- very host-specific (safflower?); lab and field tests continuing (2012-13)
- initiate host-specificity tests 2011-2012

Leaf-feeding beetle, *Galeruca* sp. (Uzbekistan)

- initiate host-specificity tests 2011-2012

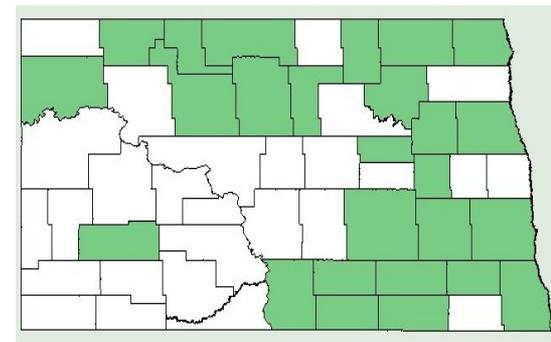
Seedhead flies, *Urophora* spp. (Uzbekistan)

- initiate host-specificity tests 2012 (in quarantine @ MSU)



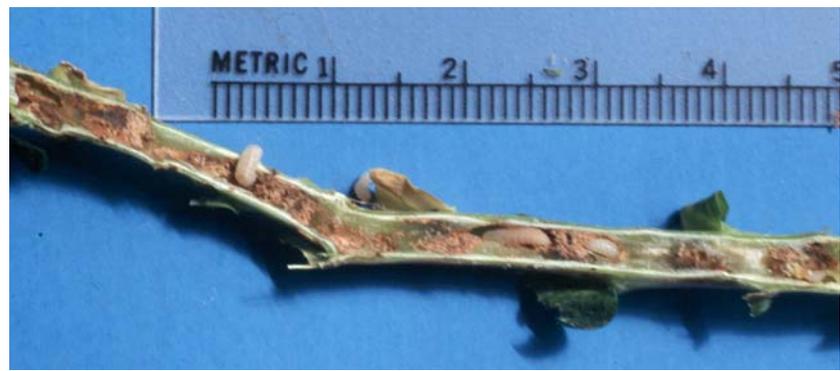


Yellow toadflax, *Linaria vulgaris* (Plantaginaceae)



Yellow toadflax ‘strain’ of Dalmatian toadflax stem-mining weevil, *Mecinus janthinus*

- discovered at several sites in western Montana
- impact: causing yellow toadflax mortality
- collected and redistributed in 2010 and 2011: CO, ID, MT, ND, SD, WV, WY
- greenhouse rearing program: CPHST FCL in cooperation with CSU
 - scaled up in 2011
 - field release of reared weevils in 2012



Yellow toadflax, *Linaria vulgaris* (Plantaginaceae)

Potential new agents in the pipeline...

Stem-galling weevil, *Rhinusa pilosa*

- native to eastern Europe
- highly specific to YTF; very minor galling on a few native plants
- impact: stunted shoot growth, reduced flowering, mortality?
- submit US petition by early 2012

Stem-mining weevil, *Mecinus heydeni*

- complete host specificity testing by 2013

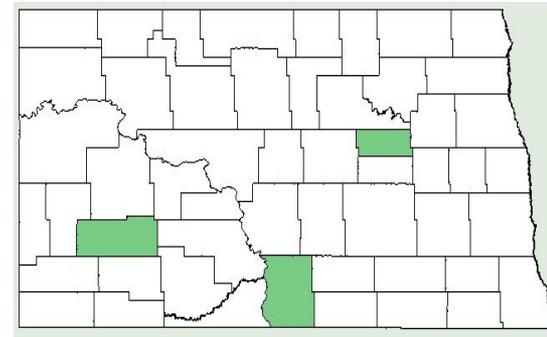
Stem-mining weevil, *Mecinus barbarus*

- better adapted to southern habitats?
- may initiate preliminary biology studies, host-specificity tests in 2012





**Dalmatian toadflax,
Linaria vulgaris
(Plantaginaceae)**



Potential new agents in pipeline...

Stem-galling weevil, *Rhinusa brondelii*

- appears host-specific; complete testing in 2012
- submit petition in 2012 or 2013?
- some taxonomic 'issues'

Stem-mining weevil, *Mecinus laeviceps*

- complete host specificity testing by 2013

Seed-feeding weevil, *Rhinusa dieckmanni*

- may begin biology and host-specificity studies in 2012



Exotic toadflaxes, *Linaria* spp. (Plantaginaceae)

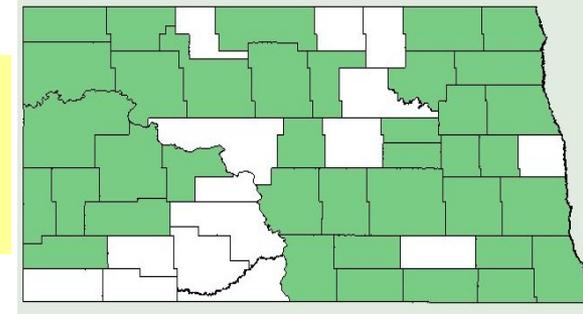
Major issue for new toadflax biocontrol agents: “demolition” of Scrophulariaceae

- plants placed into at least five new families
- revision of many genera
- generate new, more complicated test plant lists
- longer time for pre-release R&D





Creeping thistle*, *Cirsium arvense* (Asteraceae)



Pathogen survey in nw China (2009-2011)

- variety of fungi collected, IDs ongoing
- host specificity testing begun
- most promising (so far): white rust, *Albugo trapogonis*
- agents for US? >5 years



New insect biocontrol agents?

- possible new surveys in China
- may not be any 'new' insects host-specific enough for US (native *Cirsium* thistles)



* OK, Canada thistle

Canada thistle, *Cirsium arvense* (Asteraceae)

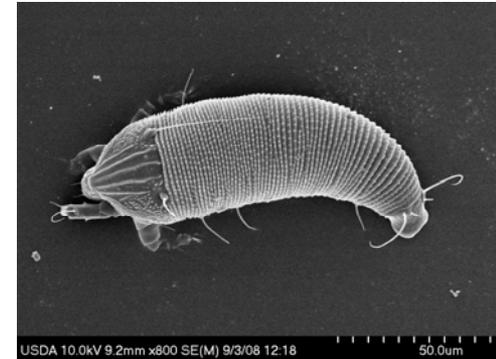
Distinct lace bug, *Corythucha distincta*

- native insect
- feeds on Canada thistle; may kill leaves, shoots
- also feeds on 9 native *Cirsium* spp. tested



Canada thistle rust mite, *Aceria anthocoptes*

- European mite accidentally introduced into US
- feeds only on *Cirsium* thistles
- found on at least 12 native *Cirsium* thistles



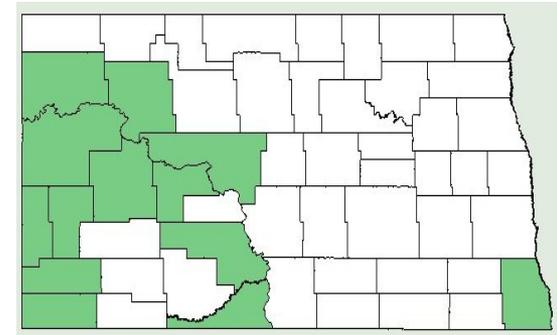
Foliar pathogen, *Alternaria cirsinoxia*

- native fungus (first US report?)
- first kills leaves and then plants
- also attacked sunflower, safflower, native *Cirsium* spp.





Saltcedars, *Tamarix* spp. (Tamaricaceae)



Saltcedar leaf beetle, *Diorhabda carinulata**, cooperative release project in northern states

- initiated in 2005
- beetles released in 10 states through 2008
- prescribed post-release monitoring program
- at least one release site established in 9 of 10 states (?)

[**Diorhabda elongata* taxonomic revision: one species, several subspecies → five species (*D. carinulata* = 'northern' beetle)]



Saltcedars, *Tamarix* spp. (Tamaricaceae)

Lawsuit vs. USDA and FWS – 2009

- shut down USDA participation
- stopped USDA funding for project partners (e.g. monitoring)
- existing PPQ permits for interstate *Diorhabda* movement revoked
- no new permits for interstate movement
- ND: ‘natural’ spread from adjacent states (e.g. SD, MT)?
- so far, limited establishment and impact at far-northern US sites

PPQ saltcedar beetle collection team



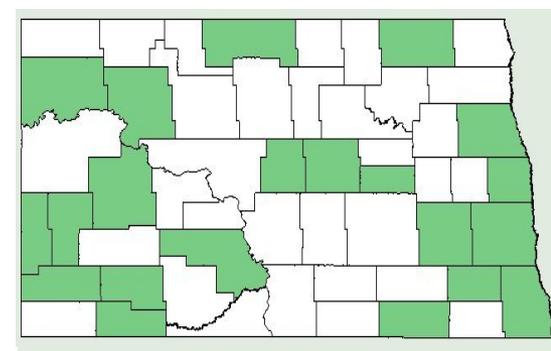
2008



2011



**Hoary cress,
*Lepidium (=Cardaria)
draba* (Brassicaceae)**



Stem-galling weevil, *Ceutorhynchus cardariae*

- host specificity testing completed in 2011
- host-specific; a few native mustards (annuals) occasionally attacked in tests, but not 'true' hosts
- petition for US release submitted in late 2011



Seed-feeding weevil, *Ceutorhynchus turbatus*

- completed testing in 2011; most host-specific HC agent
- no utilization of native US plants in experiments
- reduce viable seeds/spread but doesn't affect established plants
- submit petition in 2012 (?)



Hoary cress, *Lepidium* (= *Cardaria*) *draba* (Brassicaceae)

Stem-mining weevil, *Ceutorhynchus merkli*

- 'revisit' host-specificity testing in 2012

Root-galling weevil, *Ceutorhynchus assimilis*

- oligophagous species, but appears to be a *L. draba*-specific 'strain'
- may initiate host-specificity tests in 2012



Two potential agents not host-specific enough for US (rejected)

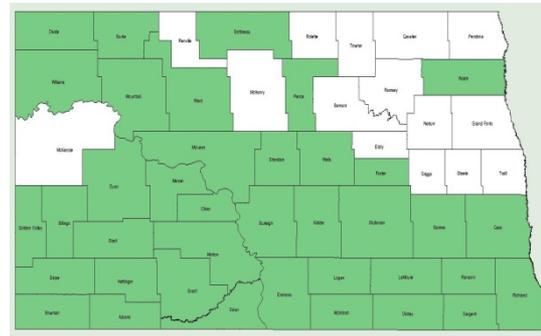
- root-mining weevil, *Melanobaris* sp. near *semistriata*
- shoot-mining flea beetle, *Psylliodes wrasei*

Conduct additional natural enemy surveys

- agents to date: central, eastern Europe
- Turkey (2010-2011: nothing), Kazakhstan, Siberia



Field bindweed, *Convolvulus arvensis* (Convolvulaceae)



Two agents released and established in US (1980s)

- Bud gall mite, *Aceria malherbae* – efficacy highly variable
- Defoliating moth, *Tyta luctuosa* – not established (?); no impact



Field bindweed, *Convolvulus arvensis* (Convolvulaceae)

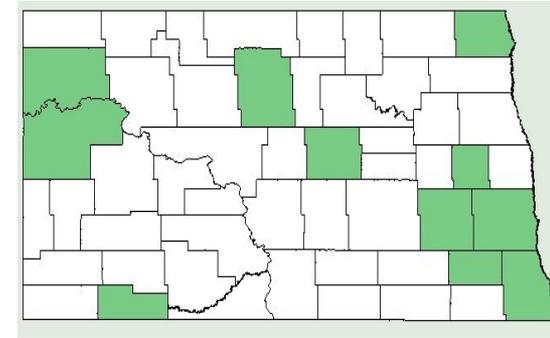
Initiated new search for potential agents in 2009

- central and eastern Europe (survey completed in Slovakia)
- concentrate on stem and root feeders
 - stem- and root-mining fly, *Melanagromyza albocilia*
 - root-mining flea beetles, *Longitarsus pellucidus* and *L. rubiginosus*
- collect insects and initiate lab colonies
- finalized test plant list; acquire seeds of test plants (US natives)
- begin host-specificity testing (2011)





Hound's-tongue, *Cynoglossum officinale* (Boraginaceae)



Root-mining weevil, *Mogulones crucifer* (formerly *cruciger*)

- permit for US field release: **not** approved (1998?)
- released, established, and effective in Canada (BC, AB)
- natural immigration into ID, WA (spreading about 3.5 km/year)...MT ('natural?')
- nontarget attack on native Boraginaceae in Canada, US – impacts?
- fairly broad host range; including native T&E plants in lab tests
- lots of native Boraginaceae in US (25+ in ND); six T/E species (CA, OR, WA, ID, TX)



Lithospermum ruderale



Hound's-tongue, *Cynoglossum officinale* (Boraginaceae)

Pest Alert

Plant Protection and Quarantine
March 2010

Mogulones Cruciger

Mogulones cruciger (Coleoptera: Curculionidae) is a European, root-feeding weevil that is not native to the United States. It has gained notoriety in North America over the past 20 years as a biological control agent because it feeds on and destroys houndstongue (*Cynoglossum officinale* L.)—a highly invasive weed that is a serious nuisance for Western ranchers and nature enthusiasts. Houndstongue is highly toxic to cattle and horses, and it prevents desirable plant species from becoming established by capturing soil resources with its deep, well-anchored taproots.

In its battle against houndstongue, Canada began releasing *Mogulones cruciger* as a biological control agent in 1997. The weevils have since diminished houndstongue in the provinces of Alberta and British Columbia, which has led some ranchers in the United States to push for their release in this country. However, because these weevils feed on federally protected and non-targeted plants in environmentally sensitive areas of the United States, releasing them here could have serious ecological repercussions. The U.S. Department of Agriculture's



Figure 1. Dorsal view of an adult *Mogulones cruciger*. The species name *cruciger* refers to the cross-shaped white marking on the dorsal surface of the insect.



Figure 2. Lateral view of an adult *Mogulones cruciger*.

(USDA) Animal and Plant Health Inspection Service (APHIS) is therefore committed to preventing *Mogulones cruciger* from being introduced into the environment through any non-natural means.

Description

Mogulones cruciger eggs are pale yellow ovals. One by one, they are deposited into

cavities chewed by ovipositing females in various locations on houndstongue plants—such as within the stalks of rosette leaves and of stem leaves nearest the crown; inside the shoot base; and in the root crown. At 82 degrees Fahrenheit, the eggs hatch in approximately 7 days. The larvae are white with a light brown head. They feed on houndstongue plants year-round, eating the root and foliage. Mature larvae leave the roots to construct chambers in the soil, where they develop into pupae. Adults emerge from the soil in April and May, feed on houndstongue leaves, and start mating within 14 days. Adult *Mogulones cruciger* weevils are black and oval-shaped, growing to approximately 3 to 4 mm in length. They have a white cross on the center top of their wing covers and can live as long as 12 to 14 months. *Mogulones cruciger* adults are capable of dispersing up to 0.3 miles annually.

Hosts

As mentioned above, the primary host for *Mogulones cruciger* is houndstongue, a biennial plant native to Eurasia. Houndstongue grows most often on rangeland, heavily grazed

Root-mining weevil, *Mogulones crucifer* (formerly *cruciger*)

- may control hound's-tongue
- **not permitted** for US release
- deliberate release in US: violation of ESA, other Federal statutes
- possible fines: \geq \$25,000; jail time?
- 'bad' for weed biocontrol in US

Hound's-tongue, *Cynoglossum officinale* (Boraginaceae)

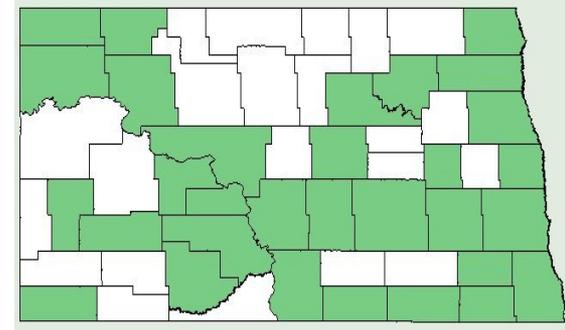
Seed-feeding weevil, *Mogulones borraginis*

- reduces seed production by >50%; important vs. biennial weed
- host range tests completed 2011; most host-specific potential BC agent
- submit US field release petition in 2012





Russian olive, *Elaeagnus angustifolia* (Elaeagnaceae)



Goal: reduce spread rather than 'kill' established plants

- find BC agents that reduce flowering and fruiting
- ongoing natural enemy surveys in Turkey, Iran, Kazakhstan (center of origin?)



- Bud gall mite, *Aceria angustifoliae*
- Fruit-feeding moth, *Ananarsia eleagnella*
- host specificity tests started in 2011

Other weed biocontrol projects of possible interest to ND (all in pre-release R&D phase)

Funded by PPQ-CPHST, in part

- ✓ Garlic mustard, *Alliaria petiolata* (Brassicaceae) - CABI
- ✓ Perennial pepperweed, *Lepidium latifolium* (Brassicaceae) - CABI

Not funded by PPQ-CPHST

- ✓ Common buckthorn, *Rhamnus cathartica* (Rhamnaceae) - CABI
- ✓ Common tansy, *Tanacetum vulgare* (Asteraceae) - CABI
- ✓ Oxeye daisy, *Leucanthemum vulgare* (Asteraceae) - CABI
- ✓ Russian thistle, *Salsola tragus* (Chenopodiaceae) - ARS



Issues affecting classical weed biocontrol in the northern US

- ▶ reduced funding
- ▶ northern insect agents often univoltine
- ▶ target weeds from large families with many native plants (e.g. Asteraceae, Brassicaceae) – have we picked the low-hanging fruit?
- ▶ longer, more complicated test plant lists
- ▶ pre-release R&D takes longer (up to 10 years)
- ▶ increasing scrutiny of classical BC: ecosystem impacts
- ▶ failure to quantify beneficial impacts (weed control) – before and, especially, after field release
- ▶ the ‘zero risk’ (safety) paradigm; failure to utilize ‘true’ risk:benefit analyses in BC regulation

▶ ***Outlook:*** new BC agents for old/new weed targets will continue to dribble from the pipeline (but...fewer agents, longer time), barring ‘regulatory meltdown’

The end....



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The end....



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