Invasive plants & noxious weeds

- Exotic plant species (for rangeland weeds most commonly form Eurasia) that increase in density and abundance

- Weeds are designated “noxious” by state law or county ordinance when causing negative impacts
...and they do increase quickly

- Rush skeletonweed
  *Chondrilla juncea* L.
  1963 – 40 acres
  2006 – 4,000,000 acres

- Yellow starthistle
  *Centaurea solstitialis* L.
  1955 – 50 acres
  2005 – 500,000 acres
More weeds in the future

Reasons

• Increased trade
• Increased travel

New Invasive species in San Francisco Bay

• 1851-1960: 1 per year
• 1961-1995: 3 per year

Fish introductions in U.S.

• 1850-1900: 67 species
• 1901-1950: 140 species
• 1951-1996: 488 species

2,000,000 Standard containers in transit every day
Integrated weed management
What is your management goal?

Is this successful management?
Biological control

- Rush skeletonweed
- Yellow starthistle
- Spotted knapweed
- Tansy ragwort
Biological control

• What is biological control?
  – **Classical:** nonnative insect, mite, nematode or pathogen for a non-native plant
  – **Conservation:** modifying conditions to favor natural enemy survival
  – **Augmentative:** biological pesticide
  – **Cultural:** utilizing other herbivores
Principle idea of classical biological control

Restore the balance between weed and its natural enemies that exist in the weed’s native range

Dyer’s woad *Isatis tinctoria* L. in its native range in Eurasia

... and in its introduced range in North America
Every plant is eaten by different types of herbivores:

- **Grazing animals:** Cows, sheep, rabbits,…
- **Generalist insects:** Grasshoppers, aphids,…
- **Specialized insects** closely adapted to weed

Purple loosestrife
Classical biological weed control

**Directed against:** plants that invade areas outside their normal distribution range

**By:** introducing natural enemies (arthropods, mites, fungal pathogens) from native range of the plant

**With the objective:** to reduce and permanently stabilize the density of the invasive plant

The natural enemies (biological control agents) are expected to **multiply and disperse by themselves**

**Prerequisite for introduction:** narrow host range
Ecological principle of CBCW

Weed population size

Impact level

1. Development of weed problem
2. Weed causing economic, environmental injury
3. Control agents established
4. Weed no longer causing economic/environmental injury

Equilibrium before control
Biocontrol introduction
Equilibrium after establishment of biocontrol agents
Ecological principle of CBCW

1. Weed introduction
2. Equilibrium before control
3. Equilibrium after establishment of biocontrol agents
4. Weed no longer causing economic/environmental injury

Impact level

Weed population size

Development of weed problem
Weed causing economic, environmental injury
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Weed no longer causing economic/environmental injury

Biocontrol introduction
Success rates

Success = substantial to complete control of target weed

Substantial control: other methods are needed but the effort required is reduced

Complete control: no other control methods required or used

Hoffmann (1995)

Success Rates:
25-30% of agents released are successful
50-83% of projects are successful

McFadyen (1998)
Success rates of weed biocontrol

• Although only 25% of agents establish after introduction, the rate of successful biocontrol programs is almost 75%

• Research goal: Try to increase the rate of agents that establish
Costs and benefits

Excellent cost-benefit ratio:

**For each $1 invested $23 return**

Based on review for 29 Australian weed biocontrol projects (McFadyen 1998)
Safety record

> 350 organisms released
15 attacked non targets
Attack either transient or predicted
Mostly on natives closely related to the target weed (1 exception)
No evidence for host shifts
Conclusion: risk remains, but overall safety record excellent

Biocontrol agents that increase rapidly are more likely to have impact.

Larinus minutus
Knapweed flower weevil

Weed densities

Initial release

Success

Lag time

1993 1997 2000

Establishment of biocontrol agents

Exponential increase
Successful biological weed control agents

The ability of agents to control weed populations depends not on

per capita impact of the biocontrol agent

but on

the numerical response of the insect
Example for a successful weed biocontrol program

Purple loosestrife
- 1988 – 1993
- $760,000
- 5 insect biocontrol agents
- 4 introduced in U.S. and Canada
- Insects successfully used to manage loosestrife
- Distributed in millions every yr.
Risks of biological control

No management option is free of risks and disadvantages

Biological control is no exception

It is, however, one of the most environmentally vetted management strategy
The seed feeding weevil *Rhinocyllus conicus* imported for the control of European thistles (musk thistle) in 1969

- Feeds on many native non-target thistles in the U.S.
- *R. conicus* present on at least 5 of the 6 rare native thistle species in California
Ecological non-target effects on native thistles

- *Larinus planus*
- *Rhinocyllus conicus*
- *Cassida rubiginosa*

Unapproved accidental introduction
Advantages & disadvantages of biocontrol

- Introduction of non-native host-specific specialist insect herbivores (and pathogens) to permanently suppress populations of introduced non-native plant species

<table>
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<tr>
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Advantages & disadvantages of biocontrol

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Where do biocontrol agents come from?

- Finding safe and effective weed biocontrol agents can be difficult
- Long term effort
- Sometimes no suitable biological control agents for specific weeds at all
Foreign exploration

Step 1: Literature surveys

- Hundreds of insects associated with leafy spurge
- Records in old books without index written in odd languages
- Some recorded as monophagous (found to feed/develop only on leafy spurge)
- However: what is leafy spurge?
Foreign exploration

Step 2: Find the plant
Step 3: Have a little road trip vacation
Foreign exploration

Step 2: Find the plant
Step 3: Have a little road trip vacation
Foreign exploration

Step 4: Study the biology of the insects
Step 5: Study impact of insect on weed
Step 6: Test the host-specificity or environmental safety of insects

(A federal requirement under ESA, PPA and NEPA prior to the introduction and field release of agents to North America)
Host-specificity

- Tarnished plant bug (*Lygus lineolaris*)
  - Worldwide pest
  - >300 host plants

- Leafy spurge clearwing moth (*Chamaesphecia hungarica*)
  - Biocontrol agent
  - Less than 1 host plant
Aims of host range testing

1. Prevent introduction of agents that may cause unacceptable damage to non-target plants

2. But not reject agents unnecessarily, reducing the probability of success of a weed biological control program
Host range testing methods

From no-choice tests under confined conditions TO

Multiple-choice tests under field cage or field conditions
Field host range of potential agents in area of origin

*Centaurea* sp.  •
(closely related non-target growing intermixed; not attacked by *Aceria*)

*Acroptilon repens*  •
(target weed; attacked by *Aceria*)
Test plant list – *Lepidium draba*

- Genetic types of target: 13
- NA plant species in same genus: 20
- NA and introduced plant species in other genera within Brassicaceae: 63
  (60% natives, 4 T&E species)
- Species in other families: 8
  (mostly with biochemical similarities)

Total: 104
Centrifugal phylogenetic method

Species more closely related to the target weed are more likely of being attacked than more distantly related ones.
Molecular analyses

Increasingly important; currently hardly any project without molecular component

Important to:
Clarify taxonomic position of target weed and test species to help build test plant lists and interpret test results
Detect cryptic species
Investigate genetic variability of target and agent populations
Identify immature stages (target and agents)
Find area of introduction

Dr. John Gaskin
USDA ARS Sidney, MT
Host-specificity testing

- Euphorbia esula: NO
- Euphorbia robusta: YES
The permitting/introduction process

- Host range testing (4 - 8 years)
- Research summarized in Petition for Release
- **TAG** (Technical Advisory Group)
- Recommends to **USDA-APHIS-PPQ**
- **U.S. FWS** has to concur
- Researcher and APHIS write **EA**
- Post release intent in Federal Register
- APHIS signs **FONSI** and permission for release
- Introduction into APHIS approved **quarantine**

- If problems occur: **Section-7 Consultations**
1st project in North America: St. John‘s Wort

Exotic rangeland weed introduced from Europe

In 1940s to 60s, seven insects introduced as biological control agents

Especially the leaf beetle *Chrysolina quadrigemina* contributed to the successful control of St John‘s wort

Huffacker (1967), Julien & Griffiths (1998)
Biocontrol of St. Johnswort was considered such a success, it was featured as title story in 1956 issue of ‘Scientific American’
Chrysolina beetles on St. Johnswort in Hells Canyon
1st project in North America: St. John’s Wort

Exotic rangeland weed introduced from Europe

In 1940s to 60s, seven insects introduced as biological control agents

Especially the leaf beetle *Chrysolina quadrigemina* contributed to the successful control of St John‘s wort

St. John‘s wort reduced to 1% of its previous level in California

4-fold increase in forage production in Ontario

Huffacker (1967), Julien & Griffiths (1998)
Release information – Nez Perce Tribe Biocontrol Center (ID)

- Clearinghouse for release information
- Releases are free
  - Submit a release form
  - Find an area that will be protected
  - Know what you are releasing and that agent’s target
- Data tabulated, put into GIS
  - Release information for 25 years
www.eddmaps/biocontrol
BCA records

- The information we need to have
  - Agent name (scientific, common)
  - Collection origin
  - Method of release
  - # released
  - Release dates
  - # of releases
  - Host material
  - Steps taken to ensure protection from pesticides
  - Very rarely done
BCA records

- BCA release record
  - Name of person making release
  - Date
  - Location
  - Acres of infestation
  - Pest species
  - Soils
  - Weather conditions
- Must be done for every release
Evaluation and assessment

• How “effective” are these agents?
• Standardized Impact Monitoring System (SIMP)
• Dwindling budgets
• The need to quantify what’s happening in the field
  – Is biocontrol working?
  – What agents are effective?
  – How long does it take?
  – How much does location matter?
  – What kind of vegetation moves in if the target weed moves out?
Standardized Impact Monitoring Protocol (SIMP)

- Initiated in 2007
- Currently eight “systems”
  - Canada thistle and *Urophora cardui*
  - Canada thistle and *Hadroplantus litura*
  - Dalmatian toadflax and *Mecinus janthinus*
  - Diffuse knapweed and *Larinus* spp.
  - Leafy spurge and *Aphthona* spp.
  - Leafy spurge and *Oberea erythrocephala*
  - Spotted knapweed and *Cyphocleonus achates*
  - Spotted knapweed and *Larinus* spp.
Standardized Impact Monitoring Protocol (SIMP)

- Educational 2-pagers
  - Documents outlining the process
- Monitoring forms
  - 30-45 minutes once per year
- Simple to do
- Many cooperators
- Minor tweaks
Status of Biological Control Agents on Weeds

What’s Hot, What’s Not, and What’s Available- Spring 2012
What’s Hot and Not in:

- Deciding if Biological Control of Weeds is Right for You
- Making Biological Control a Part of your Weed Strategy
- Site Selection
- Choosing a Biological Control Agent
- Following Through
## Deciding if Biological Control is Right for you

<table>
<thead>
<tr>
<th>Goal</th>
<th>Suppression</th>
<th>Eradication</th>
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</thead>
<tbody>
<tr>
<td>Time Frame</td>
<td>Years</td>
<td>Yesterday</td>
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<tr>
<td>Target Weed</td>
<td>Old Foe</td>
<td>New Invader</td>
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<tr>
<td>Resources</td>
<td>Minimal</td>
<td>None</td>
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<tr>
<td>Info Sources</td>
<td>Local Experts</td>
<td>No Local Information</td>
</tr>
</tbody>
</table>
The Basics: Code of Best Practices for Biological Control of Weeds

1. Ensure target weed’s potential impact justifies release of non-endemic agents
2. Obtain multi-agency approval for target
3. Select agents with potential to control target
4. Release safe and approved agents
5. Ensure only the intended agent is released
6. Use appropriate protocols for release and documentation
The Basics: Code of Best Practices

• 7. Monitor impact on target
• 8. Stop releases of ineffective agents, or when control is achieved
• 9. Monitor impacts on potential non-targets
• 10. Encourage assessment of changes in plant and animal communities
• 11. Monitor interaction among agents
• 12. Communicate results to public
Implementing the Code

• Many land management agencies are putting process into place to insure that the Code of Best Practices is met
• Coordination of biological control activities by cooperative weed management areas helps, as does offering training at meetings like this
• Statewide monitoring of weed biological control is a goal for most practitioners
We Need Your Help!

• While there are people in place to “steer the ship,” we still need rowers
• If you are releasing biological control agents, we ask that you make sure you are releasing the best agent for your area
• We also ask for your help monitoring what biological control is doing. Is it helping you meet your weed management goals?
What’s Hot, What’s Not- the Point

• The information in this talk is based on personal communication with biological control practitioners and personal observations

• The “recommendations” are based on #3 and #8 of the Code- “Select agents with potential to control the target” and “stop releases of ineffective agents”
BIG Recommendation

• Weed biological control is not new
• Many biological control agents have been released in western states for years
• Before you go to the trouble of procuring agents for release, check to see if you already have them— you may be surprised
Knapweeds:
# Knapweed Agents (15!)

<table>
<thead>
<tr>
<th>Type of Agent</th>
<th>Aceria centaureae</th>
<th>Agapeta zoegana</th>
<th>Bangasternus fausti</th>
<th>Chaetorella acrolophi</th>
<th>Cyphocleonus achates</th>
<th>Larinus minutus</th>
<th>Larinus obtusus</th>
<th>Metzneria paucipunctella</th>
<th>Pelochrista medullana</th>
<th>Pterolone inspersa</th>
<th>Sphenoptera jugoslavica</th>
<th>Subanguina picridis</th>
<th>Terella virens</th>
<th>Urophora affinis</th>
<th>Urophora quadrifasciata</th>
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<td>Site of Attack</td>
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# Knapweed Biocontrol Agents and the Species they Attack

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Current Status

- 13 agents currently released
- Seedhead feeders more available and are becoming more widespread (you probably already have some)
- N. Idaho- both *Urophoras* (seedhead flies) and *Metzneuria* (seedhead moth) very common in same heads; work synergistically
- Also seeing more *Chaetorellia acrolophi* (another seedhead fly) in spite of no organized efforts to release in last 20 years
Current Status

• Seedhead weevils *Larinus minutus* and to a lesser extent *L. obtusus* now established in many areas in Idaho and Montana and work in Oregon shows is VERY promising

• Seedhead weevil *Bangasternus fausti* becoming more available; not a lot of work to show efficacy

• Root feeders *Agapeta* and *Cyphocleonus* show most promise, work ongoing

• Other agents only limited releases and little information on effects
Suggestions

• Work in Canada shows get best control on knapweed species if combine seedhead feeders and root feeders.

• On diffuse- *Sphenoptera* in Roots and 2 *Urophora* species and *Metz* in heads lead to dramatic decrease in density. Also see dramatic results with *Sphenoptera* and *Larinus* species

• Similar trends being observed in spotted knapweed, just not as dramatic w/ *Cyphocleonus* and *Larinus* sp.
The Banded Gall Fly *Urophora affinis*

- Forms hard galls in the flower head
- Attacks many knapweed species
- Well established
UV Knapweed Seedhead Fly

*Urophora quadrifasciata*

- Form papery galls in the seedhead
- Attacks many knapweed species
- Well established
Chaetorellia acrolophi: Knapweed Peacock Fly

Cleared for release in 1992 in Montana and Oregon - now common in N. Idaho
Knapweed Seedhead Moth

(*Metzneria paucipunctella*)

- May eat other seedhead feeders
- Widespread in northern ID
- Vulnerable to extreme winter temperatures
Lesser Knapweed Flower Weevil (*Larinus minutus*)

Blunt Knapweed Flower Weevil (*Larinus obtusus*)

• Both very similar in appearance and damage

• Larvae feed on seeds, adults on stems and leaves

• Starting to be more abundant locally. In N. Idaho we are no longer actively releasing because it appears to be everywhere!
Broad-Nosed Seedhead Weevil
(Bangasternus fausti)

- Recent addition as far as availability
- Feeds on florets and ovules
- Showing great promise in OR and WA
- We are trying to make as many releases as possible locally
Sulphur Knapweed Moth

(Agapeta zoegana)

- Larvae feed in roots
- Spotted knapweed preferred
- Established in many areas, local information sketchy
- Becoming more and more abundant
Knapweed Root Weevil
(*Cyphocleonus achates*)

- Larvae mine in roots, adults feed on leaves
- Appears to be getting more abundant by the year
- An important piece to knapweed biological control
Bronze Knapweed Root-Borer (Sphenoptera jugoslavica)

- Adults feed on leaf axils, larvae feed in roots
- Feeding in roots causes gall-like swelling
- Most common on diffuse,
Poison Hemlock

• Only one agent- *Agonopterix alstroemeriana* a Moth
• APHIS recently began issuing permits for this agent- not one we recommend in Idaho
• Moth defoliates- eats stems, leaves, and flowers
• Established in poison hemlock in Idaho, does defoliate and at times substantial but not yet having a significant effect
## Purple Loosestrife

<table>
<thead>
<tr>
<th>Agent Name</th>
<th>Type of Agent</th>
<th>Feeding Site</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Galerucella calmariensis</em> and <em>pusilla</em></td>
<td><em>Beetles</em></td>
<td>Defoliators which feed on leaves and shoots</td>
</tr>
<tr>
<td><em>Nanophyes brevis</em> and <em>marmoratus</em></td>
<td><em>Weevils</em></td>
<td>Flower buds are fed upon; attacked buds usually abort and fail to produce seed</td>
</tr>
<tr>
<td><em>Hylobius transversovittatus</em></td>
<td><em>Weevil</em></td>
<td>Larvae feed in the roots and adults feed on foliage</td>
</tr>
</tbody>
</table>
Purple Loosestrife- Notes

• Most abundant agents- and most dramatic- are the *Galerucella* beetles
• Defoliation from beetles may suppress flowering
• *Nanophyes* not as available and may be starved out if *Galerucella* present (loosestrife stops flowering)
• *Hylobius* easier to deal with now that can release adults, still hard to get
Purple Loosestrife

*Hylobius transversovittatus*

*Nanophyes marmoratus*

*Galerucella sp.*

Before And After

![Image of Purple Loosestrife field](image1)

![Image of Hylobius transversovittatus](image2)

![Image of Nanophyes marmoratus](image3)

![Image of Galerucella sp.](image4)

![1994 Before Image](image5)

![1995 After Image](image6)
## Rush Skeletonweed Agents

<table>
<thead>
<tr>
<th>Agent Name</th>
<th>Type of Agent</th>
<th>Feeding Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cystiphora schmidti</td>
<td>Gall Midge</td>
<td>Rosette, leaves, stem. Reduces photosynthesis- stresses plant</td>
</tr>
<tr>
<td>Eriophyes chondrillae</td>
<td>Gall Mite</td>
<td>Rosette, leaves, stem. May kill seedlings or young plants, reduces flower production</td>
</tr>
<tr>
<td>Puccinia chondrillina</td>
<td>Rust Fungus</td>
<td>Rosettes, leaves, stem. May kill young plants, stresses older plants</td>
</tr>
<tr>
<td>Bradrrrhoa gilveolella</td>
<td>Root Moth</td>
<td>Roots- concurrent feeding by multiple larvae can destroy roots and kill plant, new plants may generate from root buds below attack</td>
</tr>
</tbody>
</table>
Rush Skeletonweed Notes

- Some skeletonweed biotypes are resistant to the fungi
- First 3 agents are considered established and ready for redistribution in ID, WA, OR
- *Bradyrrhoa gilveolella* just now becoming available
- Exploration continues for additional agents
Rush Skeletonweed

Healthy Plant

Healthy Flower

Midge Damage to Skeletonweed

Mite induced galls
<table>
<thead>
<tr>
<th>Agent Name</th>
<th>Type of Agent</th>
<th>Feeding Site</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aphthona</em> species</td>
<td>Flea Beetles</td>
<td>Adult beetles feed on the leaves and flowers while larvae feed on root hairs and young roots</td>
</tr>
<tr>
<td><em>Chamaesphecia</em> species</td>
<td>Clearwing Moth</td>
<td>Larvae deplete root reserves causing loss of plant vigor and often death</td>
</tr>
<tr>
<td><em>Hyles euphorbiae</em></td>
<td>HawkmOTH</td>
<td>Defoliates leaves and bracts producing damage – overall impact little</td>
</tr>
<tr>
<td><em>Oberea erythrocephala</em></td>
<td>Stem Borer</td>
<td>Adult feeding on leaves and stems, girdling of adult w/ subsequent egg laying and larval feeding</td>
</tr>
<tr>
<td><em>Spurgia esula</em></td>
<td>Gall Midge</td>
<td>Each generation attacks growing tips of plants preventing seed production</td>
</tr>
</tbody>
</table>
Leafy Spurge Notes

• *Aphthona* species most visible and so far effective. Number of species which differ in site preference makes most spurge patches susceptible to 1 or more species

• Other agents less prevalent, and results less obvious
Some Leafy Spurge Agents
• *Aphthona* species
• *Hyles euphorbia*
• *Oberea erythrocephala*
## St. Johnswort

<table>
<thead>
<tr>
<th>Agent Name</th>
<th>Type of Agent</th>
<th>Feeding Site</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Agrilus hyperici</em></td>
<td>Boring Beetle</td>
<td>Larvae feeding on root may completely consume the tissue, produce smaller stems and may not flower, some plants killed</td>
</tr>
<tr>
<td><em>Aplocera plagiata</em></td>
<td>Inchworm Moth</td>
<td>Larvae feed on leaves and flowers. Two generations per year. Prefers warm dry sites</td>
</tr>
<tr>
<td><em>Chrysolina hyperici</em></td>
<td>Beetle</td>
<td>Larval feeding in the fall and spring reduces foliage and root reserves making it difficult for plants to survive harsh winter or summer</td>
</tr>
<tr>
<td><em>Chrysolina quadrigemina</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
St. Johnswort

- *Chrysolina* beetles most commonly encountered and likely most effective
- *Agrilus* likely more widely distributed than thought (must pull plants up to see damage) and not certain impact
- *Aplocera* is occasionally encountered, has not been found in abundance
St. Johnswort

Chrysolina species

Agrilus hyperici

Aplocera plagiata
# Tansy Ragwort

<table>
<thead>
<tr>
<th>Agent Name</th>
<th>Type of Agent</th>
<th>Feeding Site</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Tyria jacobaeae</em></td>
<td>Cinnabar Moth</td>
<td>Feeds on leaves, terminal buds, and flowers, works best with <em>Longitarsus</em></td>
</tr>
<tr>
<td><em>Botanophila (=Pegohylemyia)</em></td>
<td>Fly</td>
<td>Larvae feed on developing seed heads, all seeds may be destroyed.</td>
</tr>
<tr>
<td><em>seneciella</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Longitarsus jacobaeae</em></td>
<td>Flea Beetle</td>
<td>Larvae mine roots of the rosette which may cause plant mortality in the spring when the plant bolts. Adults feed on leaves, heavy adult feeding on rosettes during the late fall and winter can kill plants</td>
</tr>
</tbody>
</table>
Notes on Tansy Agents

• Flies are redistributing themselves in Tansy Ragwort patches
• *Longitarsus* can maintain colonies in low host populations; in Oregon over 90% control of flowering plants was achieved w/i six years of release
• Recent work on a Swiss strain of *Longitarsus* in Palouse area showing great promise.
• *Tyria* has been effective in reducing stand densities and seed production but there are non target concerns in some areas; best w/ *Long*. 
Tansy Ragwort

Tyria jacobaeae

Longitarsus jacobaeae

Larva

Adult
Thistles

• Many agents are mentioned, but there remains some questions as to specificity.
• Best bets- a combination of *Urophora cardui* (gall fly) and *Ceutorhynchus litura* (stem mining weevil)
• This biological control program produced the “bad boy” of weed biological control- *Rhinocyllus conicus*
Thistle

Canada Thistle

Scotch Thistle

Larinus planus

Urophora galls

Urophora Cardui

Ceutorhynchus litura
Toadflaxes

• *Brachypterolus pulicarius* and *Rhinusa antirrhini* (flower feeding beetles) likely already in your patches of yellow toadflax

• *Calophasia lunula* (toadflax moth) now not suggested for redistribution by APHIS

• Best Bet- *Mecinus janthinus* (stem-boring weevil) on yellow and *Mecinus janthiniformis* on Dalmatian
Toadflaxes

Dalmatian Yellow

Calophasia lunula
Larva Adult

Brachypterolus pulcarius

Rhinusa antirrhini

Mecinus janthiniformis
Mecinus janthinus
## Yellow Starthistle

<table>
<thead>
<tr>
<th>Name of Agent</th>
<th>Type of Agent</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chaetorellia australis</em></td>
<td>Seedhead Fly</td>
<td>Seed feeder, is widely distributed</td>
</tr>
<tr>
<td><em>Chaetorellia succinea</em></td>
<td>Seedhead Fly</td>
<td>Seed feeder, displacing <em>C. australis</em></td>
</tr>
<tr>
<td><em>Urophora sirunaseva</em></td>
<td>Seedhead Fly</td>
<td>Seed feeder, not abundant</td>
</tr>
<tr>
<td><em>Bangasternus orientalis</em></td>
<td>Seedhead Weevil</td>
<td>Seed feeder, well distributed</td>
</tr>
<tr>
<td><em>Larinus curtus</em></td>
<td>Seedhead Weevil</td>
<td>Seed feeder, needs to be moved</td>
</tr>
<tr>
<td><em>Eustenopus villosus</em></td>
<td>Seedhead Weevil</td>
<td>Seed feeder, needs to be moved</td>
</tr>
</tbody>
</table>
Yellow Starthistle Notes

• Very few sites without *Chaetorellia* species and *Bangasternus*

• *C. succinea* was an accidental introduction and now seems to be displacing *C. australis*

• *Urophora* is established, low populations and not appearing to do too much

• *Larinus curtus* being moved around, studies in place to quantify its impacts
Yellow Starthistle Notes

• *Eustenopus* appears to be most damaging agent

• Is starting to redistribute itself, but redistribution efforts will speed its progress

• Have sites where can document a significant decrease in YST after *Eustenopus* was introduced, and all agents are being shown to decrease seed production
Yellow Starthistle

*Chaetorellia australis*

*Urophora sirunaseva*

*Larinus curtus*

*Bangasternus orientalis*

*Eustenopus villosus*
Hopeful Future Biocontrol Programs

- Hawkweeds
- Houndstongue
- Hoary Cress (Perennial Pepperweed)
- Common Tansy
- Salt Cedar (??????)
- Oxeye Daisy
- Russian Olive
- Dyers Woad