Canada Thistle Rust Fungus

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Upper Arkansas Cooperative Weed Management Area Conference

November 8, 2017

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Conservation Services Division

Puccinia punctiformis

Today's talk

- Canada thistle
- Rust Fungus
- Research Questions
- Inoculation Protocol
- Monitoring Protocol
- Preliminary Results
- Conclusions
- Future

Canada thistle

Cirsium arvense (L.) Scop (Asteraceae)

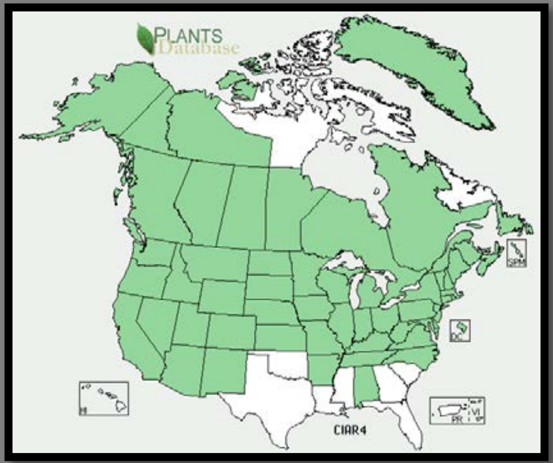
- Canada-, California-, Creeping thistle

- Herbaceous, clonal, perennial
- 1 to 5 ft. (30 to 150 cm) tall
- Reproduction
  - Sexual (1,500 seeds per ramet)
    - Low germinability (Hay, 1937)
  - Vegetative through rhizomes
    - Plowing spreads root fragments

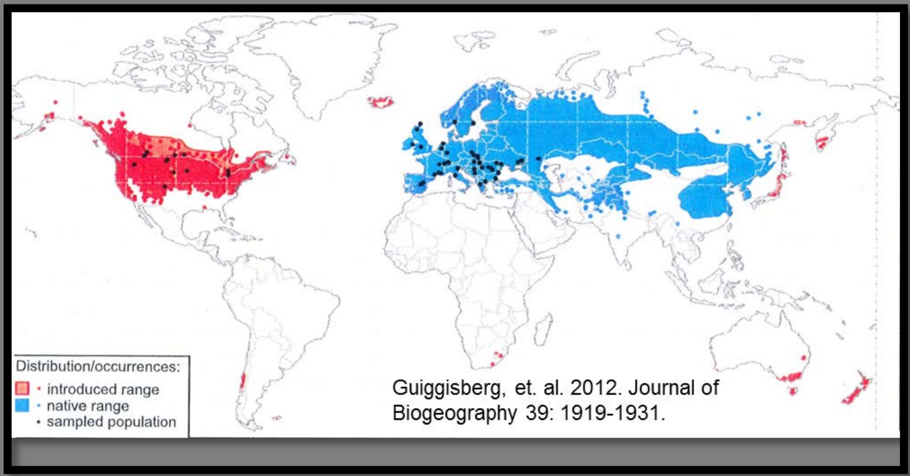
    (Bourdot et al., 1995)
- Invades open disturbed habitats (Zouhar, 2001)

Canada thistle

- Introduced to North America in 1600s from Europe (Skinner et al., 2009)
- Distributed globally in temperate regions (Guggisberg et al., 2012)
- Most problematic weed in U.S. and one of the worst globally (Moore, 1975)
- One of the worst weeds of crop and pasture lands (Donald, 1990; Jacobs et al., 2006)



Credit: USDA 2014



Guiggisberg, et. al. 2012. Journal of Biogeography 39: 1919-1931.

Economic Impact

- Problem in alfalfa, pasture, hay, barley, oats, wheat, canola (Grekul and Bork (2004) Peas, corn, beans, sugar beets (Jacobs et al., 2006)
- Prevents grazing near stems (Trumble and Kok, 1982)
- Livestock reject contaminated hay (Oswald, 1985)
- $320 m dollars of annual loss to prairie producers. 15-60% crop yield loss. (Bailey et al., 2000; Mitchell and Abernethy, 1993)
- Sprays not profitable for low-value crops w/CT (Donald and Prato, 1992)

Economic Impact

- Non-native weeds cost US 27 billion annually (Pimentel et al., 2000)
- Most frequently listed noxious weed among farmers in US/CA (Skinner et al., 2000)
- 3 x 3 ft area with 2 shoots reduced spring wheat in MT by 15% (Hodgson 1968)
- Harbors pests insects and scratches lead to infection of grazers (Link and Kommedahl 1958)

- In Colorado, List B covering more than 129,000 acres

Control

- Difficult and Expensive with herbicides
- May take many applications several years
- Not worth it on marginal land
- Ideal candidate for biological control

Biocontrol of Canada thistle

Urophora cardui – Canada thistle gall fly
Hadroplontus litura - stem-mining weevil

Biological Control 86 (2015) 28–35

Contents lists available at ScienceDirect

Biological Control

journal homepage: www.elsevier.com/locate/ybcon

ELSEVIER

Asymptomatic systemic disease of Canada thistle (*Cirsium arvense*) caused by *Puccinia punctiformis* and changes in shoot density following inoculation

CrossMark

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Puccinia punctiformis (F. Strauss) Rohl.

- First plant pathogen suggested as biocontrol (1893)
- Present throughout CT range
- Obligate biotroph (living plants)
- Autoecious (no alt. host)
- Host specific (only attacks CT)
- Heterothallic (sexually dioecious)
- Systemic disease that kills host
- Much cheaper control method

Co-evolved host-parasite interaction

- Systemic disease kills the host and ultimately eliminates the pathogen — limited disease perpetuates both
- Only one complete disease cycle per year – very slow
- Three epiphytotic stages, Aeciospore, teliospore and root system
- Each epiphytotic results in only short-distance disease spread
- Unfavorable environmental conditions, during any of the three epiphytotics, can stop spread of systemic disease

Winter

Germinating basidiospores produce hyphae that travel down to survive in roots

Early Spring

Systemically diseased shoots from infected root

Late Spring

Spermagonia cross to produce aeciospores on diseased shoots

Summer

Aeciospores blow to neighboring shoots that give rise to urediniospores

Fall

Uredinia produce teliospores on senescing leaves that infect rosettes

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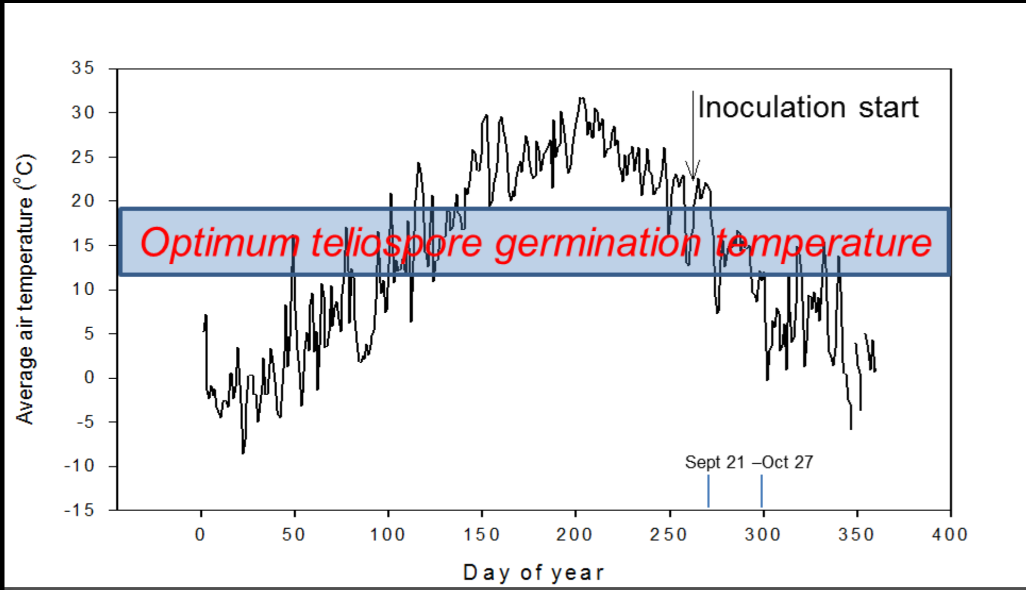
Research Questions

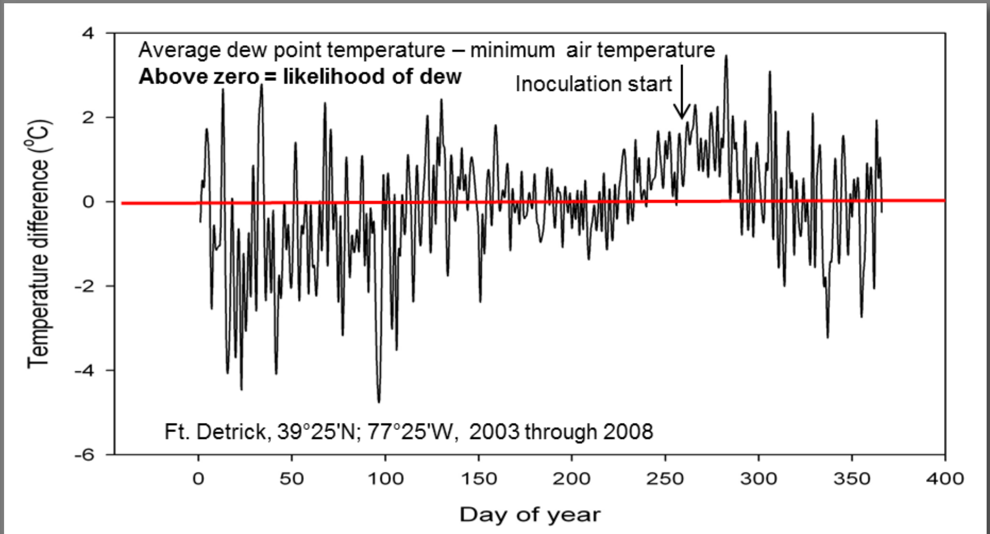
1. Can the rust establish in the varied environments across the state of Colorado?

2. Does establishment of the rust result in decreased density of Canada thistle infestations?

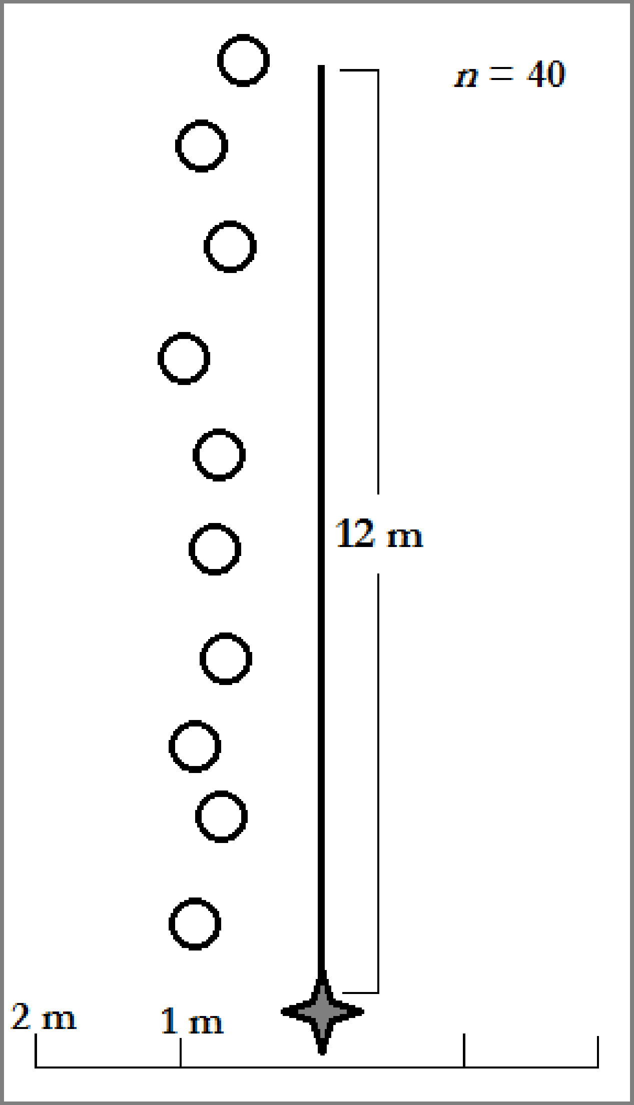
3. What is the best method of inoculum spread for significant infection?

Inoculation Protocol



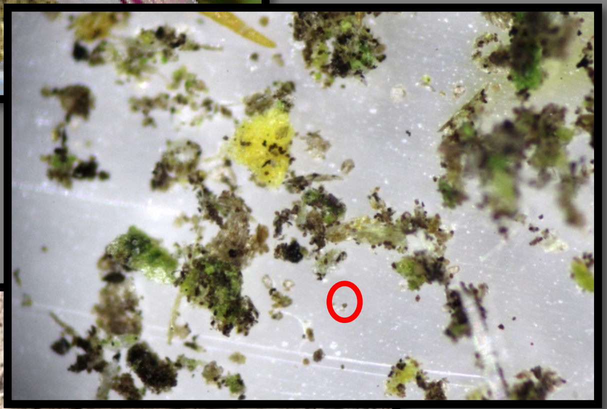


Inoculation Protocol



0.5 g

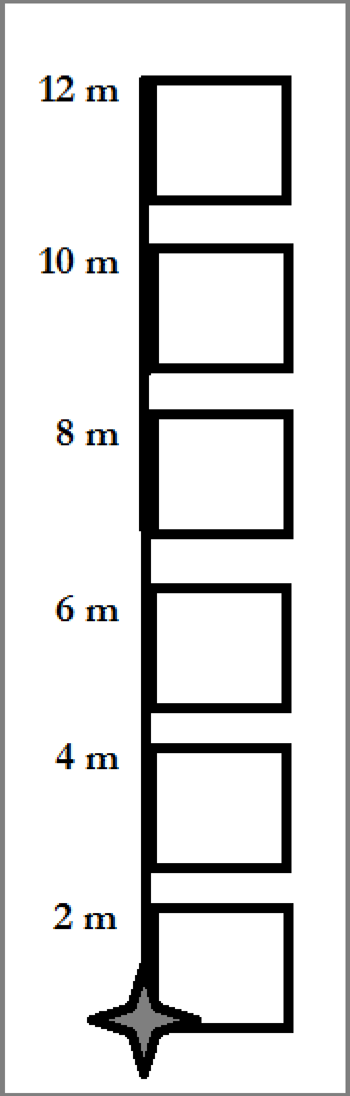
> 1 m spores

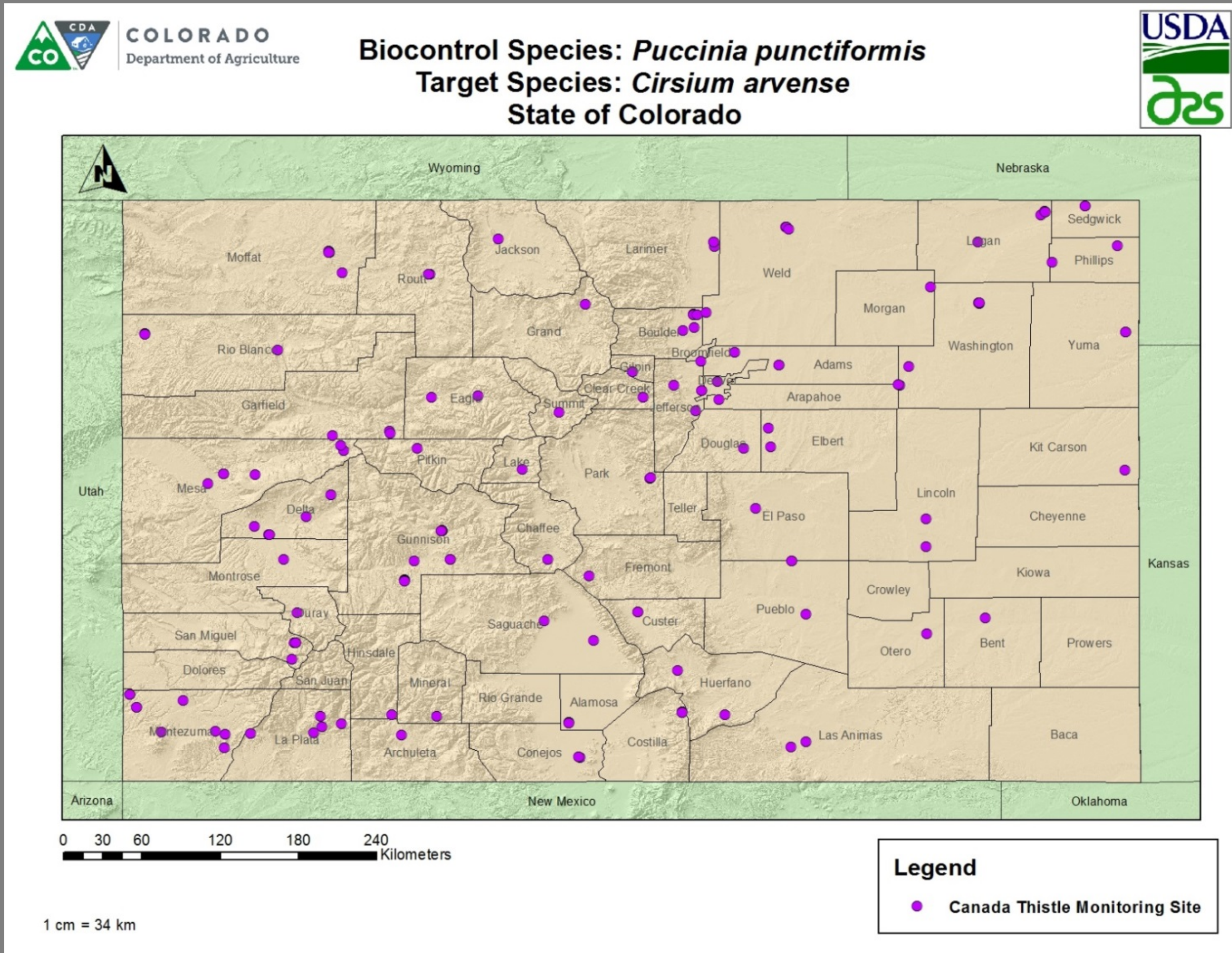


H_2O

Monitoring Protocol

- Difficult to est. true control sites
  - Req. locations outside of wind-blown spore distribution range
  - Req. western dot blot testing of roots or fungicide treatments to ensure control fidelity
- Use a simple and fast protocol that allows monitoring of larger number of sites
- Approach is based on repeated measurements of plant density and infection rate in plots (n = 6) along permanent 12 m transects
- Plots are 4 sq. ft. (0.37 sq. m)
- Photo points



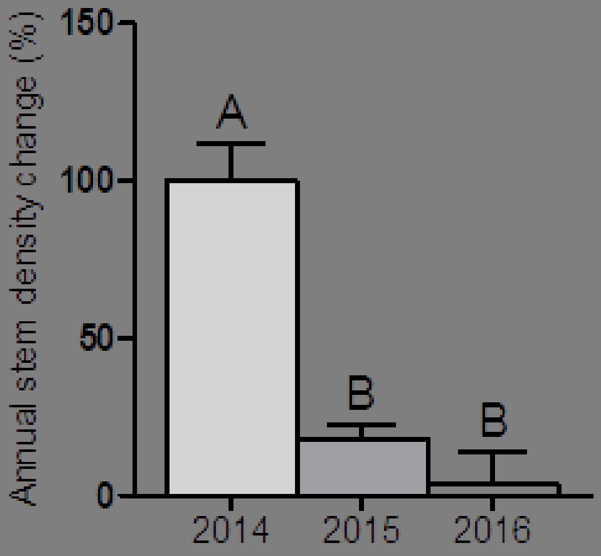


Year	Sites inoculated	Amount (g)
2013	8	1170
2014	80	1929
2015	92	3938
2016	107	5425
2017	59	1805
	In freezer	+7660

141 monitoring, 105 releases

Preliminary Results

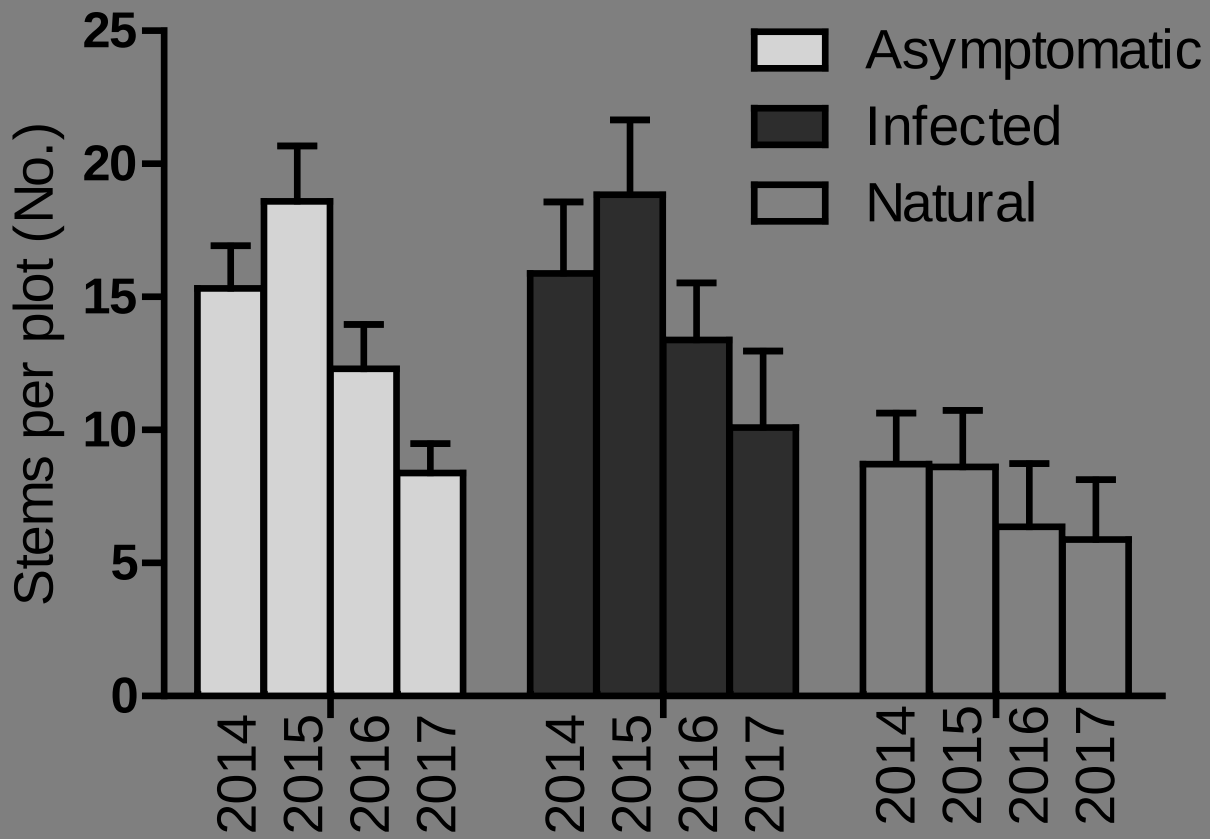
2013 Experimental Plots



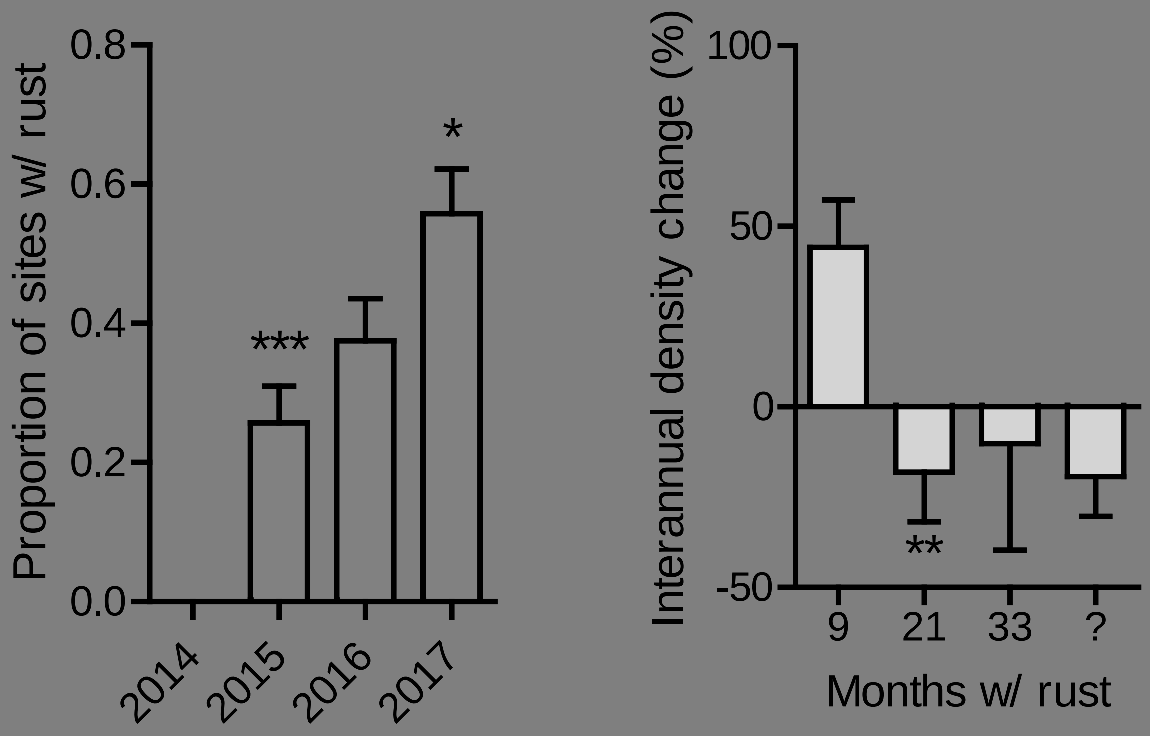
Treatment	Time span	Change (%)
Inoculated	2013-2014	51.82
	2014-2015	4.7
	2015-2016	-27.91
Natural	2013-2014	19.76
	2014-2015	17.36
	2015-2016	-35.82
Control	2013-2014	23.05
	2014-2015	-11.83
	2015-2016	-1.97

Preliminary Results

72 of 141 est. (51%)



Increasing rust, decreasing density



Visible Cues

How to Recognize Rust

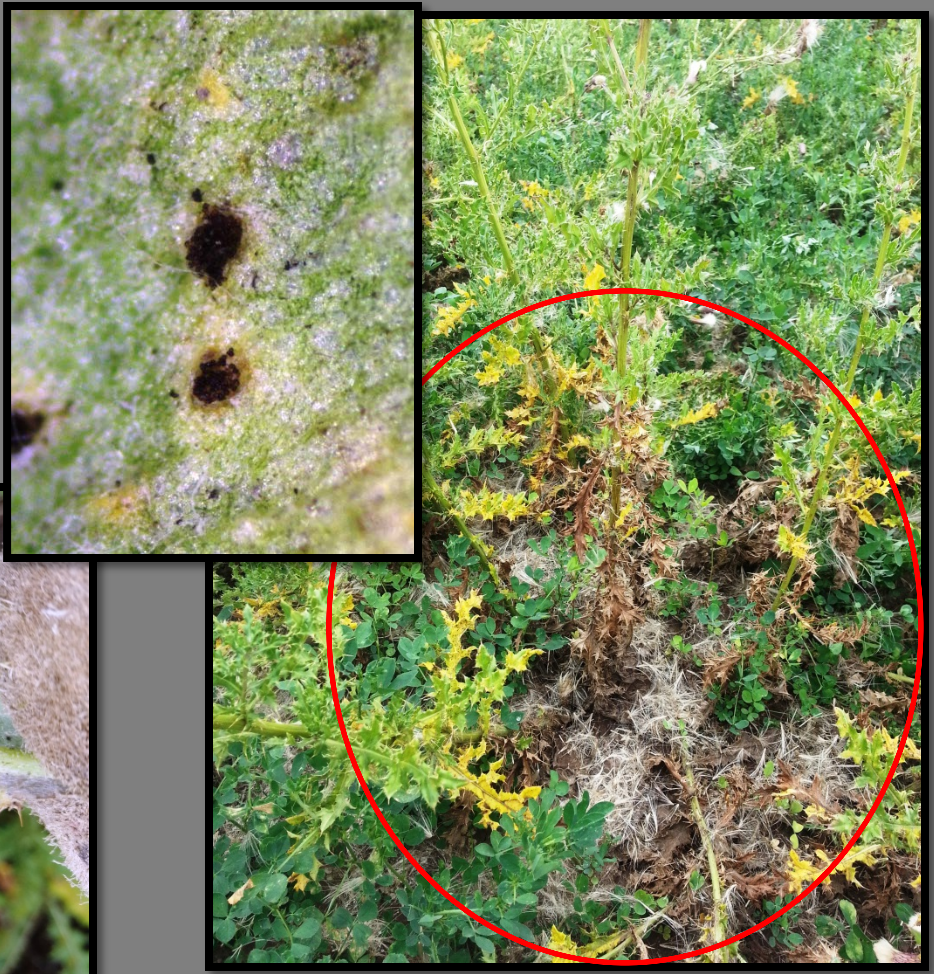
Spring

Stringy, yellow, no flower but fragrant, sometimes

How to Recognize Rust

Fall

1 m around old systemic, yellowing basal leaves, spotting on underside



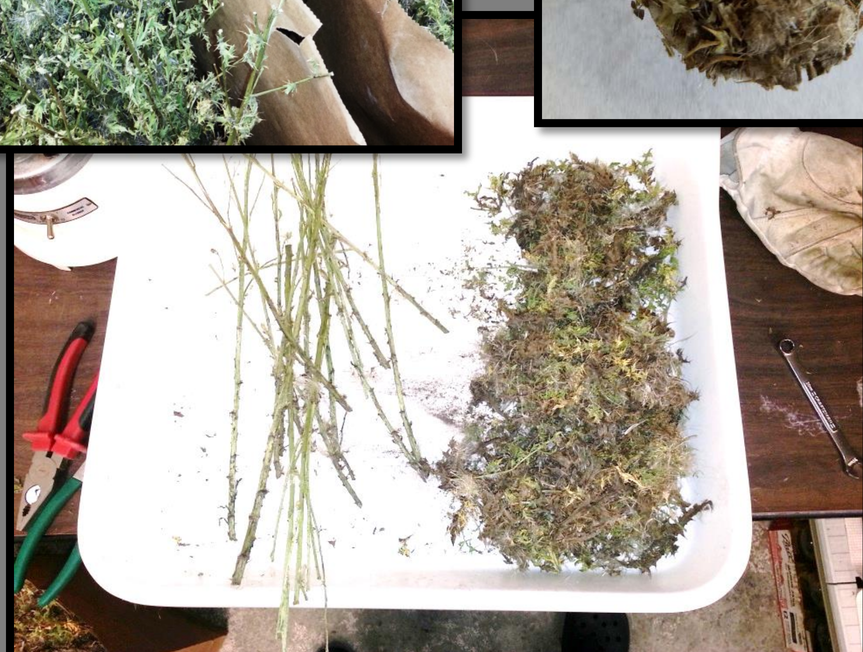
How to Collect

- Best time to begin…spring time
- Take GPS, Photo point
- Pin flag systemic shoots
- September
- Neighboring plants around pin flags
- Cut whole plants
- Store dry in paper bags
- Strip leaves and grind in blender

How to Spread

- Fall, warm days cool nights
- When there is dew sufficient moisture
- Evening time is best
- Mist water until running off leaves
- 0.5 g per rosette (1/2 tsp)
- Target less than 6 inch healthy green rosettes
- ~40 rosettes per site
- Mow rusty sites late summer through fall


1/2
tsp



Conclusions

- Canada thistle negatively affected by *P. punctiformis* in Colorado.

- The rust fungus continues to show promise as a biological control.
- Further testing required:
  - Improve application methodology
  - Determine other factors conducive patch decline

Future

- We expect:
  - 2018, Increased detection and decreasing infestation density
  - 2019, Several good collection sites in and out-of-state
- Continued tech transfer:
  - Provide educational materials
  - Travel to collect
  - Limited inoculum
  - Expand to other states

Table 1
Percent thistle density reduction following inoculation of rosettes in the fall with telia-bearing leaf pieces.

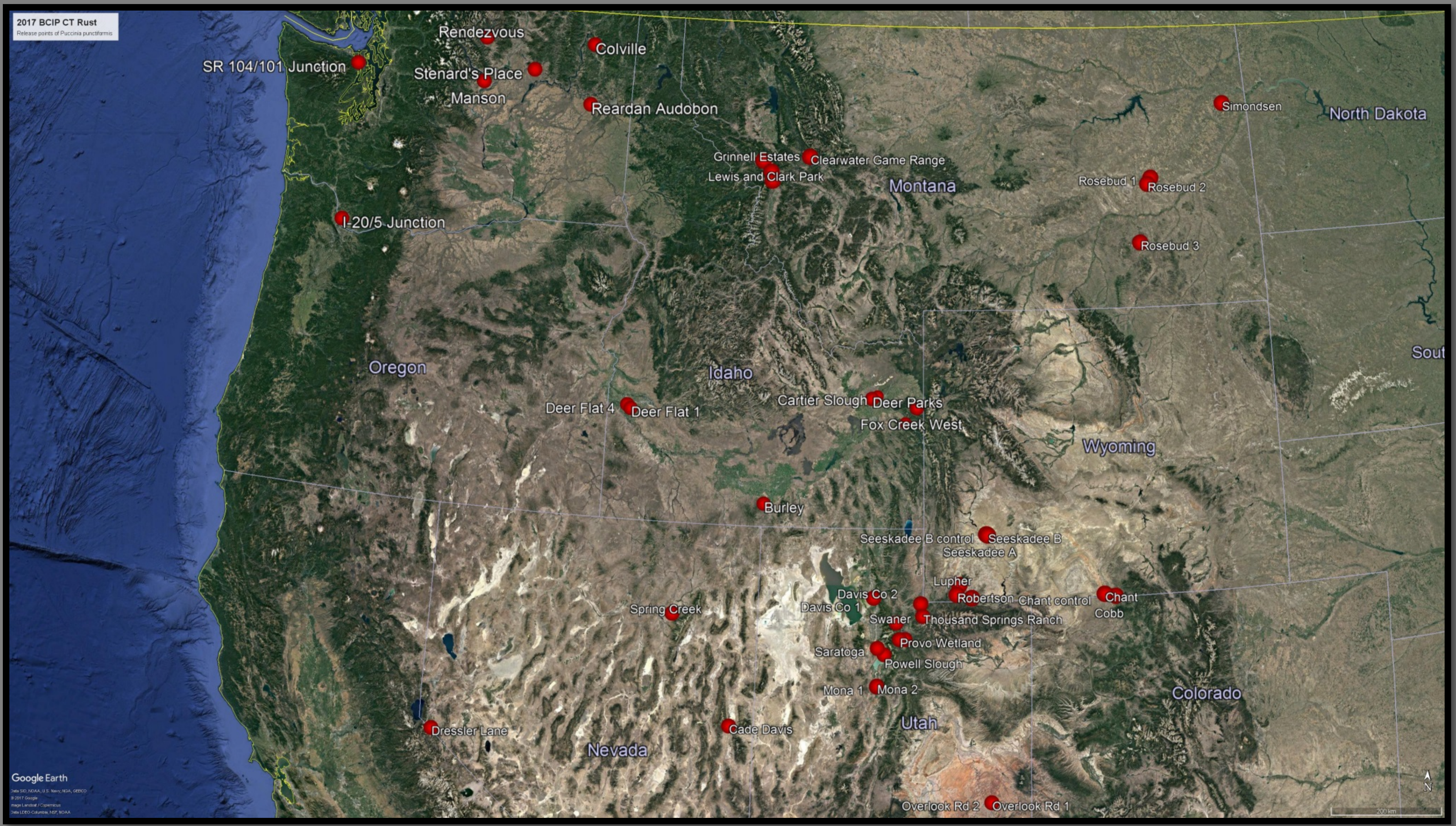
Location/site	Months after inoculation			
	18 (%)	30 (%)	42 (%)	54 (%)
Keymar, MD (2010 inoculation)	54.8	83.0	–	–
Keymar, MD (site 1, 2011 inoculation)	36.6	52.2	–	–
Keymar, MD (site 2, 2011 inoculation)	60.8	45.6	–	–
Keymar, MD (2012 inoculation)	41.0	–	–	–
Kozani, Greece (2010 inoculation)	81.2	95.2	94.7	–
Bolshie Vyazemy, Russia (site 1, 2011 inoculation)	32.4	65.1	–	–
Bolshie Vyazemy, Russia (site 2, 2011 inoculation)	7.0	50.3	–	–
Bolshie Vyazemy, Russia (site 3, 2011 inoculation)	17.7	52.9	–	–
Fort Detrick, MD (2008 inoculation)	100	100	100	100
Fort Detrick, MD (2009 inoculation)	0.0	30.2	48.0	45.7
Average ± SE	43.1 ± 10.0	63.8 ± 8.0	80.9 ± 16.5	72.9 ± 27.2

– = No data.

Credit: D. K. Berner

Out-of-State

1,961 grams provided, 42 releases (17 SIMP, 6 controls)



Top CT Rust Successes

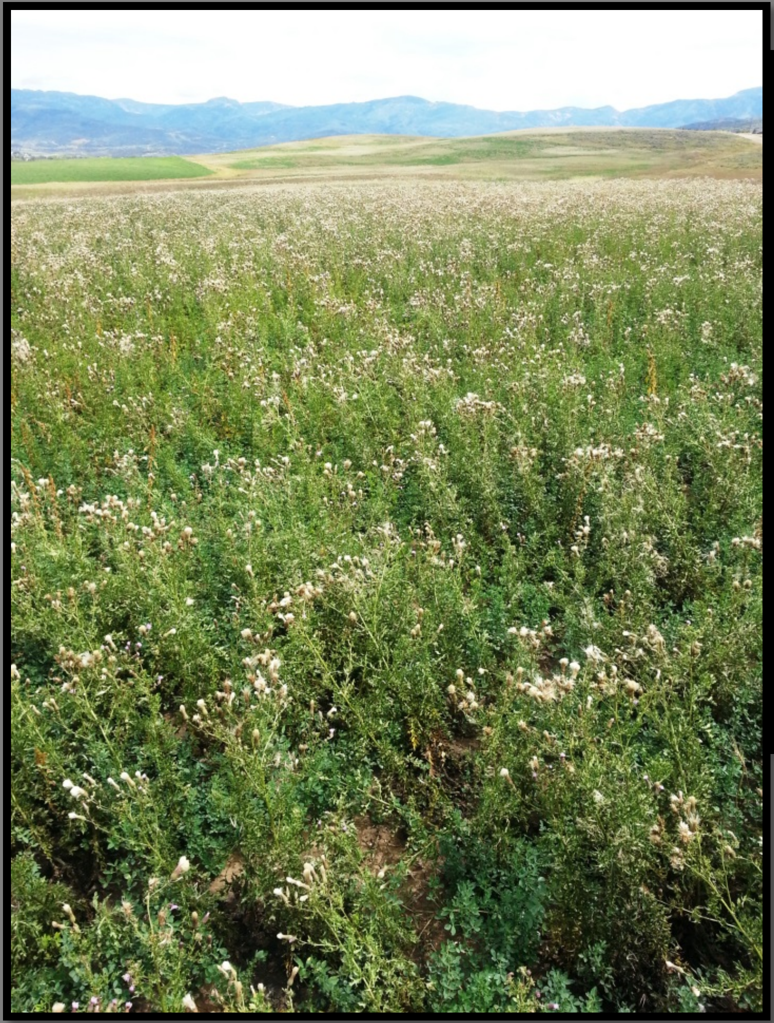
MC 1 - ↓100%

2014

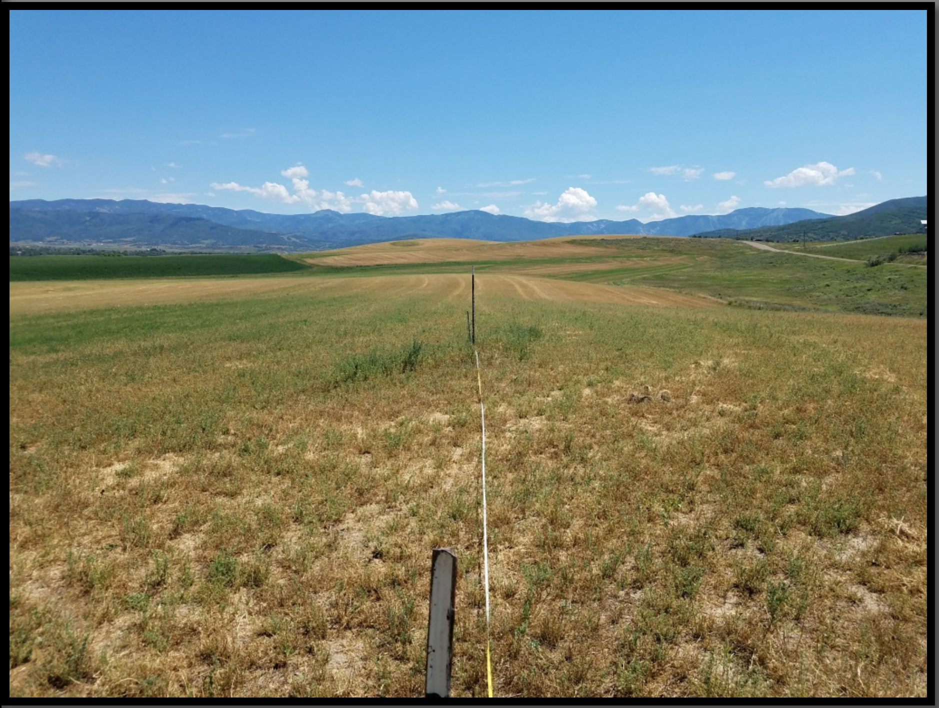
2017

Clay 2 - ↓99%

2014



2017



Clay 1 - ↓92%

2014

2016

Napoli - ↓91%

2014

2016

Dove 2 - ↓70%

2015

2016

McFarland - ↓100%

2014

2017

Kelly 1 - ↓98%

2014

2017

Friends - ↓91%

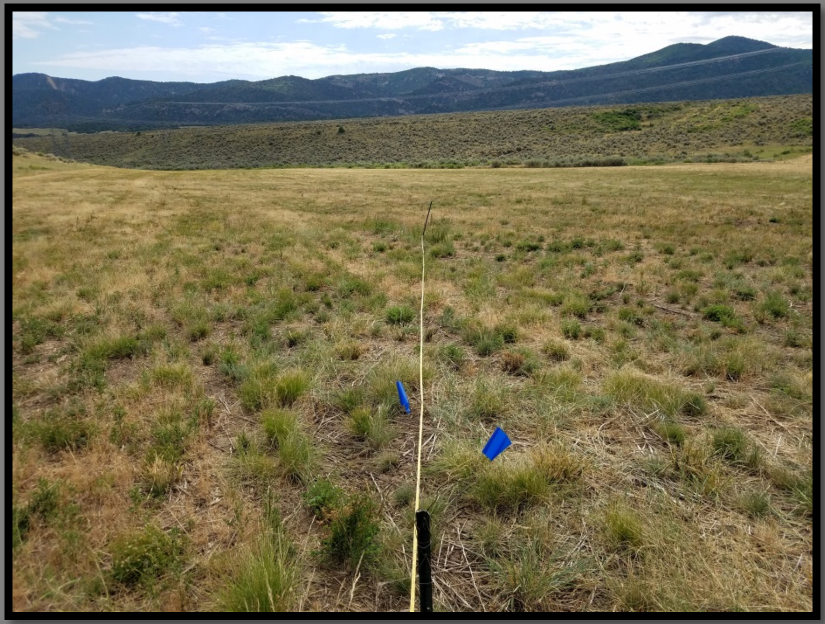
2015

2017

Nine Mile - ↓97%

2015

2017



Bow 3 - ↓100%

2014

2016

Acknowledgements

USDA-ARS:

Dr. Dana K. Berner

CO Dept. of Ag:

Joel Price

Karen Rosen

Kristi Gladem

Dr. Dan Bean

Michael Racette

Research supported by:

- USDA/ARS Co-op agreement (58-1920-3-004)
- US Forest Service Biocontrol of Invasive Plants (BCIP)17-CA-11420004-452

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