How Effective Is Biological Control?

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Successful Biological Control

Knapweeds (diffuse, spotted & squarrose) - at many sites.

Leafy spurge - at many sites (+ integrated control).

Mediterranean sage - if with competitive perennial plants.

Musk thistle - at many sites.

Puncturevine - in warmer regions of CA.

Purple loosestrife - at many sites, NY to OR (but drowning).

Rush skeletonweed - from CA to WA.

St. Johnswort - in most areas w. of Rocky Mts. since 1940s.

Tansy ragwort - west of Cascade and Sierra Mts. since 1970s.

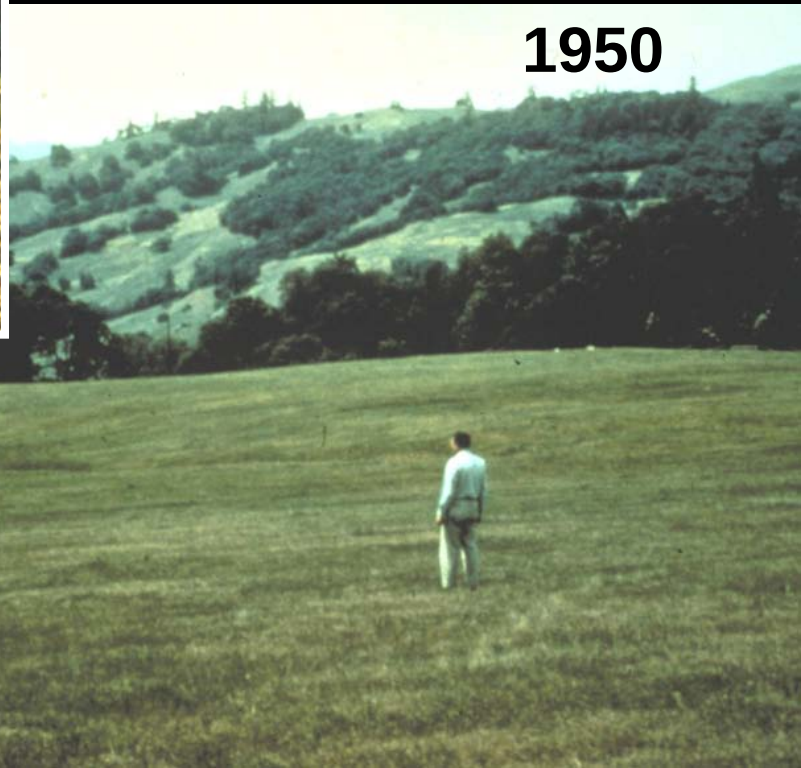
Alligatorweed - widespread in southeast; less effective in north.

Waterhyacinth - widespread in southeast; not in CA.

St. Johnswort / Klamathweed

1940s - toxic to cattle, 4 million acres infested

flea beetle



- **Released 4 insects in 1940s-50s,**
- **extensive control**
- **still continuing**

Tansy Ragwort


N. Poritz

flea beetle

cinnabar moth


E. Coombs, Oregon Dept. Agr.

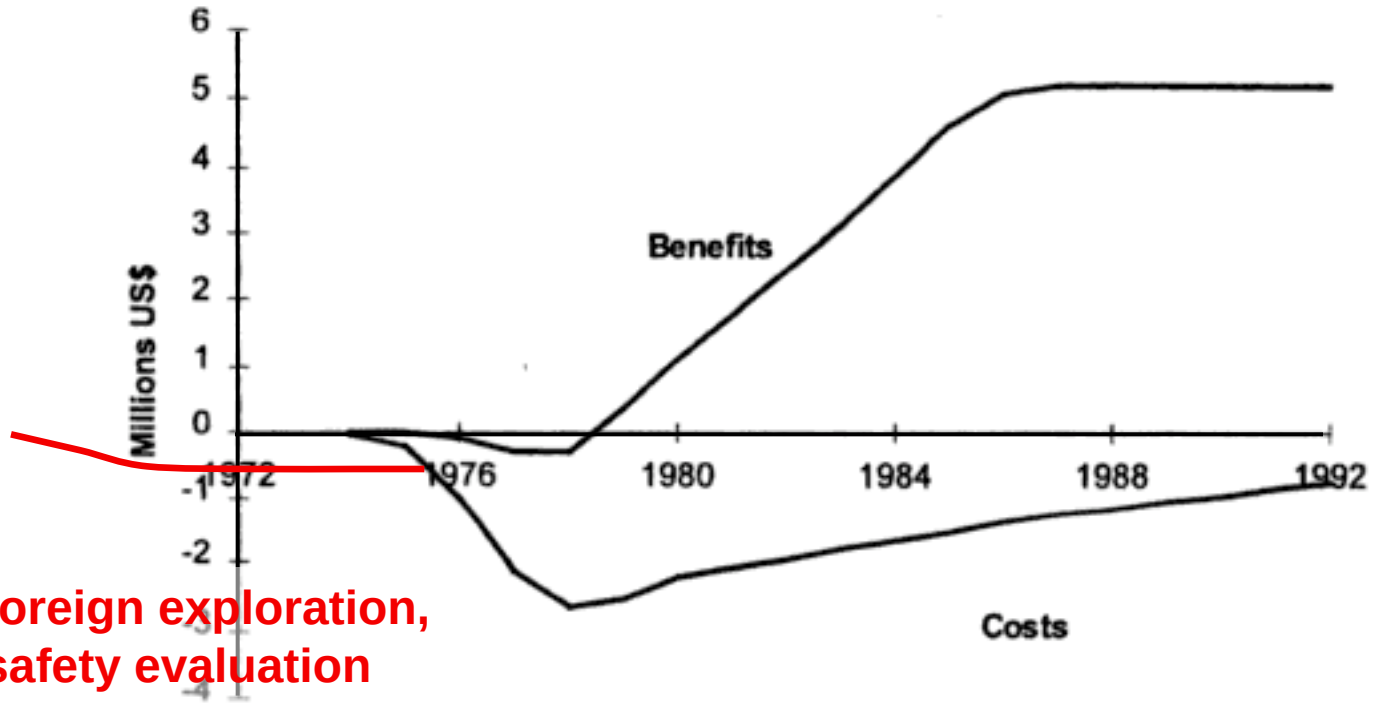
Oregon Dept. Agr.

Tansy Ragwort

- **99% reduction in CA, 99% in OR.**
- **>$5 million/year** benefit; **13-15:1** benefit-to-cost ratio.
- **Livestock losses** reduced $3.7 M/year.
  Pasture productivity increased $1.27 M/year.
  Herbicide use reduced $0.85 M/year).
- **Cost** of achieving control: about $5/ha (**$2.23/acre**).
- **Non-market benefits** include return of desirable plants in habitats once dominated by ragwort and a reduction in herbicide in the environment.

Turner & McEvoy (1995) *In* Biological Control in the Western United States: Accomplishments and Benefits of Regional Research Project W-84, 1964-1989, pp. 264-269.

Economic Benefits of Controlling Tansy Ragwort in Oregon



foreign exploration, safety evaluation

Figure 9. Estimated net costs and benefits for the biological control of *Senecio jacobaea* (ragwort) in Oregon, USA. Produced from data presented in Coombs *et al.* (1996).

from **Syrett et al. 2000**. In: Gurr & Wratten (eds.), Biological Control: Measures of Success. Kluwer Academic Publ. pp. 189-230.

Musk thistle

T. horridus

R. conicus

1969: will attack native *Cirsium*

Rhinocyllus conicus on Musk Thistle in Canada

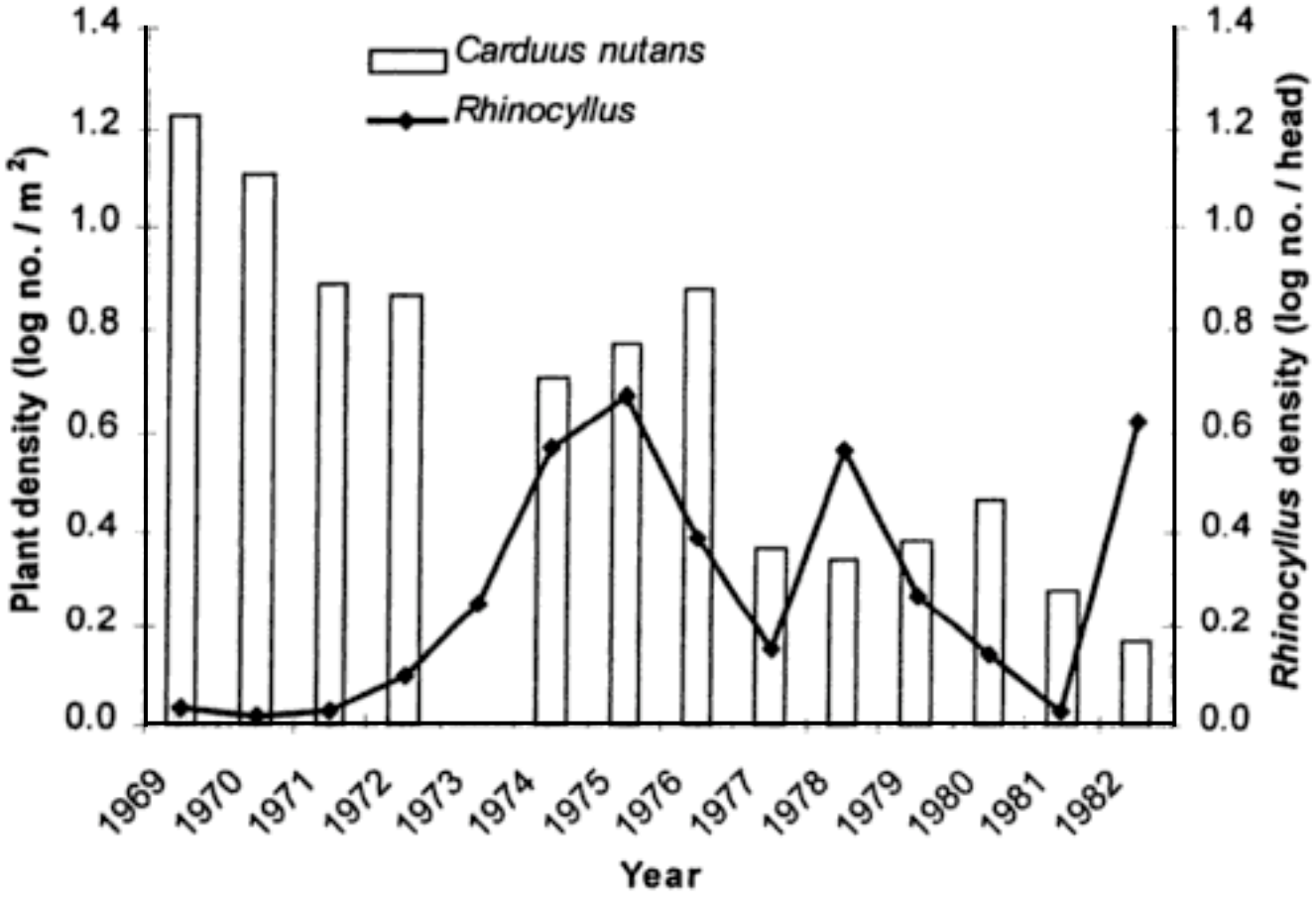


Figure 6. Changes in target weed and agent density following release of the seed weevil, *Rhinocyllus conicus*, for the control of nodding thistle, *Carduus nutans*, at a site in Canada. (From data of Harris, 1984).

from **Syrett et al. 2000**. In: Gurr & Wratten (eds.), Biological Control: Measures of Success. Kluwer Academic Publ. pp. 189-230.

How Many Agents Do You Need?

just enough !

(it depends …)

Diffuse Knapweed

- Gall formers best — nutrient sink (Harris 1980)
- Impossible to control by seed reduction alone (Myers & Risley 2000)

Gall flies

Urophora quadrifasciata & U. affinis

Seed Head Weevil *Larinus minutus* on Diffuse Knapweed

- **“Silver bullet” (Myers 2004)**
- **but also root feeder: *Spenoptera jugoslavica***

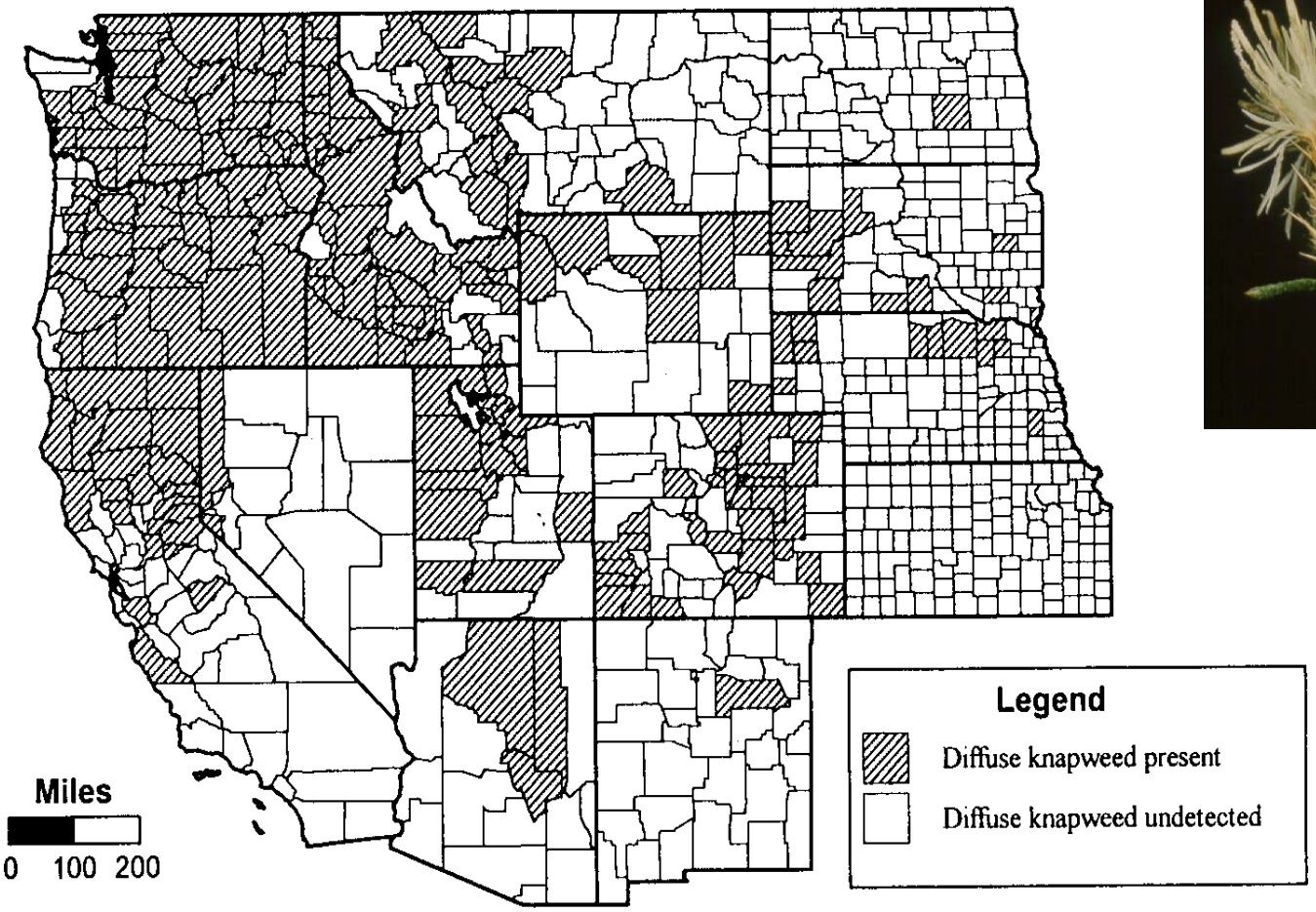
1990

Diffuse Knapweed

Fergus co., MT

1997

Distribution of Diffuse Knapweed



Sheley, Jacobs & Carpinelli (1998)

Rush Skeletonweed

gall mite

rust

Some genotypes resistant

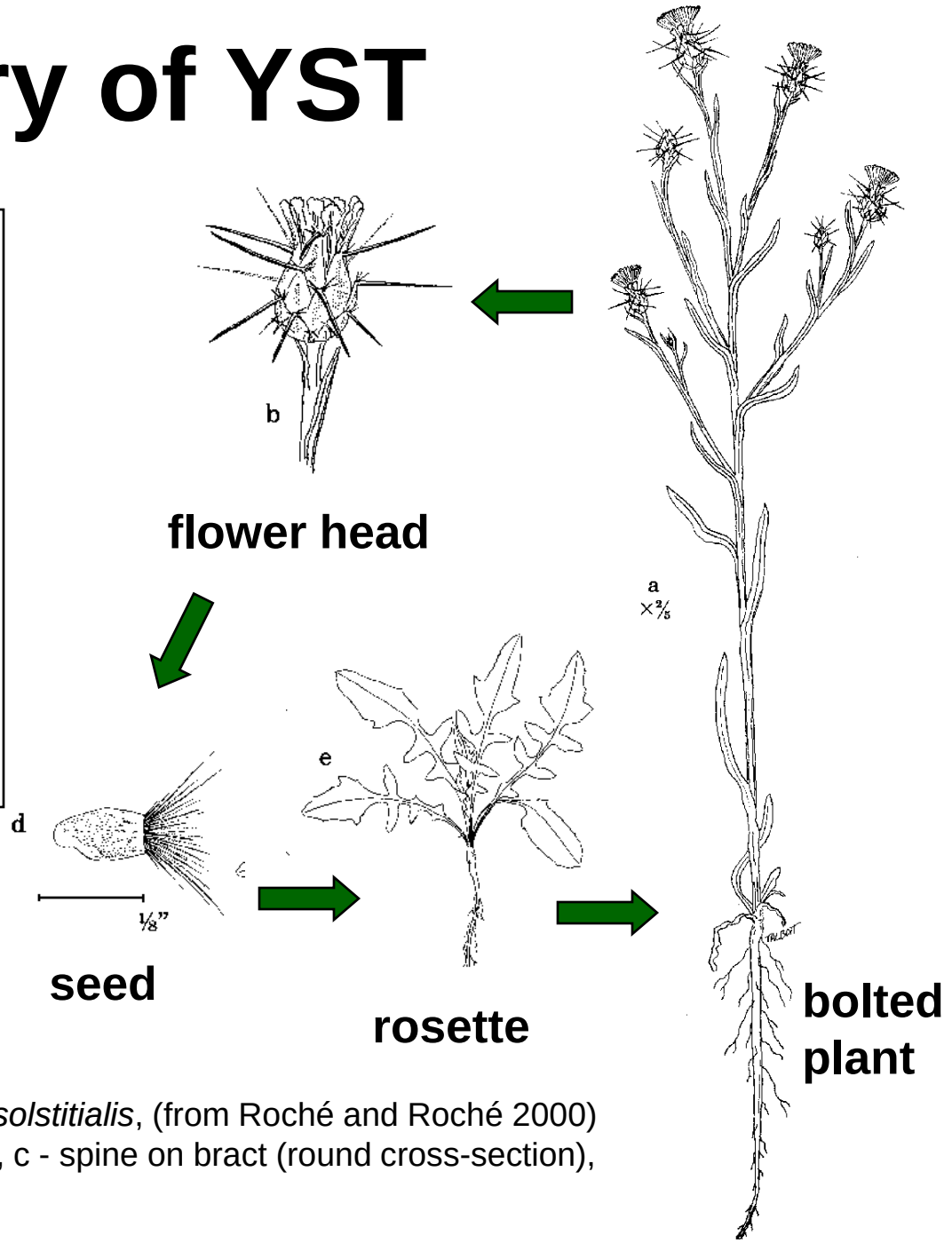
Yellow Starthistle

Centaurea solstitalis

Asteraceae (sunflower family)

Life History of YST

- **Seeds germinate in late fall - early spring**
- **rosettes**
- **“Bolts” in May-June**
- **Flowers continuously until too dry or frost**



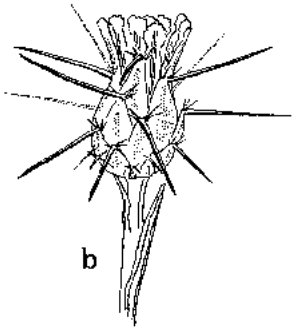
Illustrations of Yellow starthistle, *Centaurea solstitialis*, (from Roché and Roché 2000) (a - mature plant, b - flowerhead (capitulum), c - spine on bract (round cross-section), d - seed (achene), e - rosette).

Which Agent is Best?

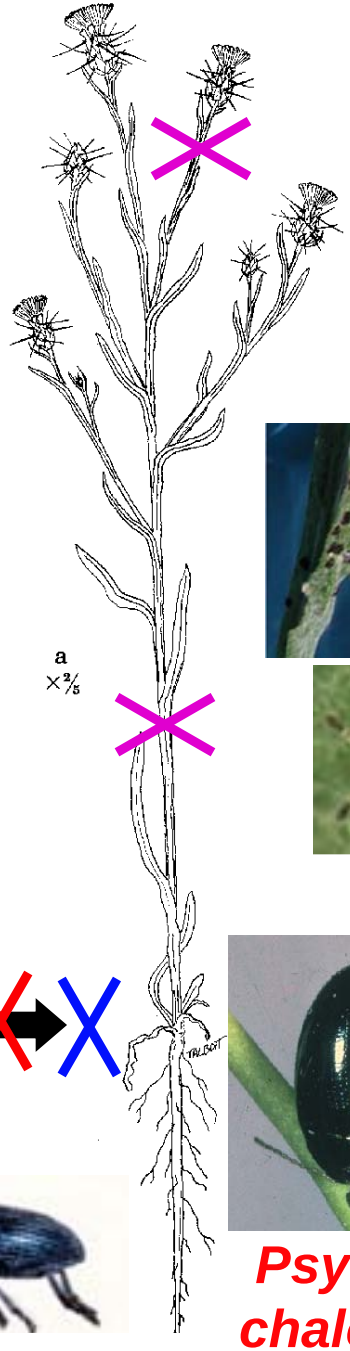
Eustenopus villosus

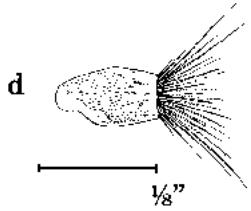
Chaetorellia succinea

Larinus filiformis

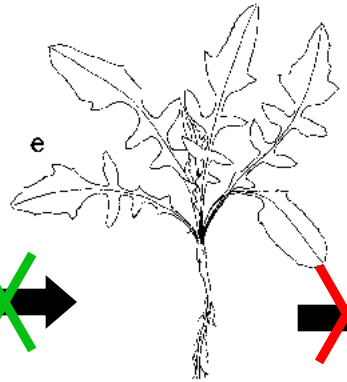


flower head





seed



rosette

Ceratapion basicorne

Aceria solstitialis

Rust

Puccinia jacea* var *solstitialis

Tingis grisea

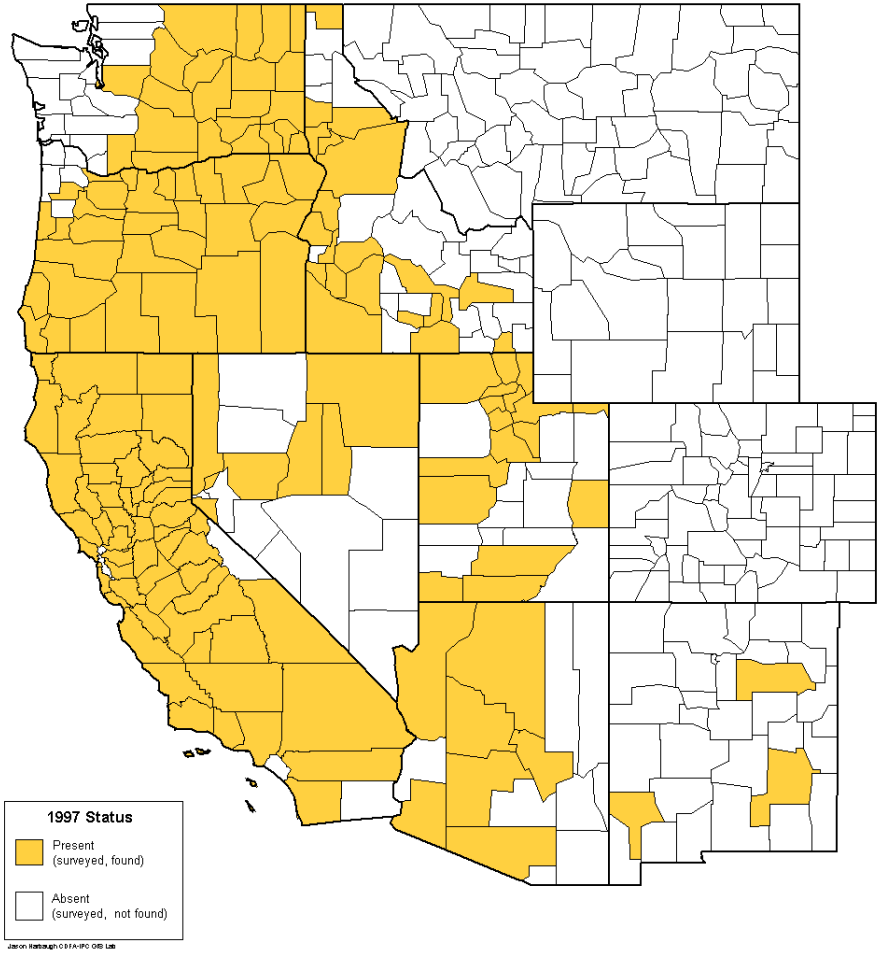
Psylliodes chalcomera

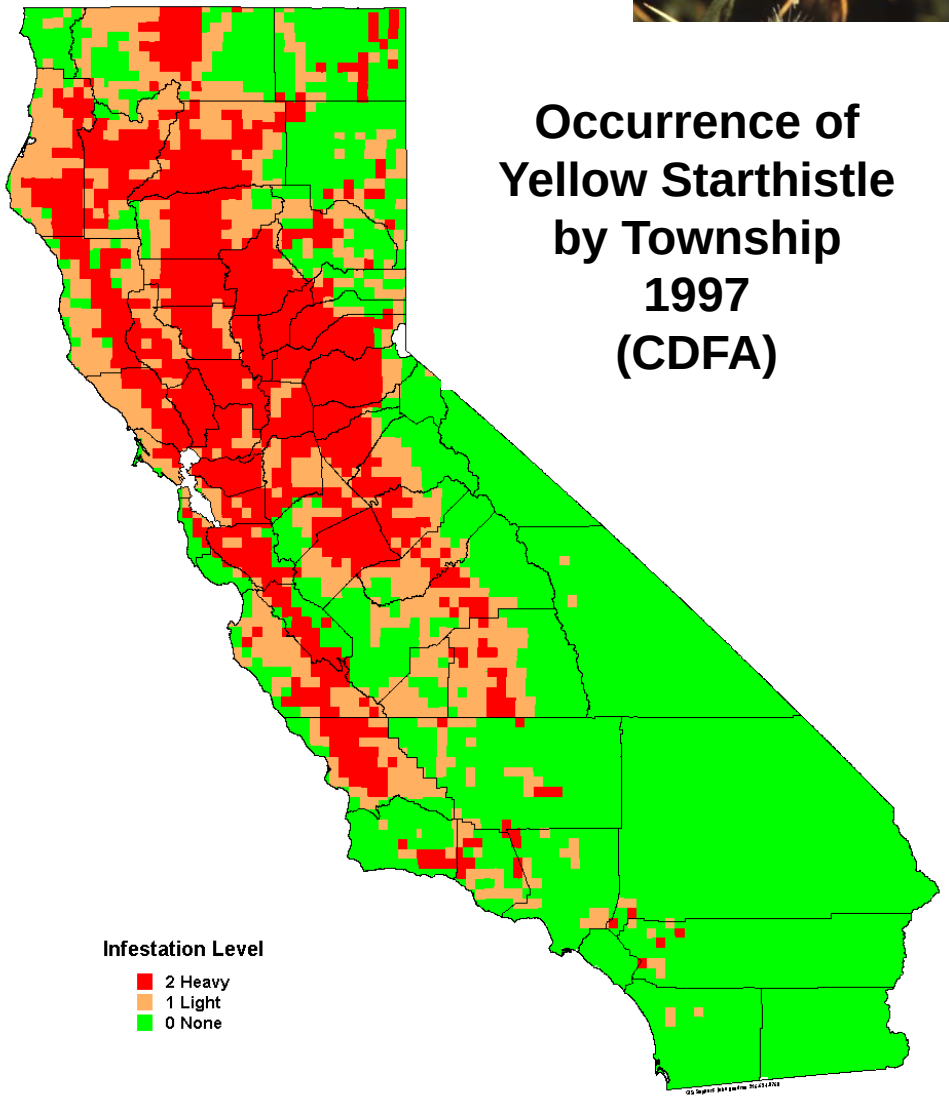
Generalist pathogens, slugs, competition, etc.

Yellow Starthistle Distribution

Distribution of Yellow Starthistle by County in the Western United States

Data for California from Woods, D.M. (ed.), 1998, Biological Control Annual Summary, 1997, California Department of Food and Agriculture, Plant and Health Pest Prevention Services, Sacramento, CA. p64-66; Data for the other western states are from Sheley, R.L. and J.K. Petroff (eds.), 1999, Biology and Management of Noxious Rangeland Weeds, Oregon State University Press, Corvalis, OR, p.408-416

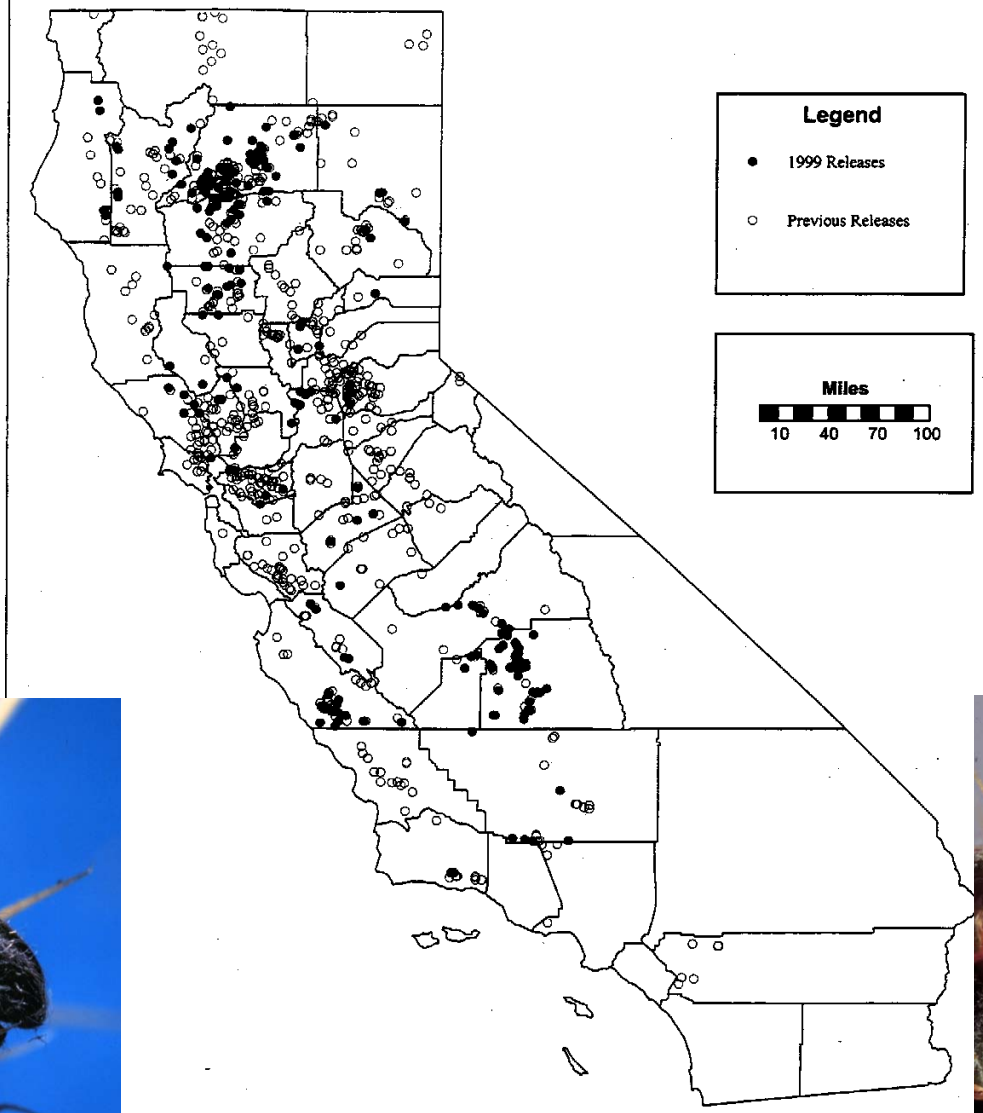




Hairy weevil

Figure 1: Releases of the Hairy Weevil in California in 1990-1999

Biological Control Program, CDFA



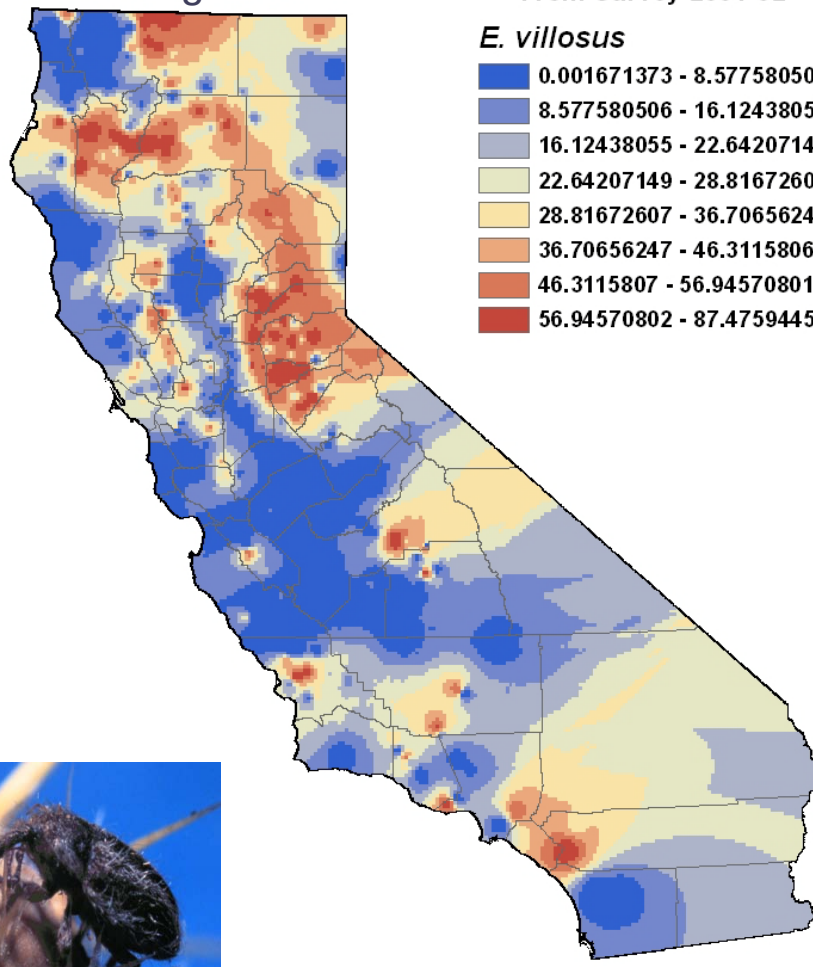
False Peacock Fly

Hairy Weevil

Recovered at 80% of locations

Mean attack rate: 25%

Range: 0 - 93%

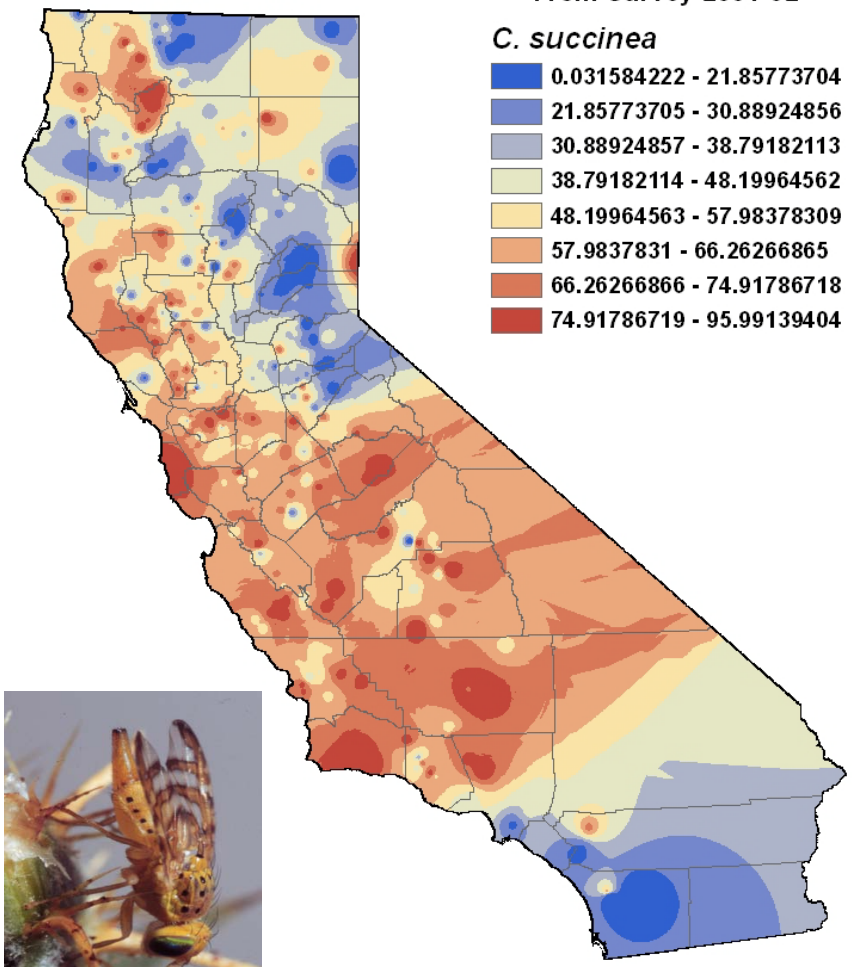


False Peacock Fly

Recovered at 99% of locations

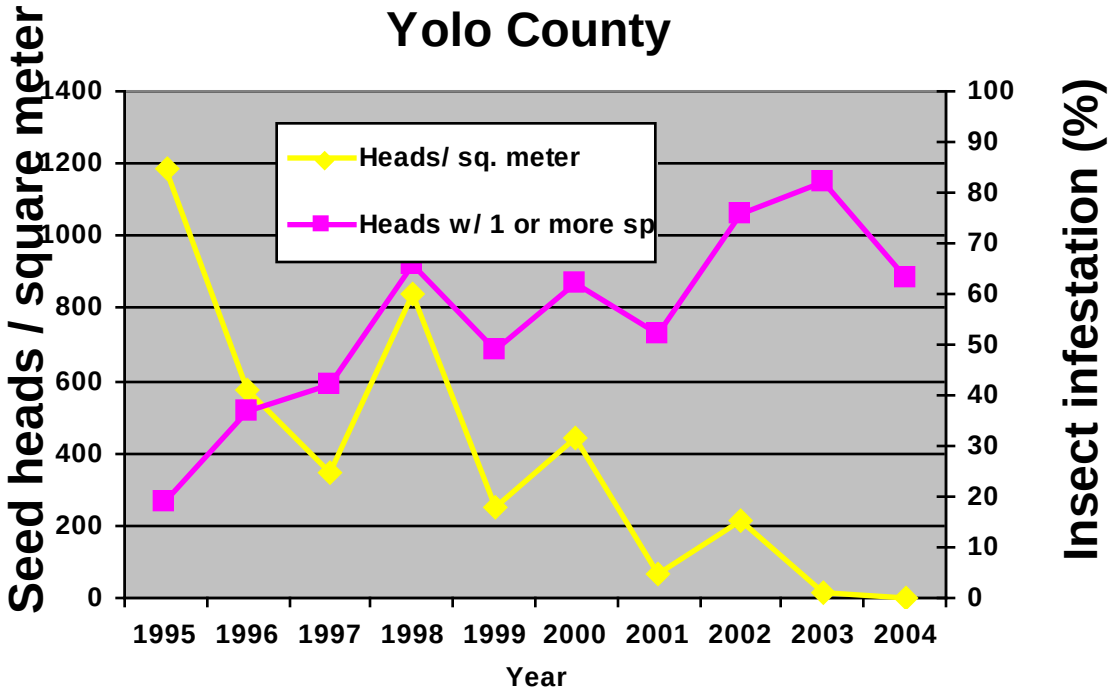
Mean attack rate: 53%

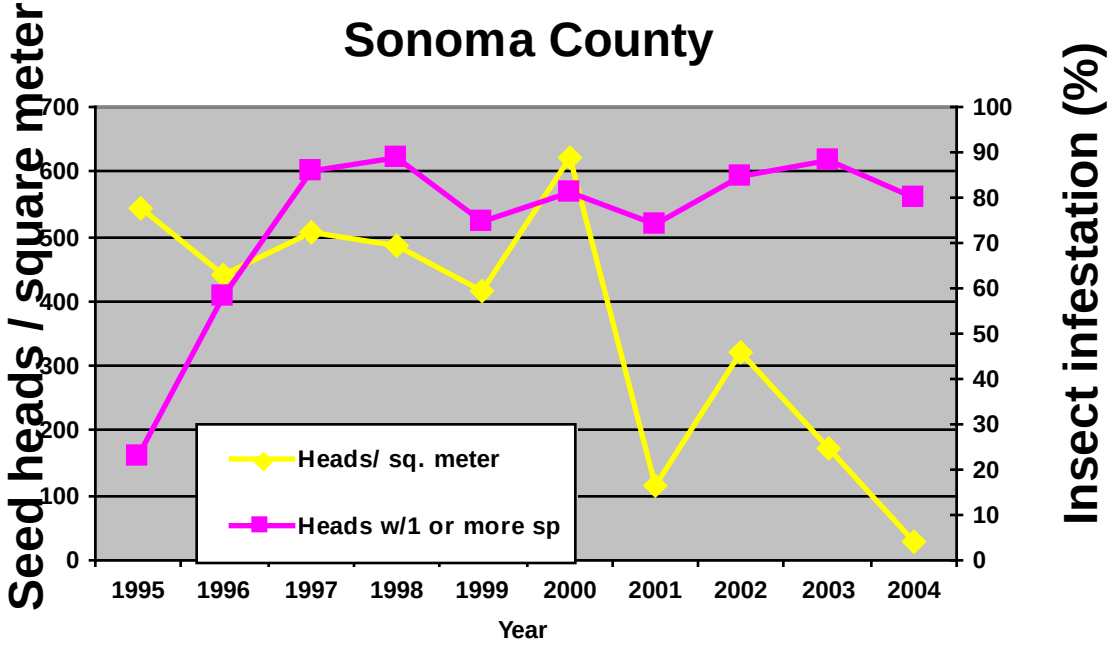
Range: 0 - 96%



R. Yacoub & M. Pitcairn (CDFA)

Effect of seed head insects on YST in California





Data from CDFA (2005)

Yellow Starthistle, Myrtle Creek, Oregon

Hairy Weevil
&
not grazed
by cattle

Economic Benefit

- **Australia:** Generated **$23** for every **$1** invested.

  Ave. net benefit of **$95.3 M** from ave. **$4.3 M** investment per year.[1]

- **USA:** ____? [tansy ragwort in OR = 14:1][2]

- **World:** range of estimates: **2:1 to 112:1**.[3]

  80-90% probability of success for a properly resourced and conducted program.

  A program **costs** $200,000 to $500,000 per year for 5-15 years, i.e., a total of about **$3 to $8 million**.

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1) **Page & Lacey (2006)** CRC for Australian Weed Management Technical Series No. 10.
2) **Turner & McEvoy 1995)** *In* Biological Control in the Western United States: Accomplishments and Benefits of Regional Research Project W-84, 1964-1989, pp. 264-269.
3) **Syrett et al. (2000)** *In* Gurr and Wratten (eds.), Biological Control: Measures of Success, pp. 189-230.

Duration of Some Projects

Weed	Start	No. of agents	Duration (yrs)
Tansy ragwort	1930s	2 of 3	50*
St. Johnswort	1930s	2 of 5	20*
Leafy spurge	ca. 1960	4 of 14	40
Diffuse knapweed	1961	~3 of 10	45
Musk thistle	1960s	2? of 6	30
Rush skeletonweed	ca. 1970	3? of 3	20*
Purple loosestrife	ca. 1990	5? of 5	15

*Benefited from prior projects in Australia

Is it possible to speed up BC of Weeds?

- Molecular genetics
- GIS software & data
- Internet
- Physiology
- Databases
- Learning from experience
- Organization of work
- Regulatory process

Other Biocontrol Projects

- Bindweed
- Brooms (French, Scotch)
- Cape ivy
- Giant reed (arundo)
- Houndstongue
- Perennial pepperweed
- Medusahead
- Saltcedar
- Teasel
- Toadflaxes
- Tree of heaven
- Russian knapweed
- Russian thistle (tumbleweed)
- Salvinia (waterlettuce)
- Yellow starthistle

Possible Ways to Improve the Process

- **Use foreign scientists** for Exploration, Identification, Rearing, 1° evaluation.
- **Cryptic species:** know your enemey, more prospective agents.
- **Better prediction of efficacy:** Climate matching, Host plant matching, Avoidance of top-down control by other ne's, “Designer” BC agents.
- **Shorten test list:** Taxonomy vs. attractiveness & suitability (Electroantennograms, Chem. databases).
- **Shorten regulatory process:** APHIS needs an incentive to act, foster more communication.
- **Mass rearing:** artificial diets, rearing center.

Traditional Approach

- Target selection
- Foreign exploration
- Selection of candidate agents
- Host specificity testing
- Efficacy evaluation
- Regulatory approval
- Multiplication
- Release, establishment, distribution