Biological Control of Weeds 101

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Part 1

Great Falls, MT – 12 January 2012

University of Idaho
College of Agricultural and Life Sciences

Exotic Plant Invasion Bio-Control Laboratory

Forest Service
US
Department of Agriculture

Invasive plants & noxious weeds

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

- 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

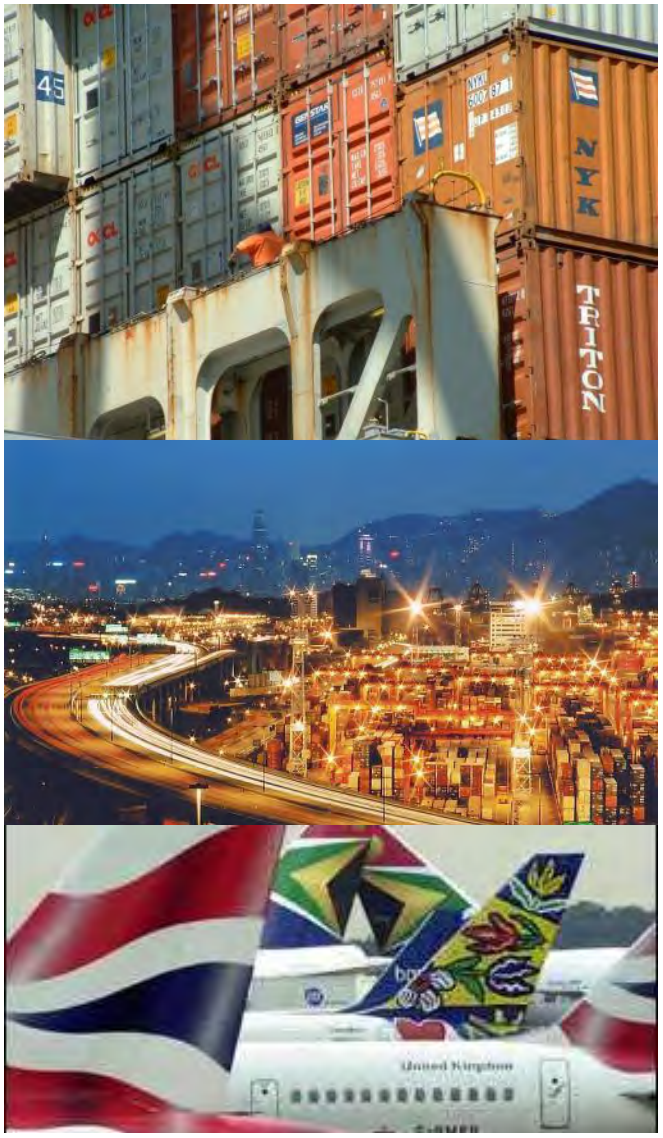
New Invasive species in San Francisco Bay

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

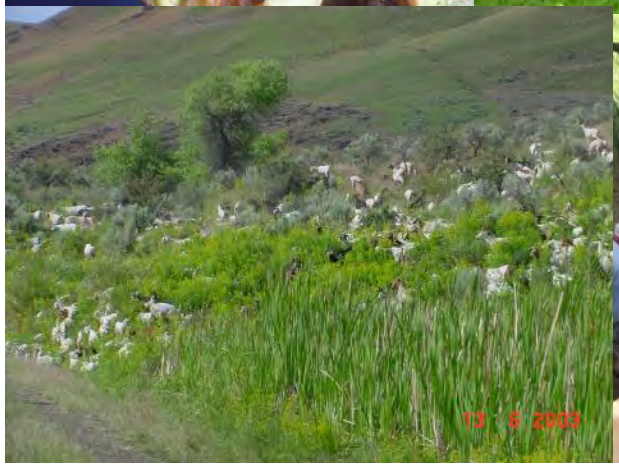
Fish introductions in U.S.

- 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?

Biological control

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

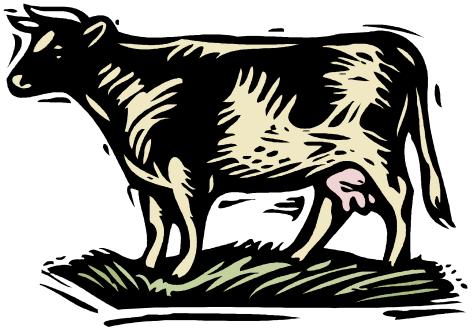
Principle idea of classical biological control

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

Dyer's woad *Isatis tinctoria* L.
in it's native range
in Eurasia

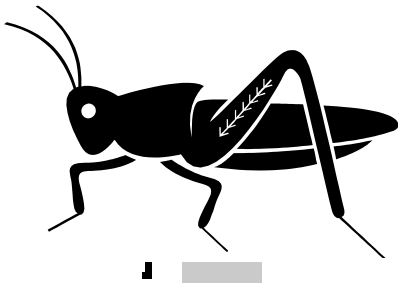
... and in it's introduced range in North America

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

Biocontrol introduction

Weed population size

Impact level

Equilibrium before control

Equilibrium after establish-ment of biocontrol agents

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

Ecological principle of CBCW

Weed population size

1

2

Equilibrium before control

Impact level

Equilibrium after establish-ment of biocontrol agents

3

4

Development of weed problem

Weed causing economic, environmental injury

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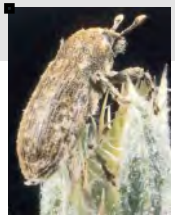
Weed introduction

Biocontrol introduction



Success rates

Success = substantial to complete control of target weed

Sustantial 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)

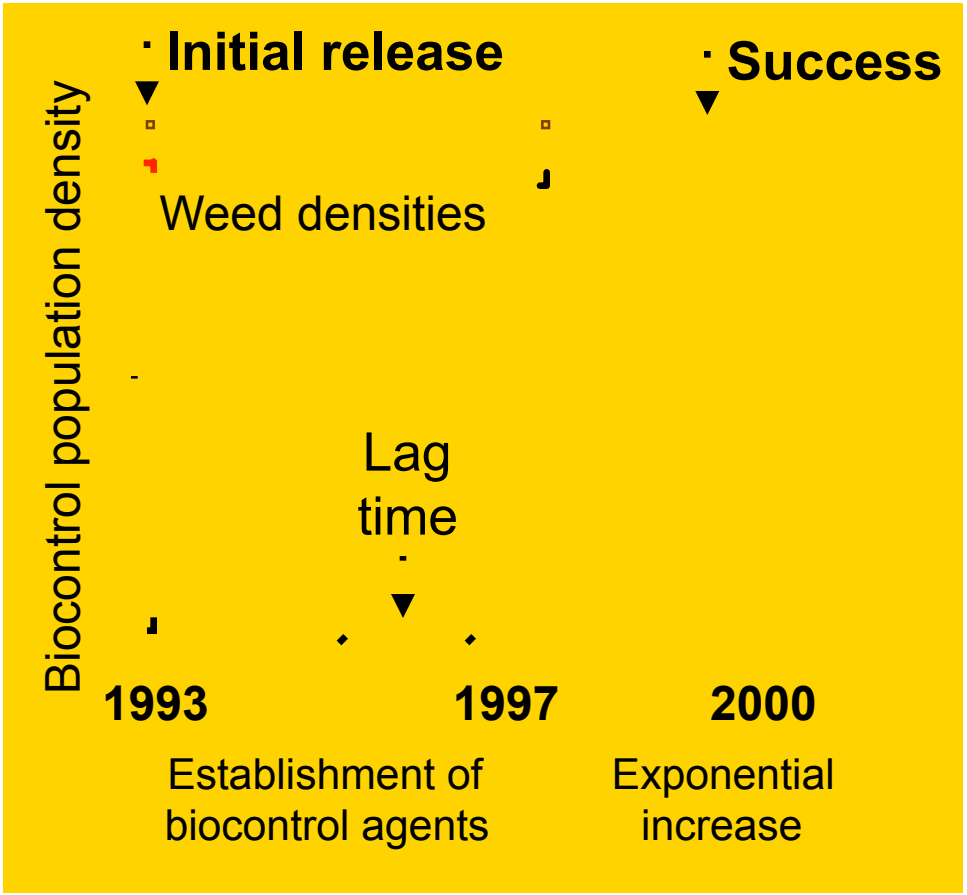
No evidence for host shifts

Conclusion: risk remains, but overall safety record excellent

Pemberton (2000), Van Klinken & Edwards (2002)

Julien & Griffiths (1998)

Biological weed control requires patience



Larinus minutus
Knapweed flower weevil

Biocontrol agents that increase rapidly are more likely to have impact

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

Aphthona nigriscutis
Leafy spurge flea beetle

Hyles euphorbiae
Leafy spurge hawkmoth

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

Ecological non-target effects

Rhinocyllus conicus
larvae in Wavyleaf thistle

Rhinocyllus conicus
on Tracy's thistle

Larinus planus
on Tracy's thistle

- 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

Advantages	Disadvantages
Target specificity	**Initial high costs**
Continuous action	**Protracted time until impact likely**
Long-term cost effective	**Uncertainty over ultimate scale of impact**
Gradual in effect, environmentally non-intrusive	**Uncertain 'non-target' effects in ecosystems**
Self dispersing (even into difficult terrain)	**Irreversible**

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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

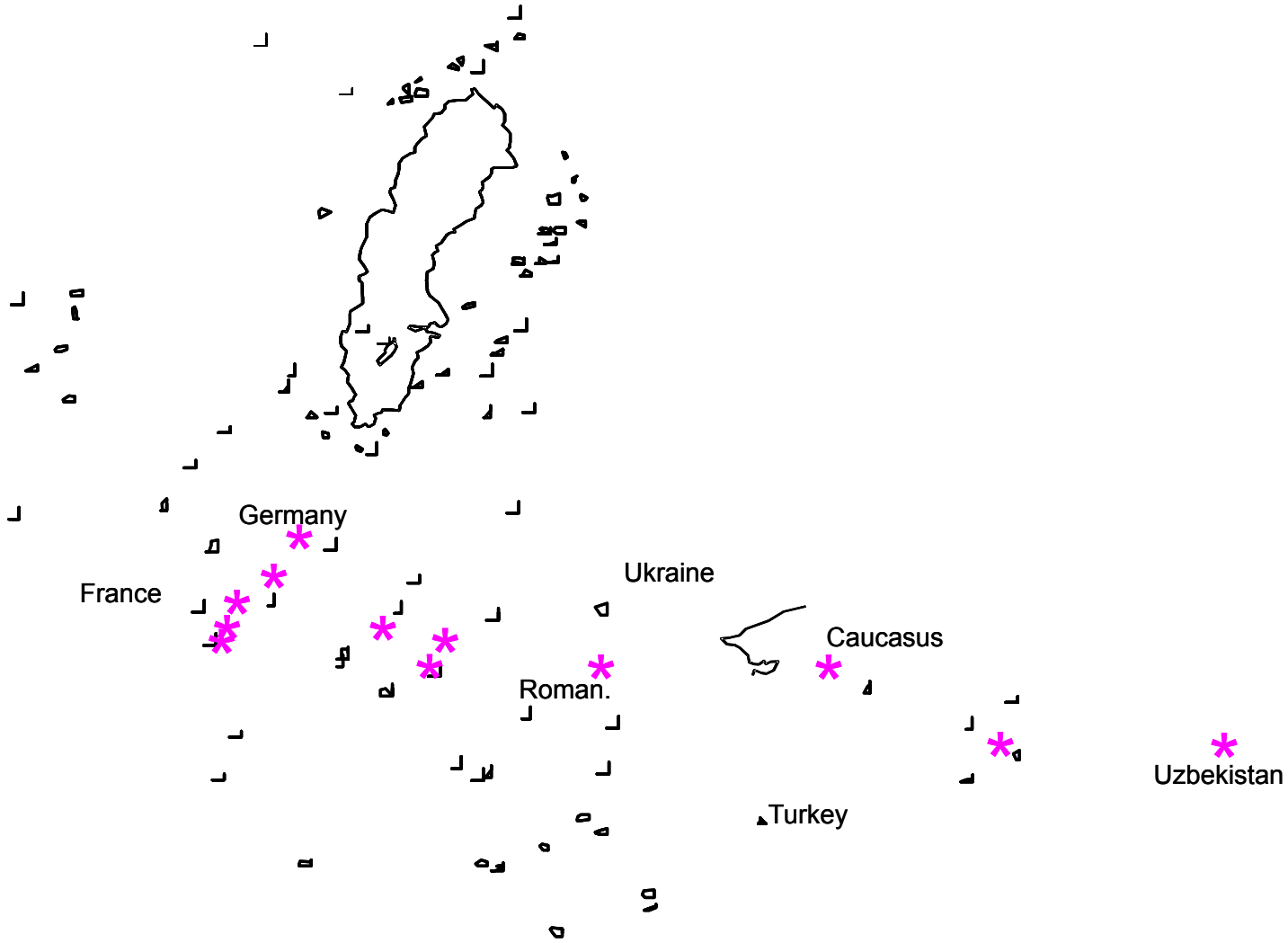
Step 1: Literature surveys

- Hundreds of insects associated with leafy spurge
- Records in old books without indix 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

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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 mot (*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*)

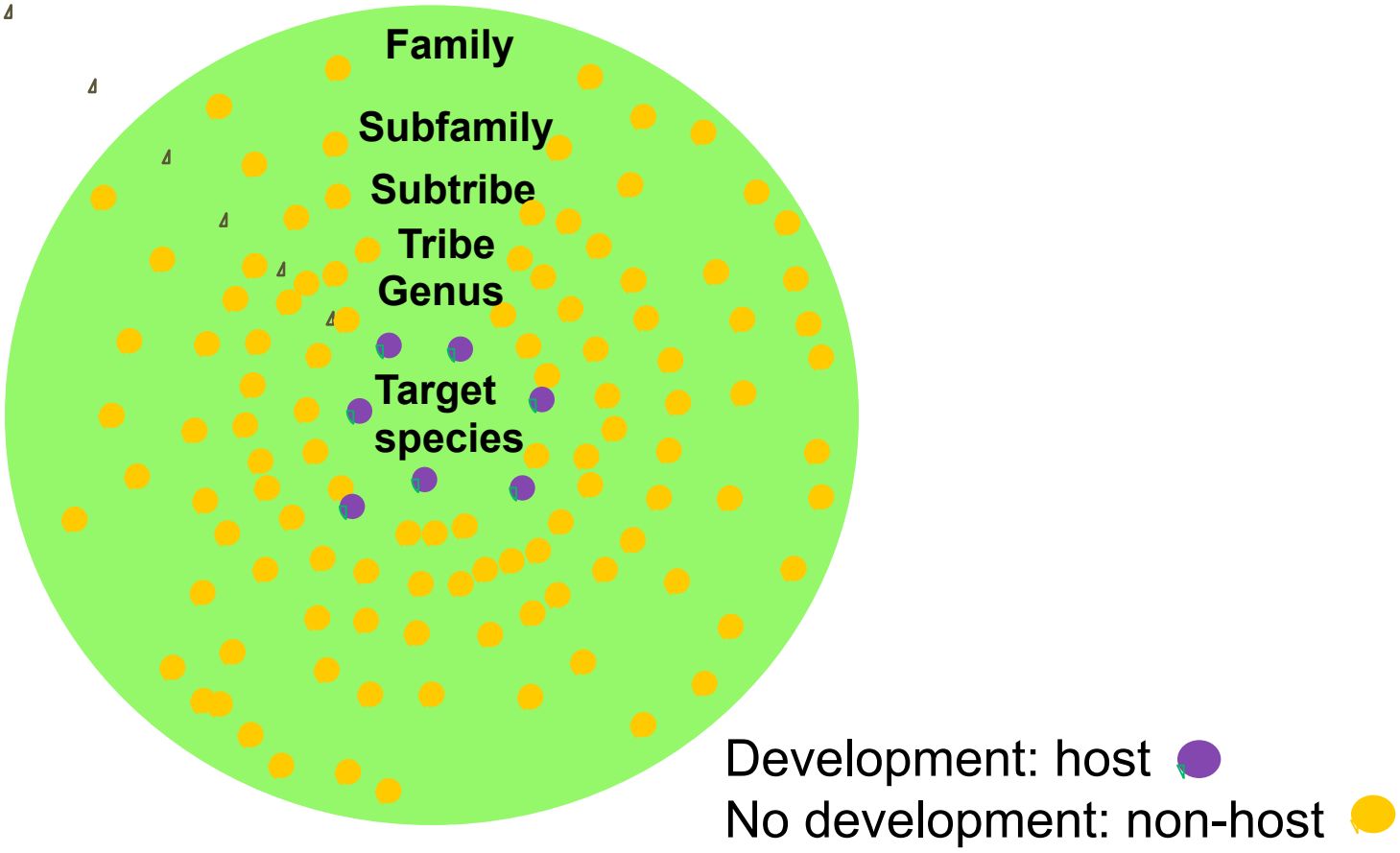
Acroptilon repens
(target weed;
attacked by *Aceria*)

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 (60% natives, 4 T&E species)	63
• Species in other families (mostly with biochemical similarities)	8
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

YES

NO

Euphorbia robusta

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 Amercia: St. John‘s Wort

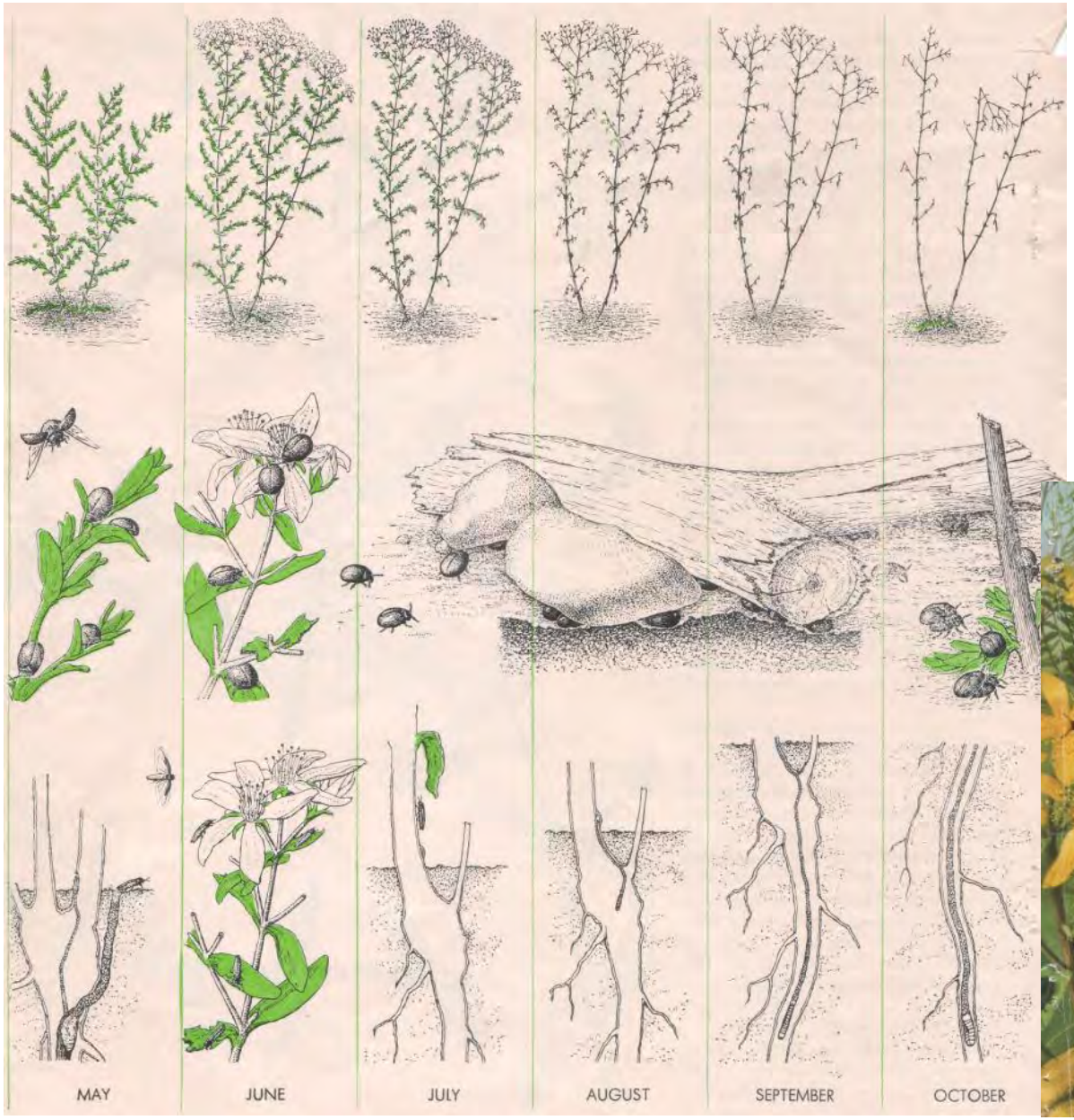
Exotic rangeland weed introduced from Europe

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)


1948
Photos: USDA-ARS



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

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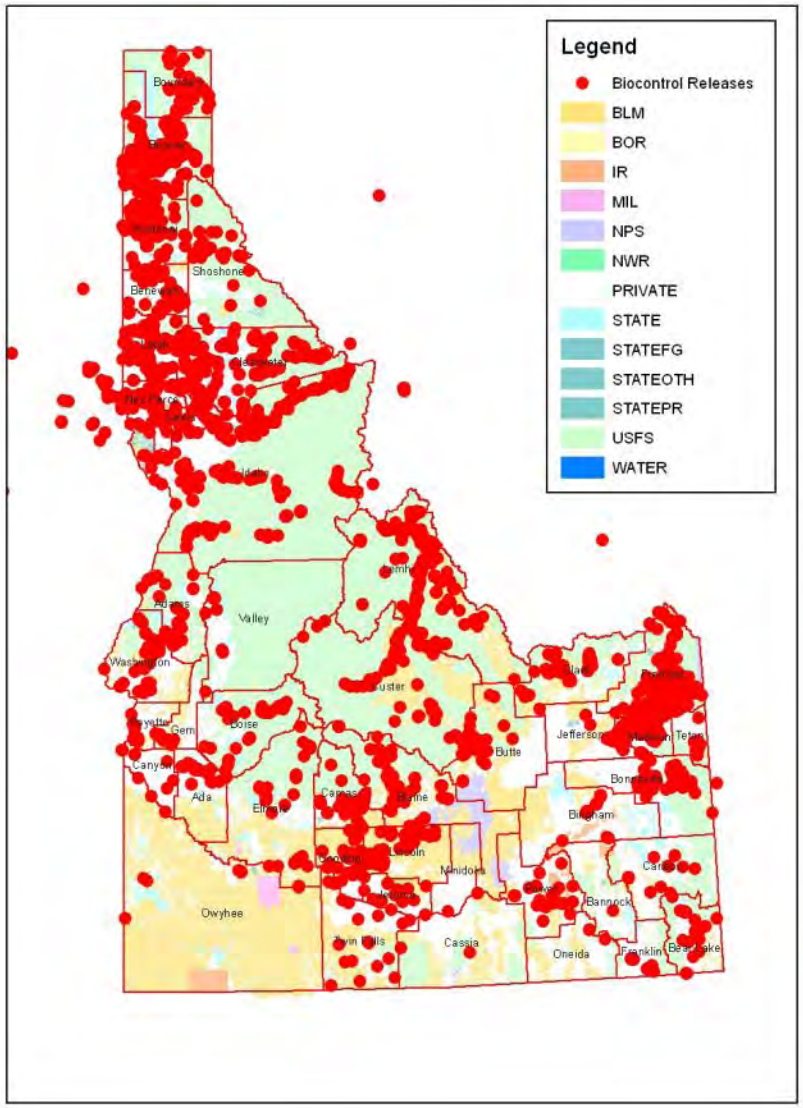
St. John‘s wort reduced to 1% of its previous level in California

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

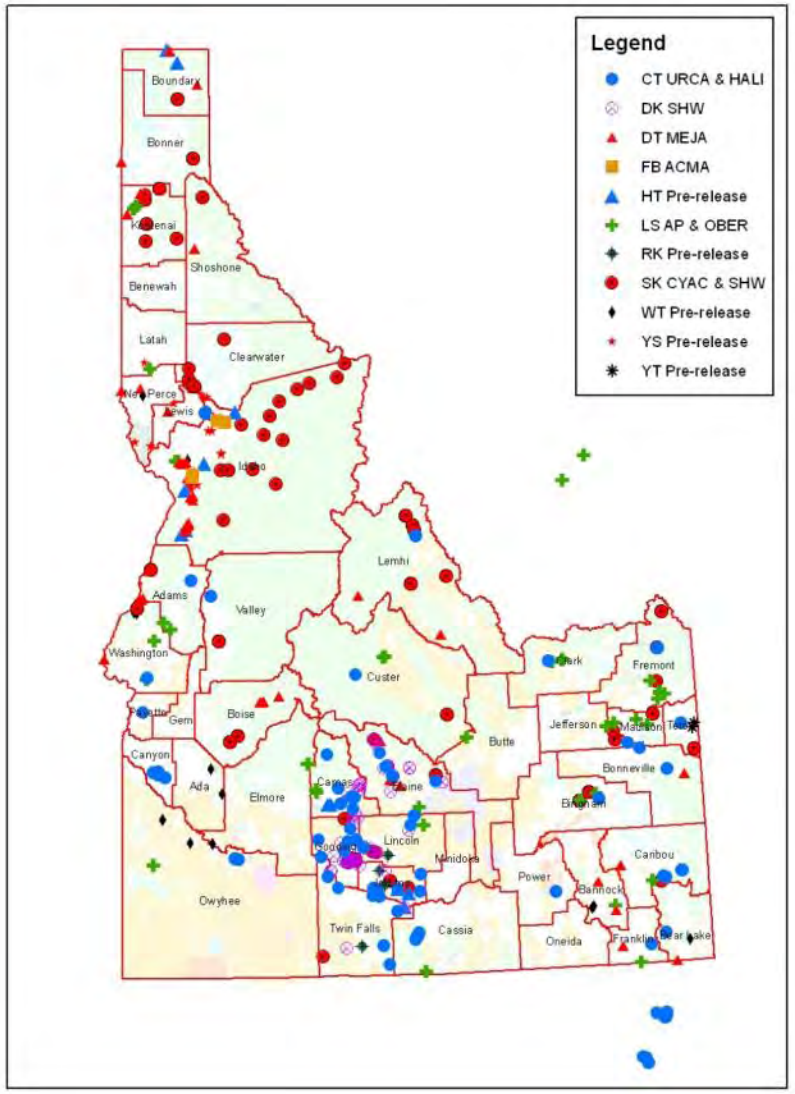
- BCA release record
  - Name of person making release
  - Date
  - Location
  - Acres of infestation
  - Pest species
  - Soils
  - Weather conditions
- Must be done for every release

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

Goal	**Suppression**	**Eradication**
Time Frame	**Years**	**Yesterday**
Target Weed	**Old Foe**	**New Invader**
Resources	**Minimal**	**None**
Info Sources	**Local Experts**	**No Local Information**

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 activites 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!)

::	*Aceria centaureae*	*Agapeta zoegana*	*Bangasternus fausti*	*Chaetorellia acrolophi*	*Cyphocleonus achates*	*Larinus minutus*	*Larinus obtusus*	*Metzneria paucipunctella*	*Pelochrista medullana*	*Pterolonche inspersa*	*Sphenoptera jugoslavica*	*Subanguina picridis*	*Terellia virens*	*Urophora affinis*	*Urophora quadrifasciata*
Type of Agent	MITE	MOTH	WEEVIL	FLY	WEEVIL	WEEVIL	WEEVIL	MOTH	MOTH	MOTH	BORER	NEMATODE	FLY	FLY	FLY
Site of Attack	FOLIAGE	ROOTS	SEED HD	SEED HD	ROOTS	SEED/FOL	SEED/FOL	SEED HD	ROOTS	ROOTS	ROOTS	ROOTS	SEEDS	SEED HD	SEED HD

Knapweed Biocontrol Agents and the Species they Attack

	Aceria centaureae	*Agapeta zoegana*	*Bangasternus fausti*	*Chaetorellia acrolophi*	*Cyphocleonus achates*	*Larinus minutus*	*Larinus obtusus*	*Metzneria paucipunctella*	*Pelochrista medullana*	*Pterolonche inspersa*	*Sphenoptera jugoslavica*	*Subanguina picridis*	*Terellia virens*	*Urophora affinis*	*Urophora quadrifasciata*
Spotted Knapweed	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Diffuse Knapweed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Squarrose Knapweed			X	X						X				X	X
Black Knapweed															X
Brown Knapweed															X
Meadow Knapweed															X
Russian Knapweed												X			X

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**

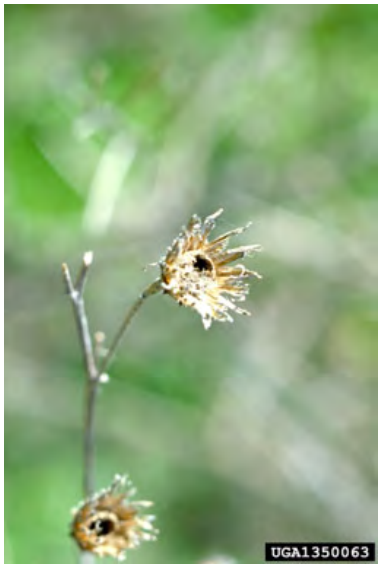
Chaetorellia acrolophi: Knapweed Peacock Fly

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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Purple Loosestrife

Agent Name	Type of Agent	Feeding Site
Galerucella calmariensis and *pusilla*	Beetles	Defoliators which feed on leaves and shoots
Nanophyes brevis and *marmoratus*	Weevils	Flower buds are fed upon; attacked buds usually abort and fail to produce seed
Hylobius transversovittatus	Weevil	Larvae feed in the roots and adults feed on foliage

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

Rush Skeletonweed Agents

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

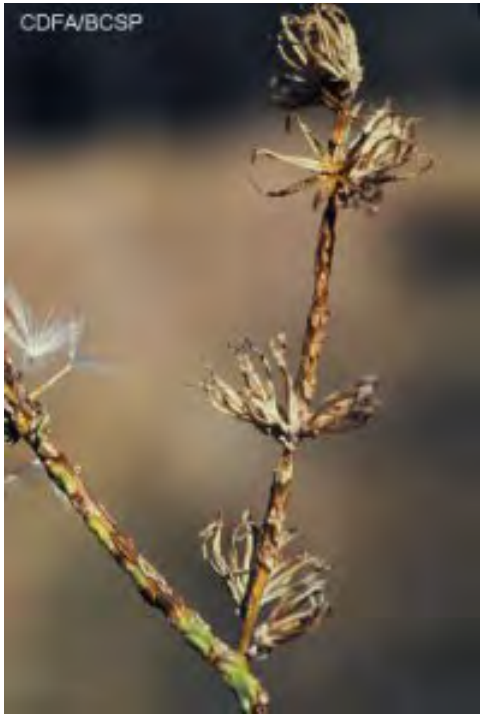
Rush Skeletonweed Notes

- 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

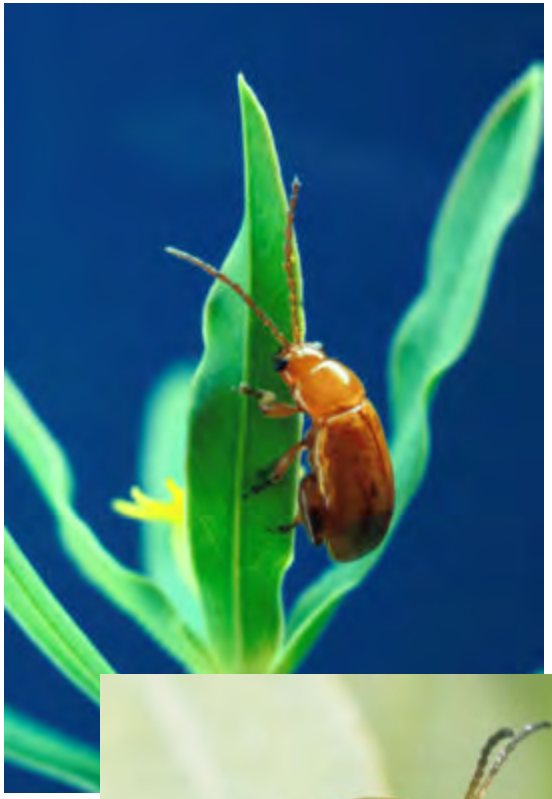
Mite induced galls

Leafy Spurge

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

Leafy Spurge Notes

- *Apthona* 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***

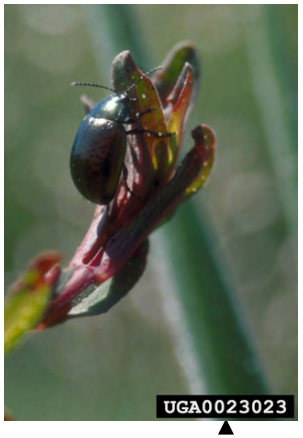
St. Johnswort

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

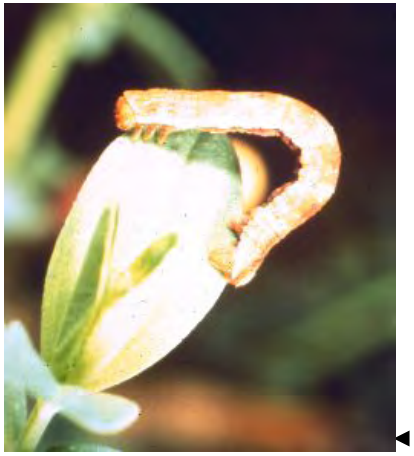
St. Johnswort

- *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

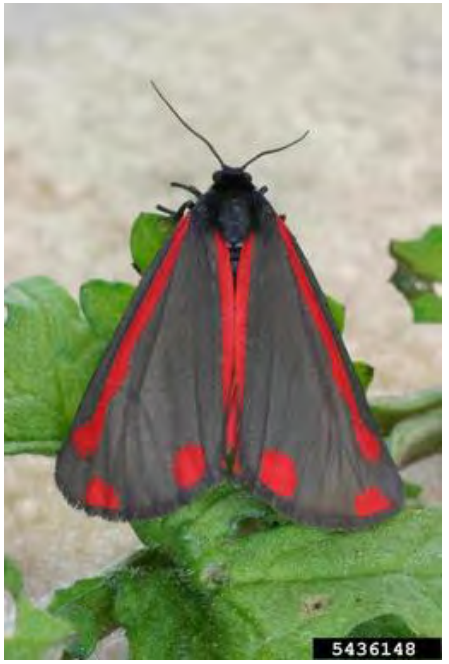
Tansy Ragwort

Agent Name	Type of Agent	Feeding Site
Tyria jacobaeae	Cinnabar Moth	Feeds on leaves, terminal buds, and flowers, works best with *Longitarsus*
Botanophila (=Pegohylemyia) seneciella	Fly	Larvae feed on developing seed heads, all seeds may be destroyed.
Longitarsus jacobaeae	Flea Beetle	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

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

Urophora Cardui

Urophora galls

Scotch Thistle

Larinus planus

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

Name of Agent	Type of Agent	Notes:
Chaetorellia australis	Seedhead Fly	Seed feeder, is widely distributed
Chaetorellia succinea	Seedhead Fly	Seed feeder, displacing *C. australis*
Urophora sirunaseva	Seedhead Fly	Seed feeder, not abundant
Bangasternus orientalis	Seedhead Weevil	Seed feeder, well distributed
Larinus curtus	Seedhead Weevil	Seed feeder, needs to be moved
Eustenopus villosus	Seedhead Weevil	Seed feeder, needs to be moved

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