Welcome to the Conservation Lecture Series

CALIFORNIA
DEPARTMENT OF
FISH &
WILDLIFE

Upcoming Lectures

- **Sierra Nevada Red Fox** – April 11, 1:00-3:00. Presented by Dr. Ben Sacks
- **Alameda Striped Racer** – April 24, 1:00-3:00. Presented by Karen Swaim
- **California Tiger Salamander** –April 28, 10:00 am-12:00. Presented by Dr. Chris Searcy
- **Shasta Crayfish** – April 29, 10:00-11:30. Presented by Dr. Maria Ellis. Location: Redding
- **Desert Tortoise** – May 22 (time TBD). Presented by Becky Jones. Location: Los Alamitos
- **Amargosa Vole** – June 9, 1:00-3:00. Presented by Dr. Janet Foley and Dr. Robert Klinger

Questions?

Contact: margaret.mantor@wildlife.ca.gov

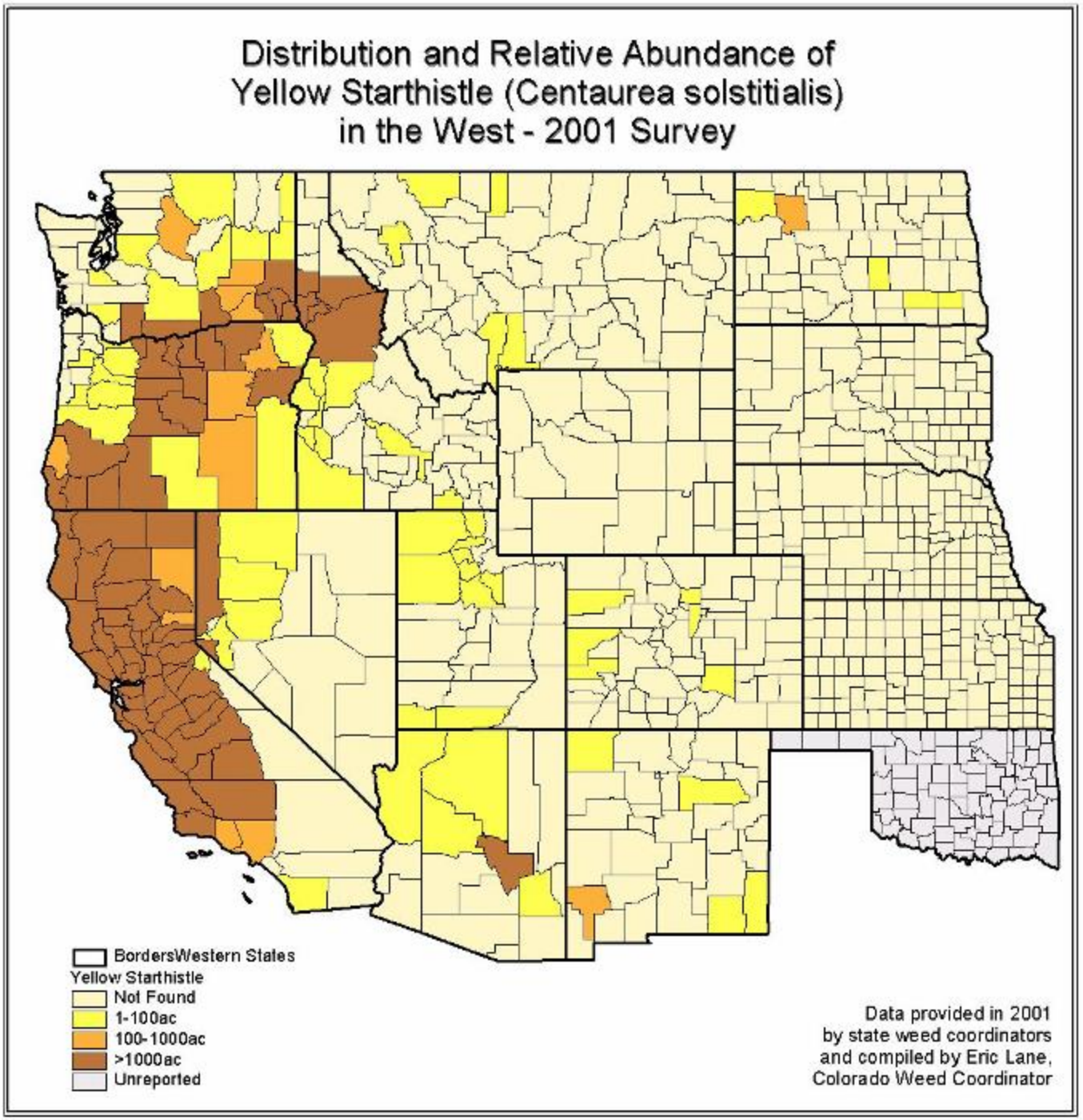
Yellow starthistle biology and control

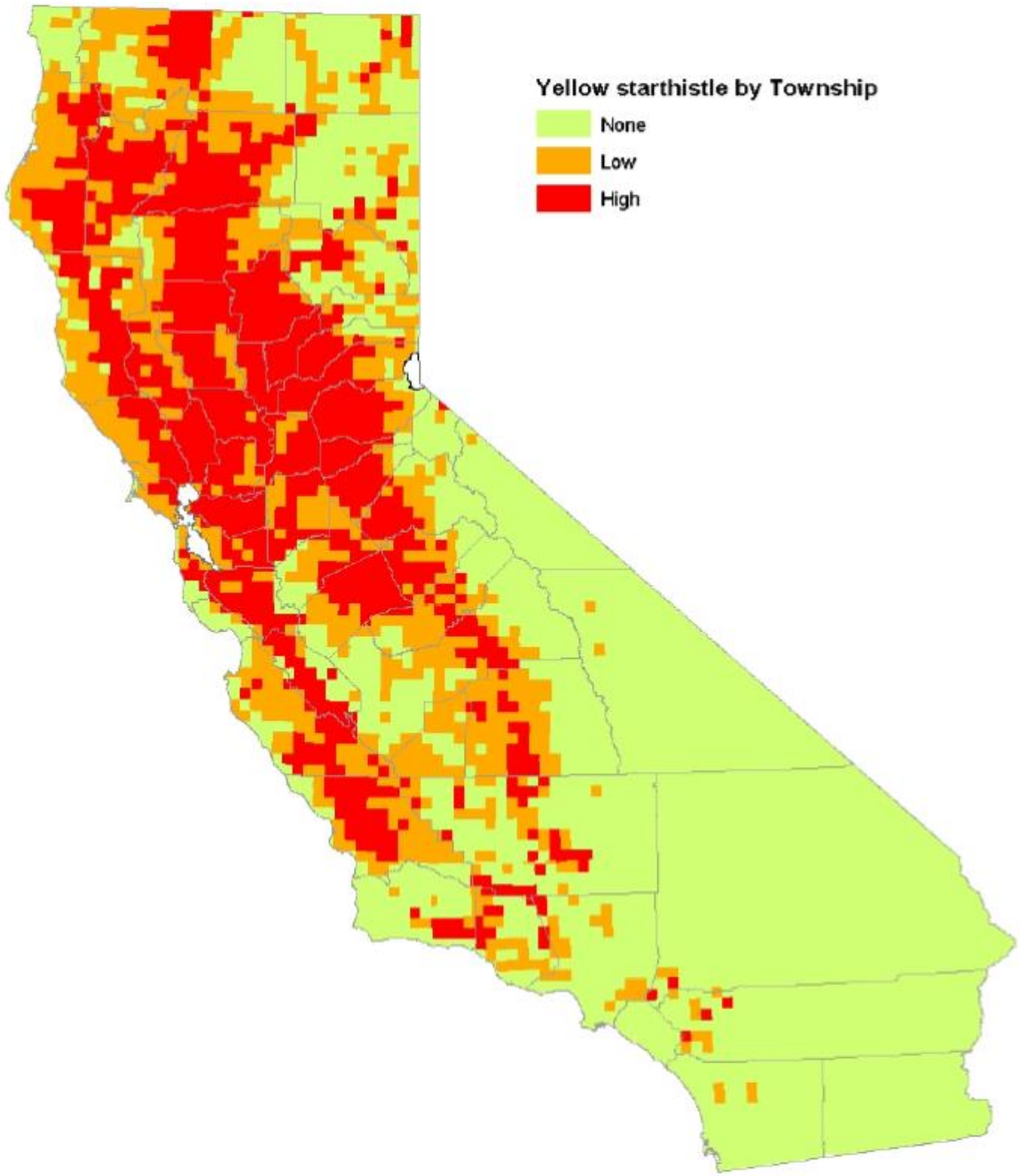
Joe DiTomaso
UC Davis

Acres of western states infested with major invasive species

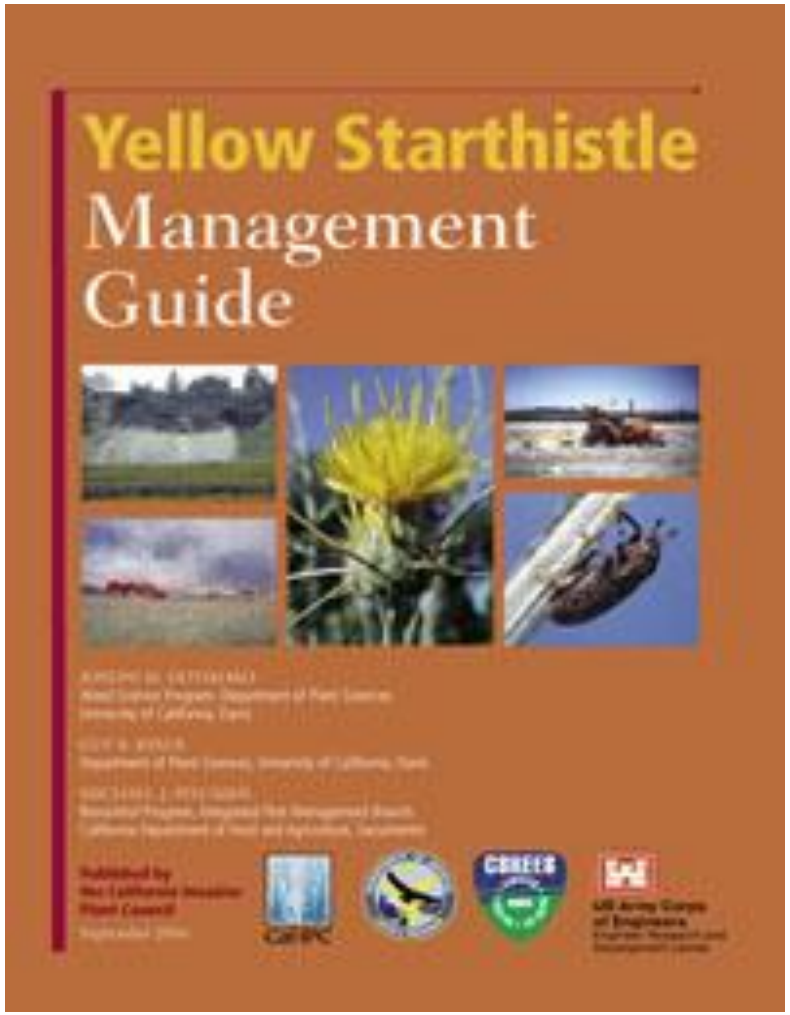
Species	Acres infested (x million)	% annual increase
Downy brome	56.0	14
Yellow starthistle	14.8	13-17
Canada thistle	7.1	10-12
Sericea lespedeza	5.5	24
Spotted knapweed	5.2	10-24
Musk thistle	4.7	12-22
Leafy spurge	3.7	12-16
Saltcedar	3.7	1-25
Medusahead	2.4	12
Perennial pepperweed	2.0	11-18
Diffuse knapweed	1.8	16
Russian knapweed	1.2	8-14

Duncan, Jachetta, DiTomaso et al. 2004. Weed Technology 18, 1411

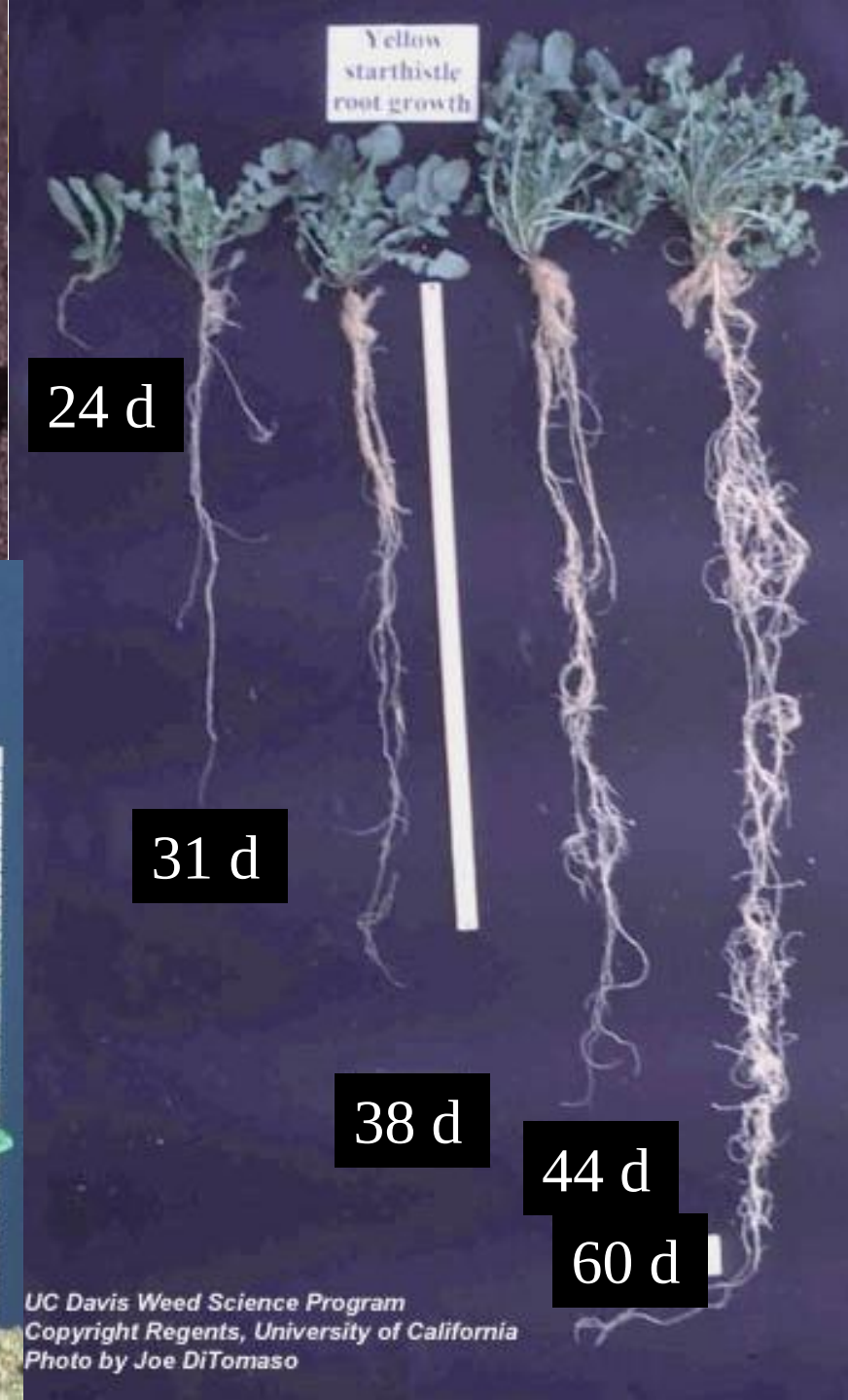

Distribution and Relative Abundance of
Yellow Starthistle (Centaurea solstitialis)
in the West - 2001 Survey
BordersWestern States
Yellow Starthistle
Not Found
1-100ac
100-1000ac
>1000ac
Unreported
Data provided in 2001
by state weed coordinators
and compiled by Eric Lane,
Colorado Weed Coordinator

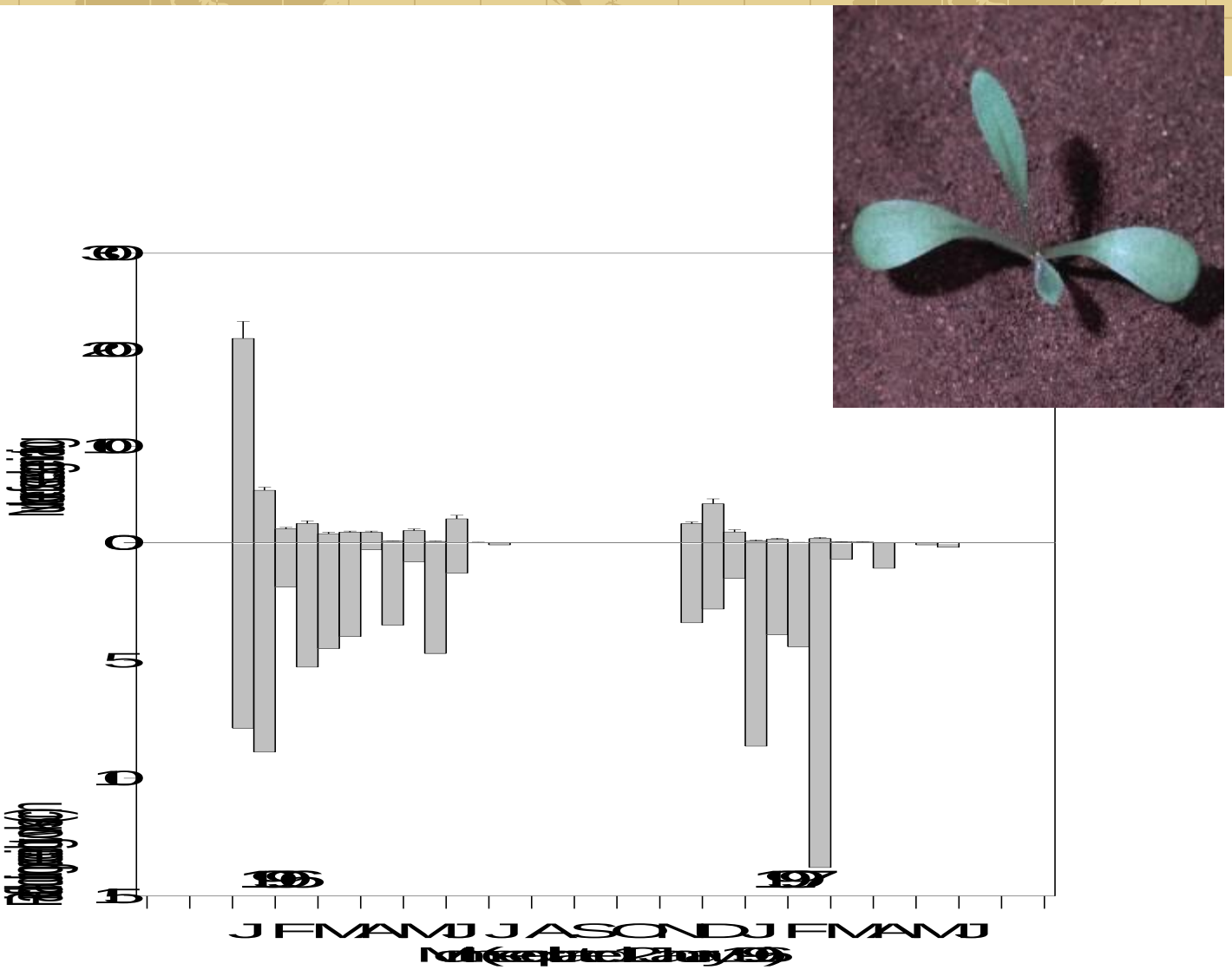

Yellow starthistle by Township
None
Low
High

Available through the Cal-IPC.org website

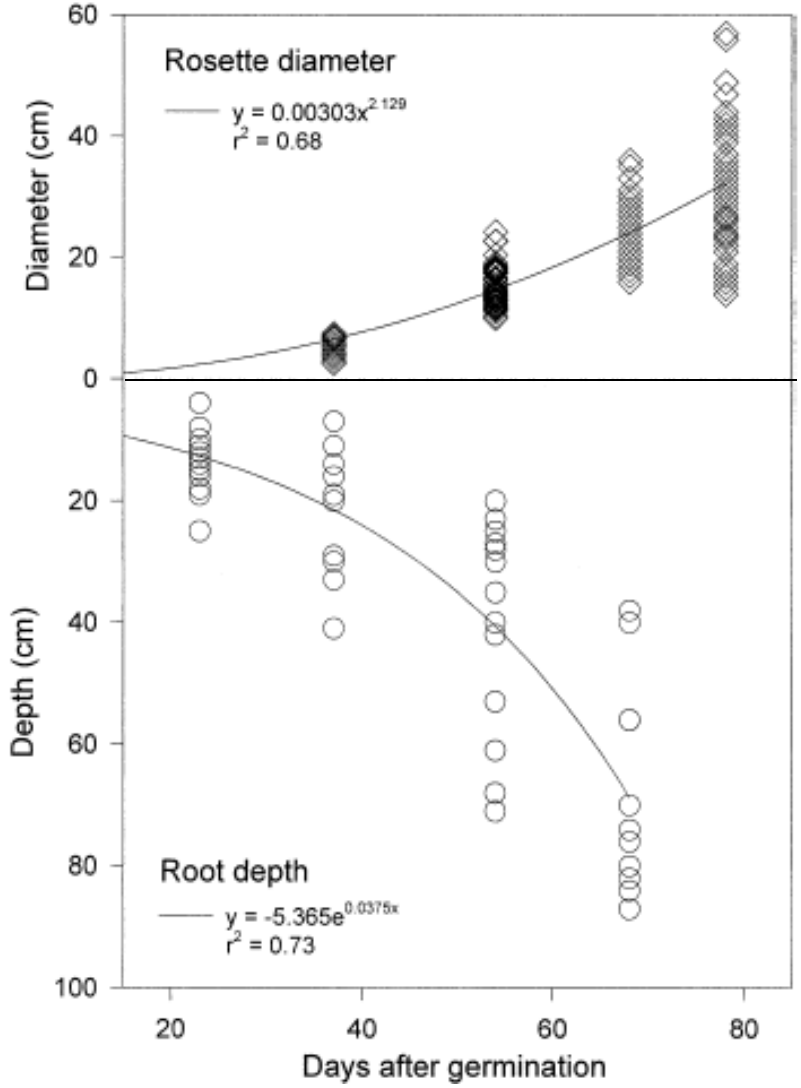


1
3
4
5
6


Yellow
starthistle
root growth
24 d
31 d
38 d
44 d
60 d
UC Davis Weed Science Program
Copyright Regents, University of California
Photo by Joe DiTomaso



DiTomaso, Kyser and Pirosko. 2003. Weed Science 51, 334


Rosette diameter
y = 0.00303x^2.129
r^2 = 0.68
Diameter (cm)
Root depth
y = -5.365e^0.0375x
r^2 = 0.73
Depth (cm)
Days after germination
60
40
20
0
20
40
60
80
100
20
40
60
80

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UC Davis Weed Science Program
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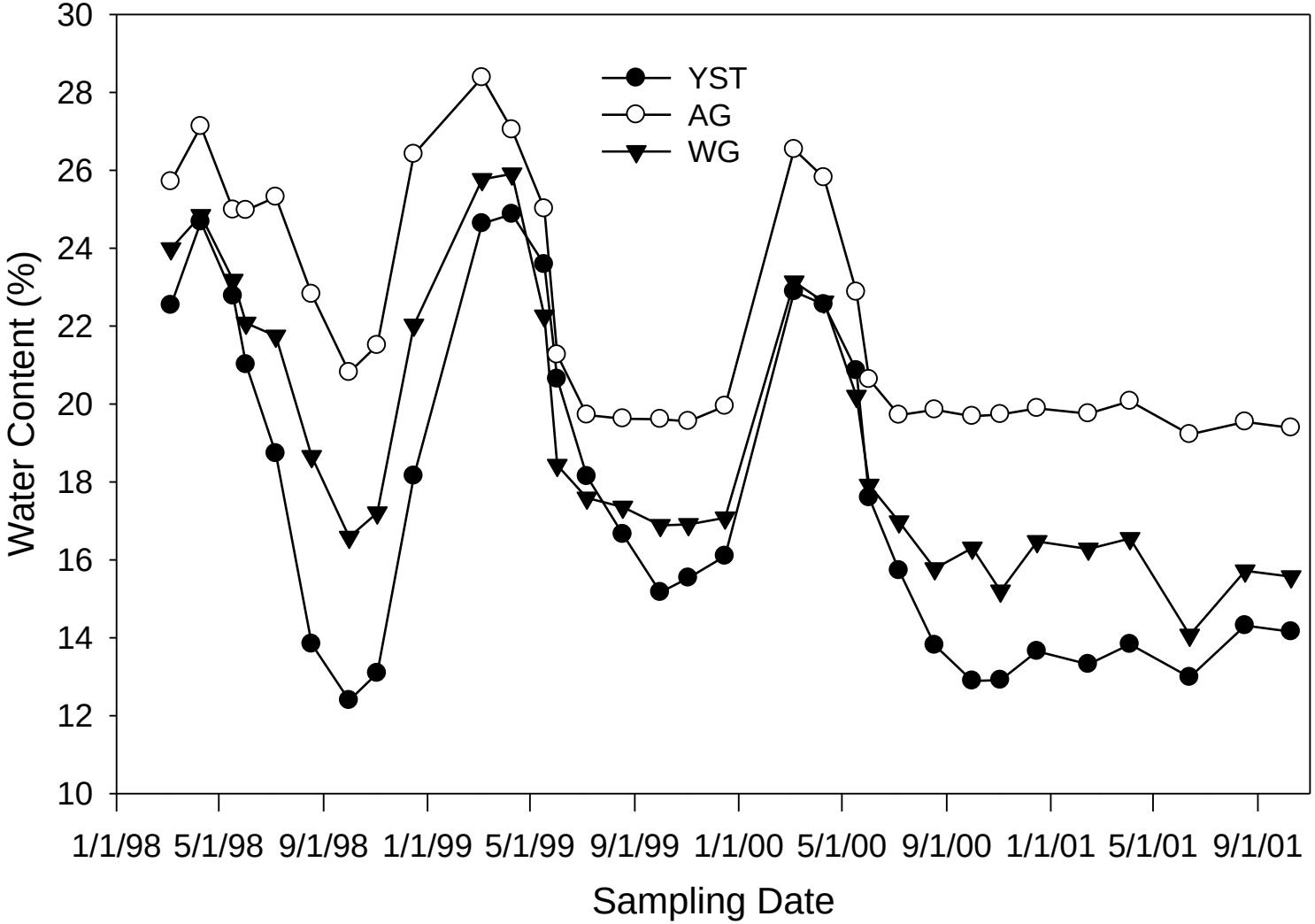
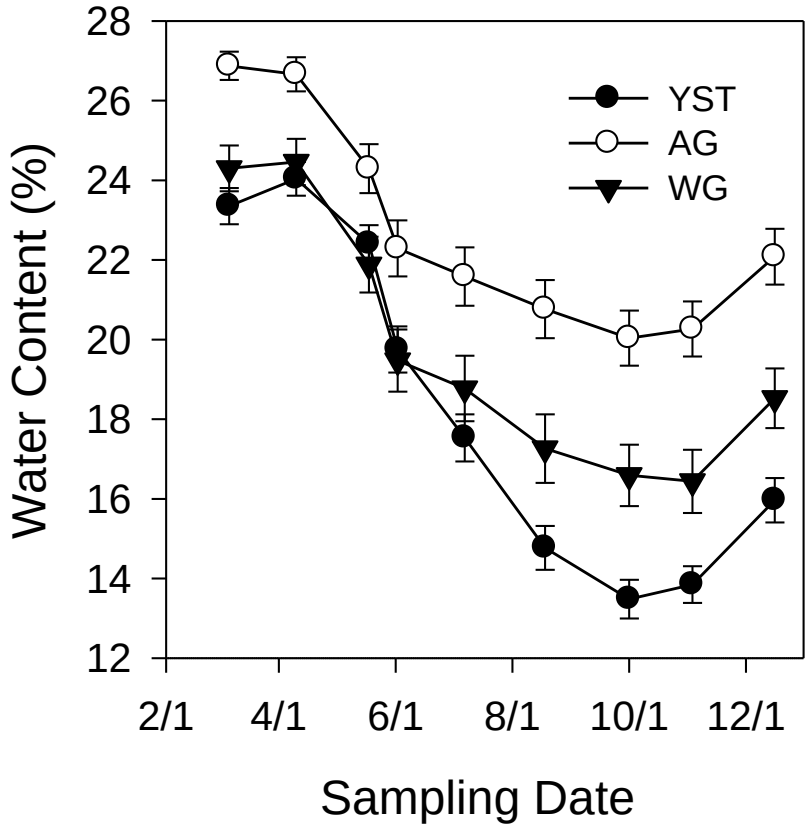
Pattern of Total Soil Water content (cm/150 cm) Over Four Years



Total Soil Water Content by Season Averaged Across Years



<u>Max-min water content</u>

YST = 15.8 cm

WG = 11.8 cm

AG = 9.9 cm

Potential Water Cost Estimates

- YST maintained a drier soil profile by 6.6 cm H_2O compared to the annual grasses
  - (0.066m H_2O) x 10,000 m^2/ha = 660 m^3/ha
    - 0.21 acre feet of water
    - ($12.00-30.00/Acre ft) = ($2.58-6.47 lost)
- A higher estimate by Gerlach (2000)
  - (0.12m H_2O) x 10,000 m^2/ha = 1200 m^3/ha
    - 0.39 acre feet of water
    - ($12.00-30.00/Acre ft) = ($4.72-11.70 lost)
- Siskiyou County alone, 26.4 million gallons water lost/yr, equivalent to 15-25% of mean annual precipitation

Yellow starthistle
(*Centaurea solstitialis*)

Root chamber

Root chamber dimensions: 1 m wide on both sides X 2.4 m tall

Sunken telephone booths

Root chamber

June 3, 2005 – counting yellow starthistle roots.

Root chamber

Senescing yellow starthistle in late summer

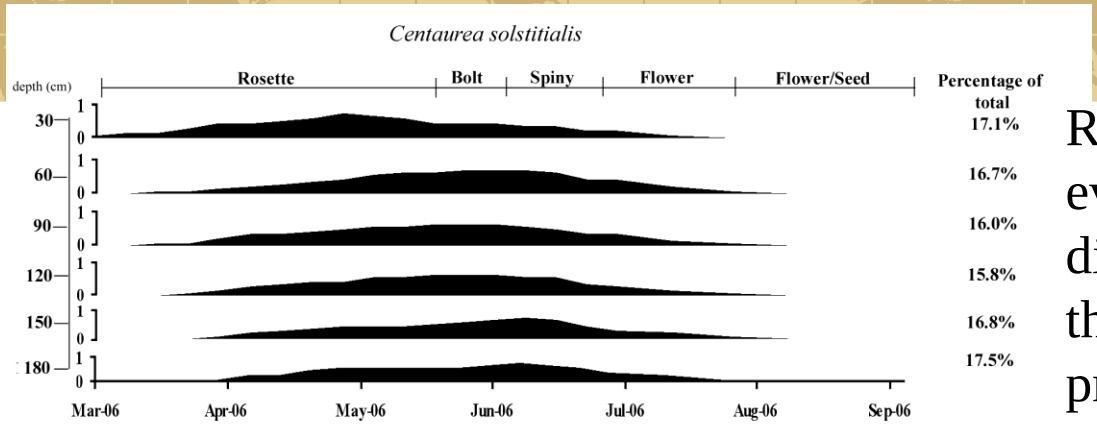
Root chamber

Red marks show amount of individual root growth.

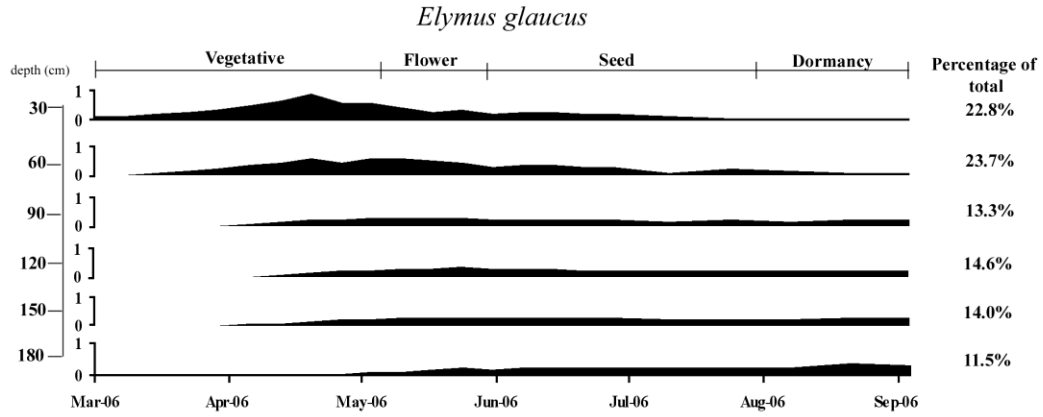
Depths correlate with neutron probe soil moisture depths.

Neutron probes

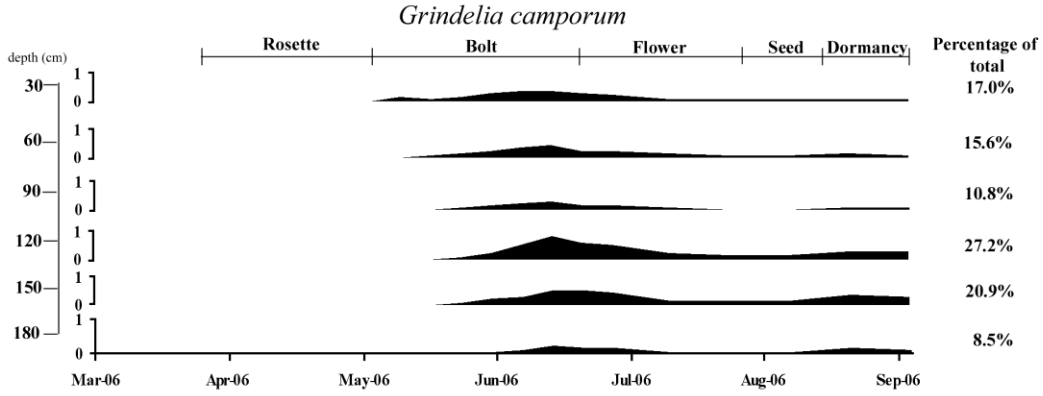
Roots observed on the chamber wall were derived from lateral root development



Roots evenly distributed throughout profile

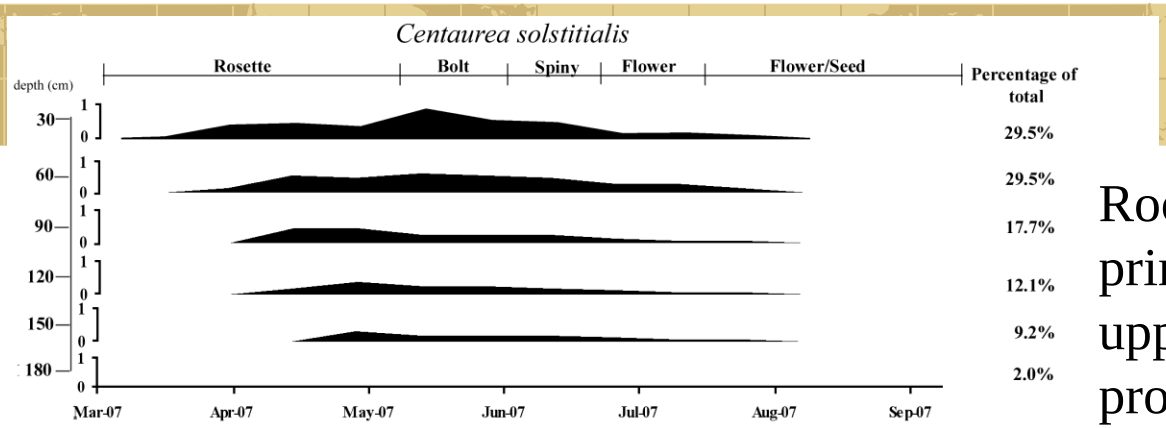


Roots primarily in upper profile

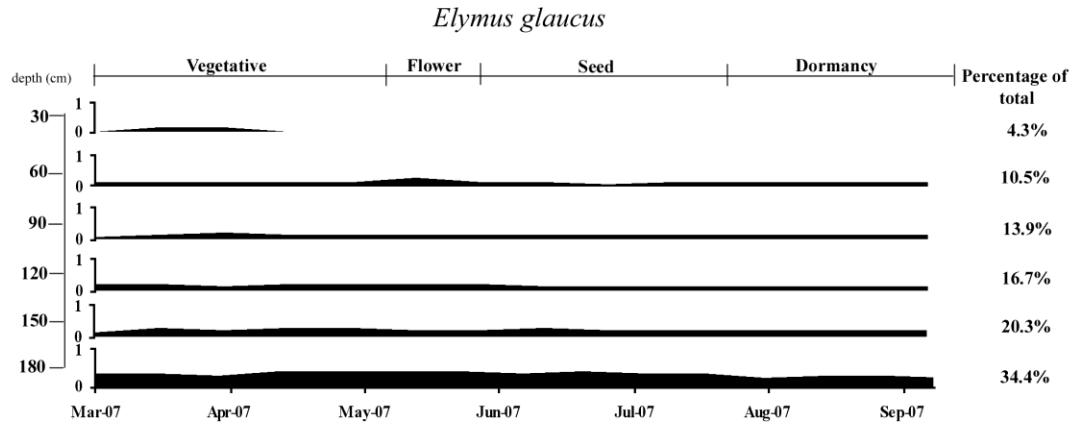


Next year under drought, YST produced 72% fewer roots compared to previous year

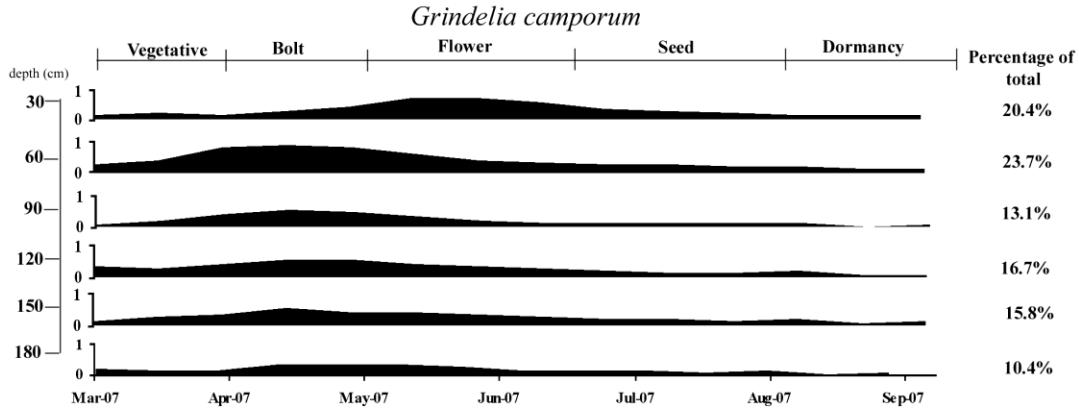
Under drought, *Elymus* produced 50% fewer roots compared to previous year



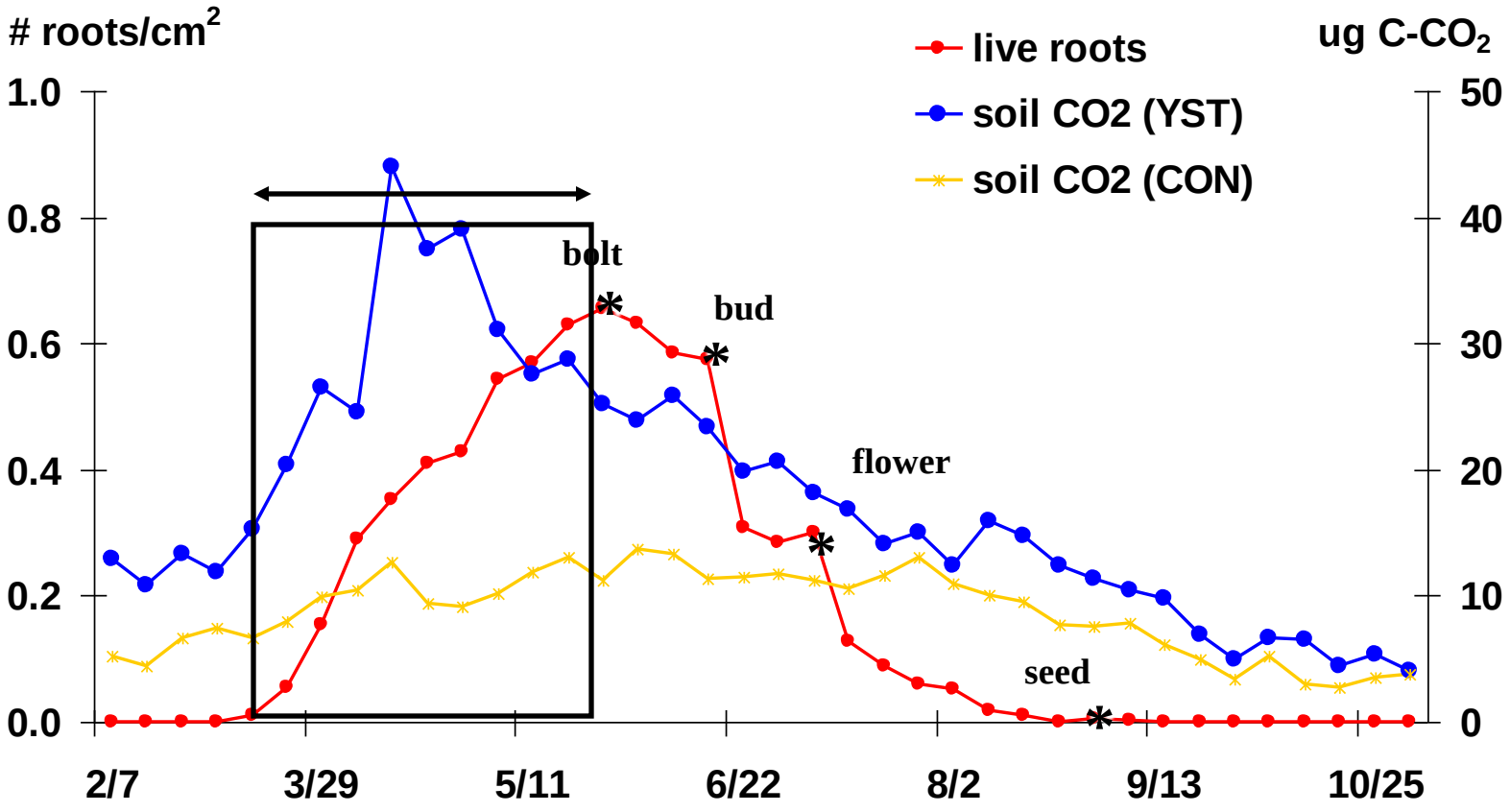
Roots primarily in upper profile



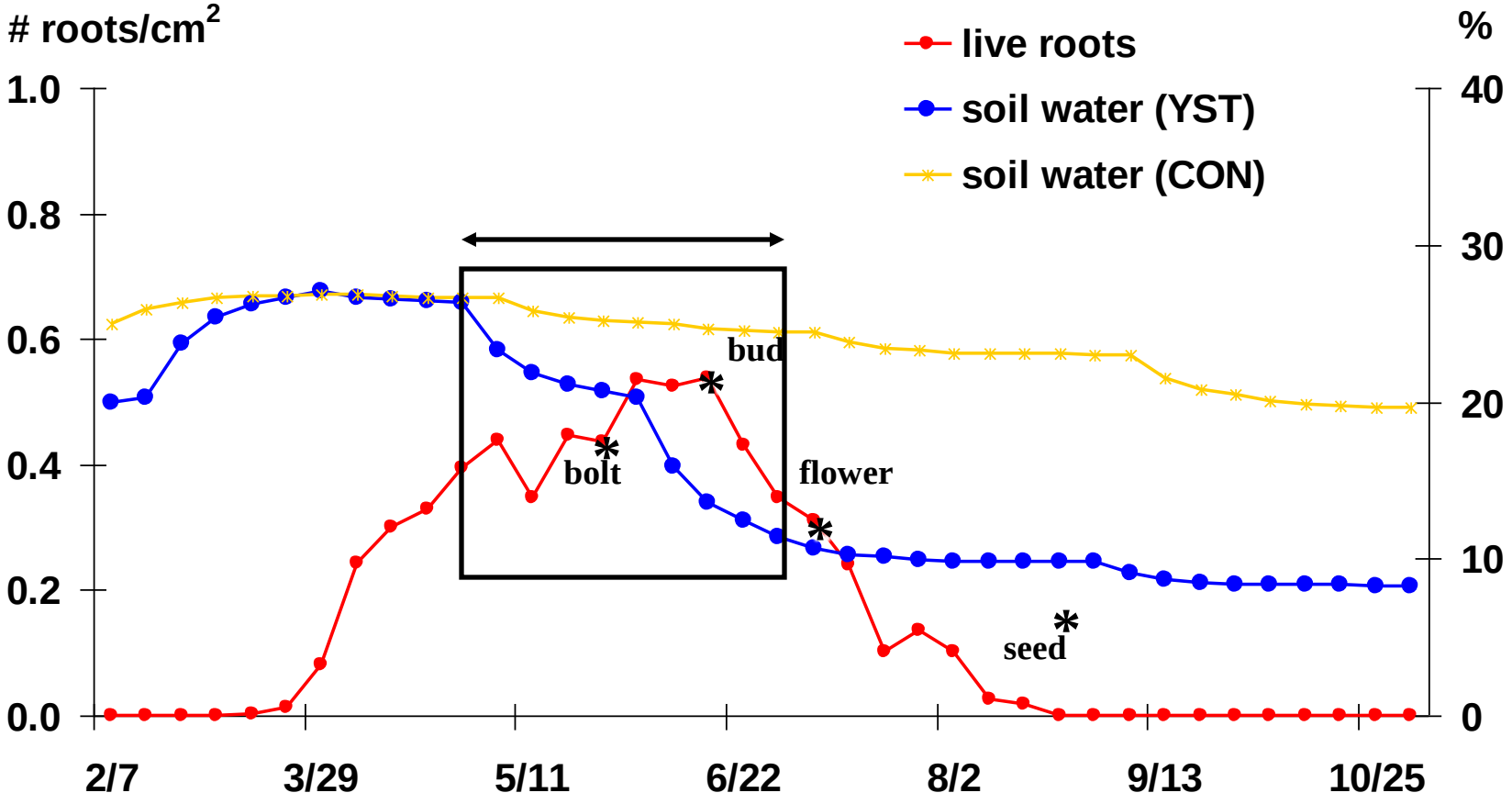
Roots primarily in lower profile



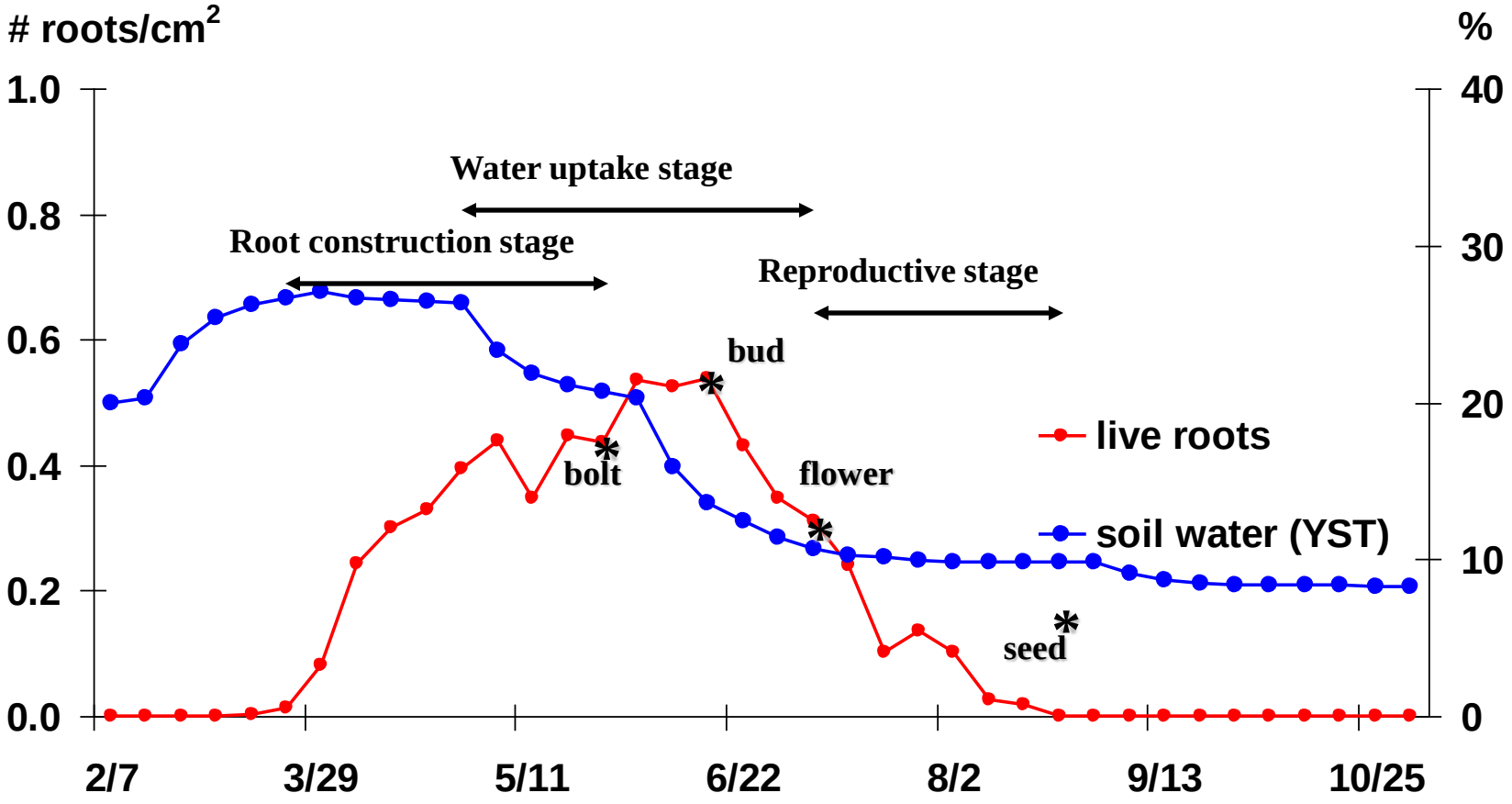
YST [CO_2] at 120 cm



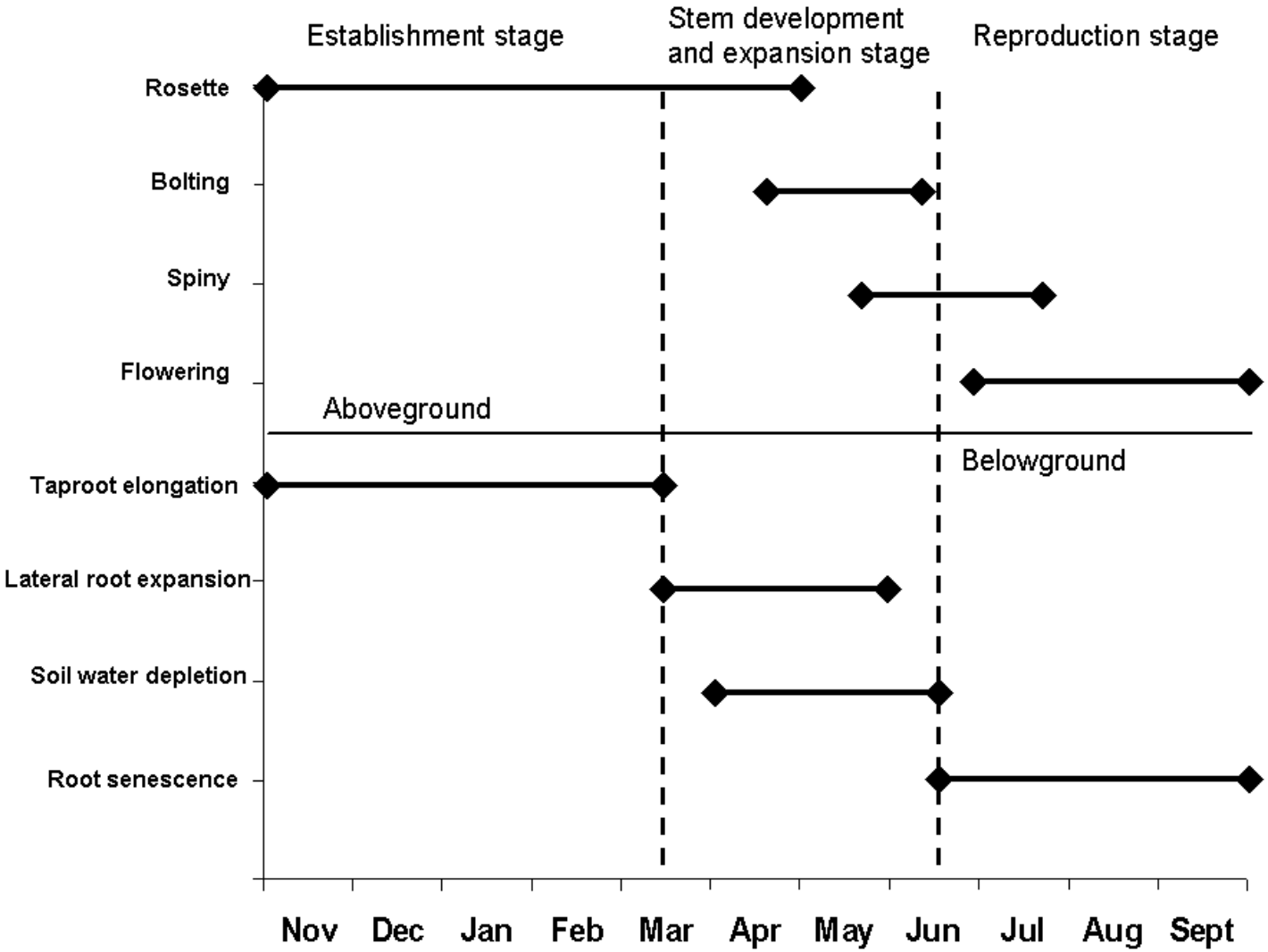
YST soil water use at 180 cm



Overall


roots/cm2
%
1.0
0.8
0.6
0.4
0.2
0.0
40
30
20
10
0
Water uptake stage
Root construction stage
Reproductive stage
bud
bolt
flower
seed
live roots
soil water (YST)
2/7
3/29
5/11
6/22
8/2
9/13
10/25

Three distinct stages of development in the life cycle of YST



Conclusions

- Years with little to no deep soil moisture recharge, roots remain in the shallow regions of the soil typically occupied by annual grasses, thereby intensifying competitive interactions.
  - YST would be functionally similar to annual grasses in drought years (also competes with perennials)
  - In normal or wet years would be functionally similar to deep-rooted perennial species, such as *E. glaucus*.
- *G. camporum* is an early-succession species and a good colonizer in newly restored or disturbed plant communities, but is not tolerant to further disturbance or competition with other grassland species in California.

Significance

- Control of yellow starthistle is most efficient a couple of weeks before plants reach bolting stage
  - No impact to water use
  - Greatest benefit to desirable competing species
- Biomass and reproductive output of plants already determined by the beginning of the flower stage
  - Can explain the efficacy of burning and mowing during the early flowering stages
  - Little opportunity for plants to recover after soil moisture content has been maximally reduced

Dittrichia graveolens (stinkwort)

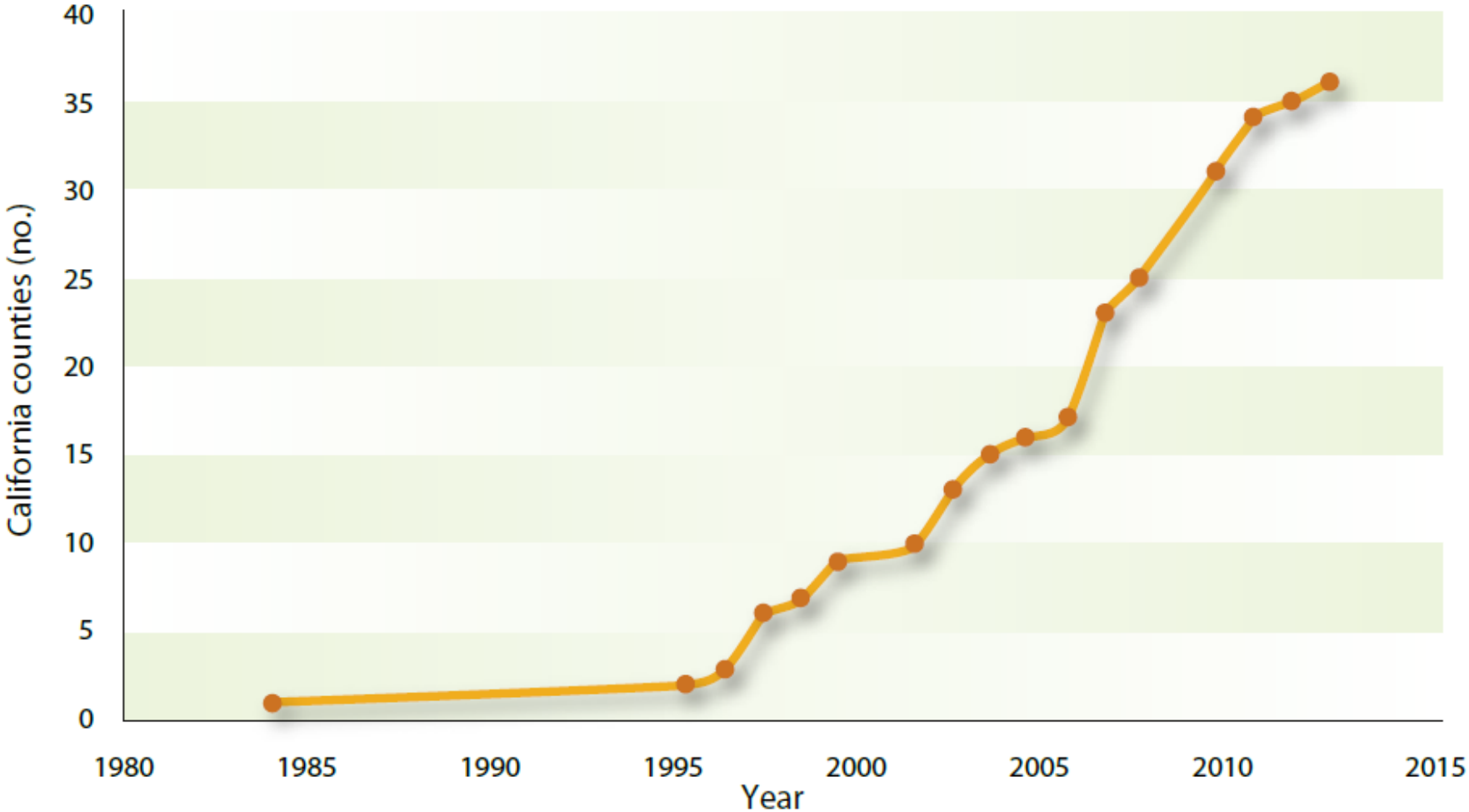


Fig. 1. Approximate rate of spread of *Dittrichia graveolens* in California as represented by the number of California counties where plant collections have been made between 1984 and 2012 (Consortium of California Herbaria 2012).

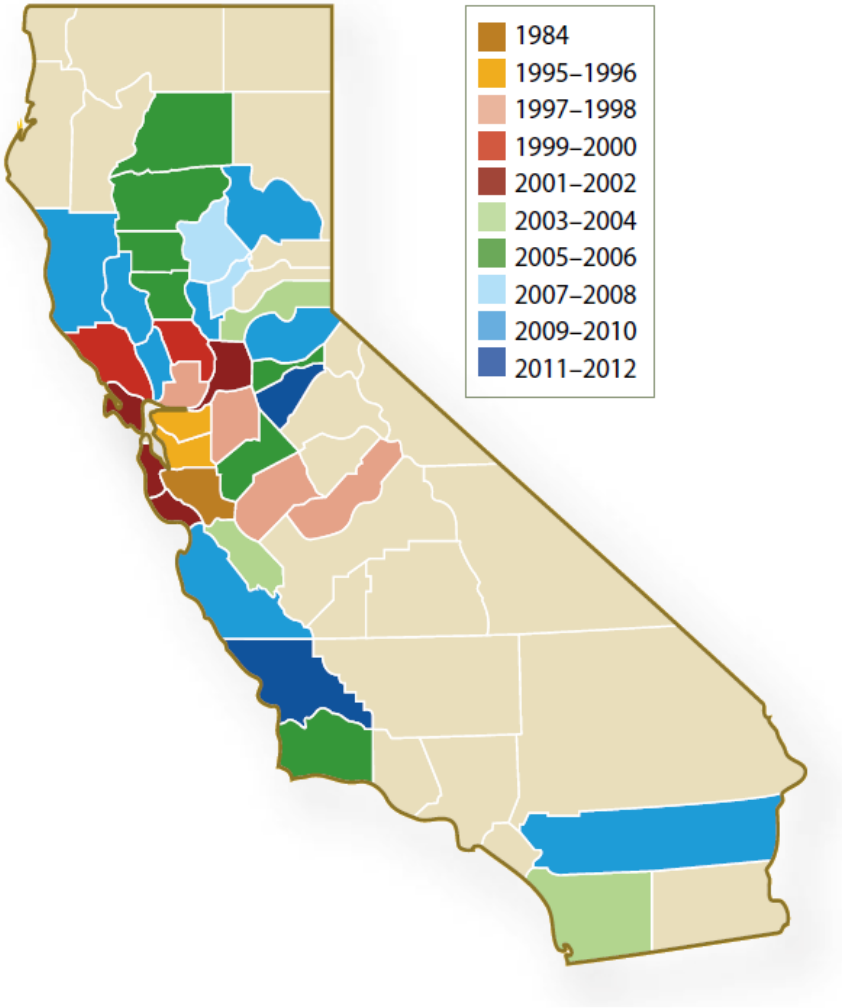


Fig. 2. Chronological spread of stinkwort in California counties from 1984 to 2012.

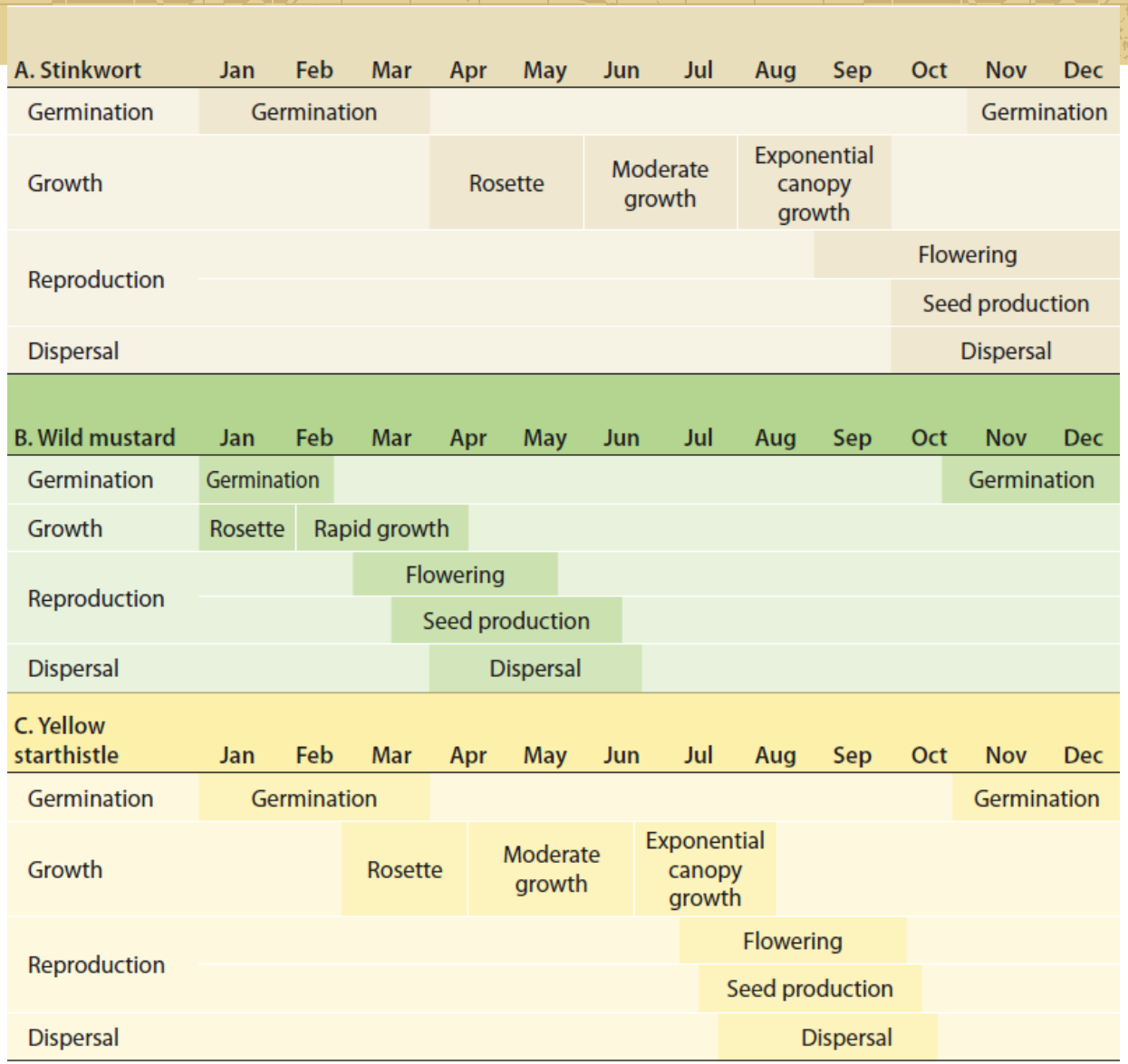
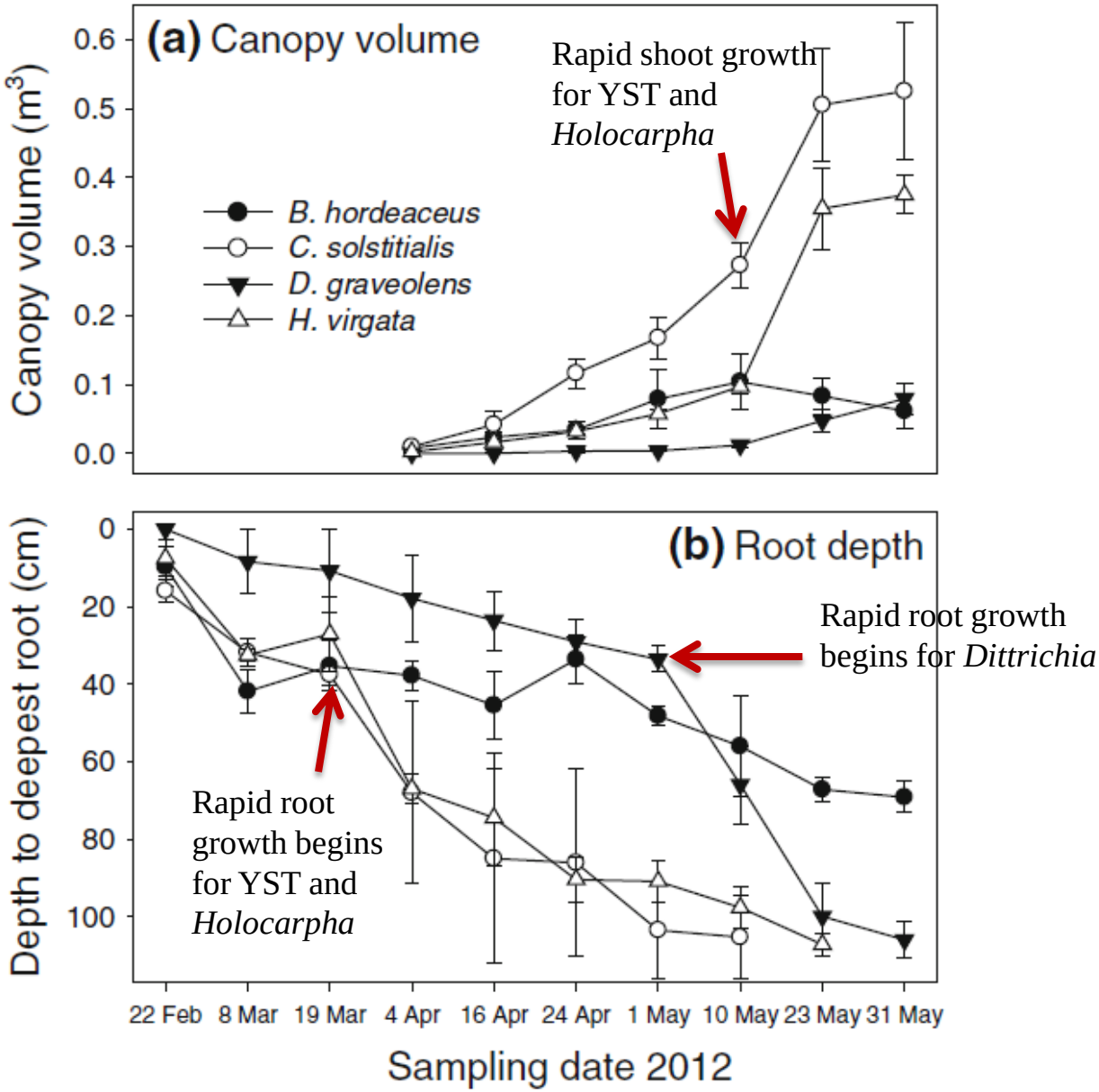


Fig. 3. Life cycle of (A) stinkwort (*Dittrichia graveolens*), a late-season winter annual, compared to the life cycles of (B) wild mustard (*Sinapis arvensis* L.), a typical early-season winter annual, and (C) yellow starthistle (*Centaurea solstitialis* L.), a typical late-season winter annual.


(a) Canopy volume
Canopy volume (m3)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
B. hordeaceus
C. solstitialis
D. graveolens
H. virgata
Rapid shoot growth for YST and Holocarpha
(b) Root depth
Depth to deepest root (cm)
0
20
40
60
80
100
Rapid root growth begins for Dittrichia
Rapid root growth begins for YST and Holocarpha
22 Feb
8 Mar
19 Mar
4 Apr
16 Apr
24 Apr
1 May
10 May
23 May
31 May
Sampling date 2012

Control options

- Mechanical
  - Handpulling, hoeing, weed whips
  - Tillage
  - Mowing
- Biological
- Cultural
  - Grazing
  - Prescribed burning
- Chemical
- Integrated approaches
  - Burning and chemical
  - Revegetation

Harrow

Disk

Mowing

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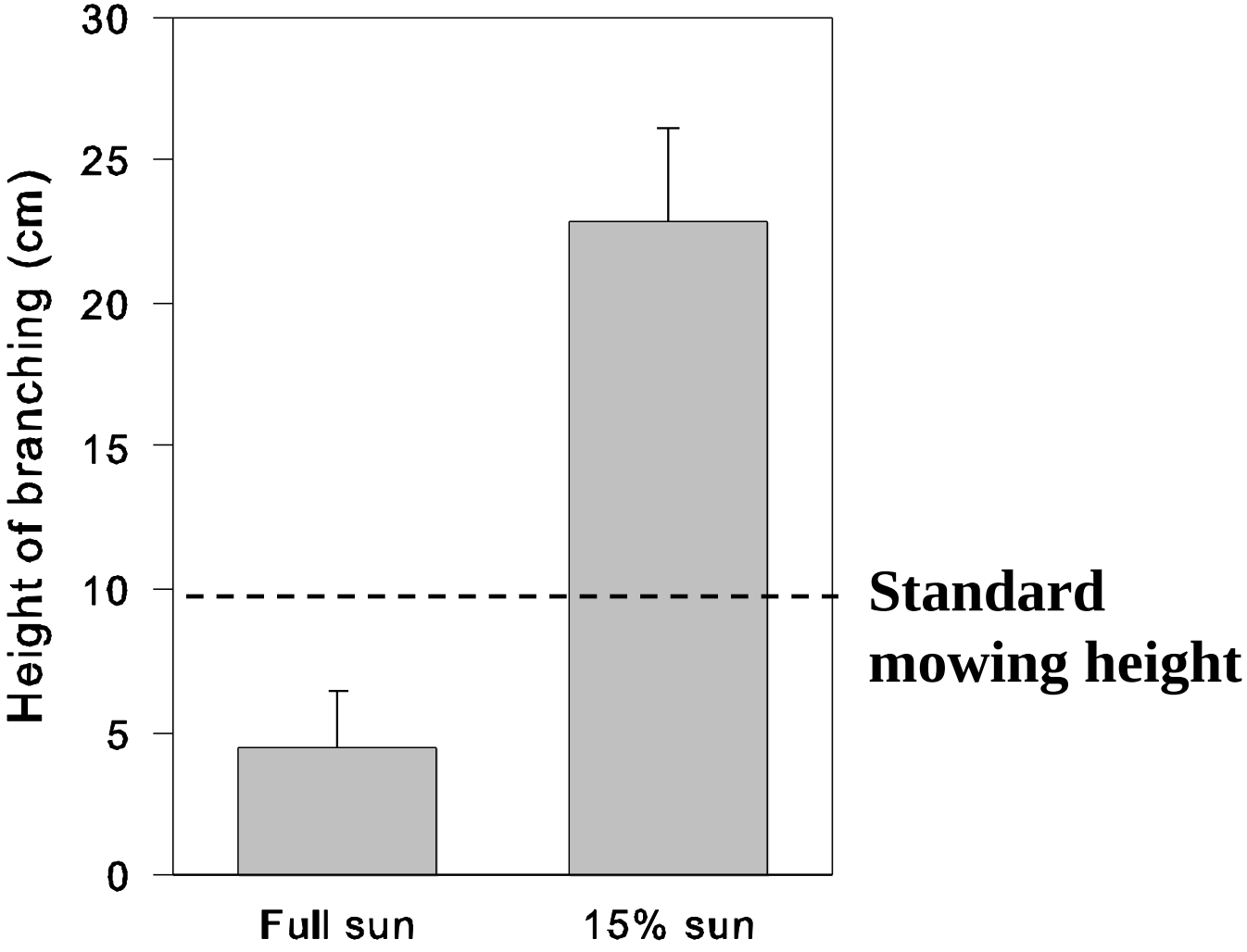
Photo by Joe DiTomaso

Rotary mower

Flail mower

Growth form of YST affects mowing success

Yellow starthistle rosette height under shadecloth and in full sun (ca. 100 days after germination)



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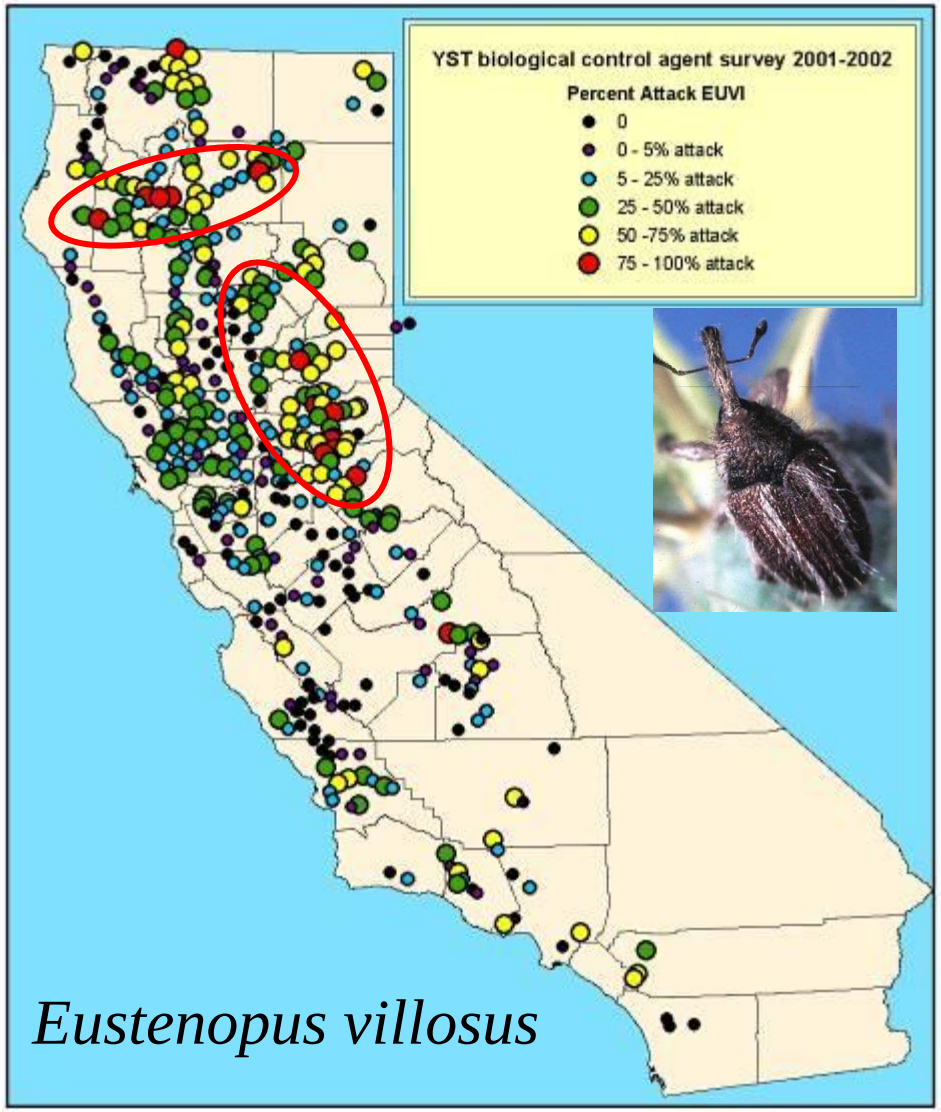
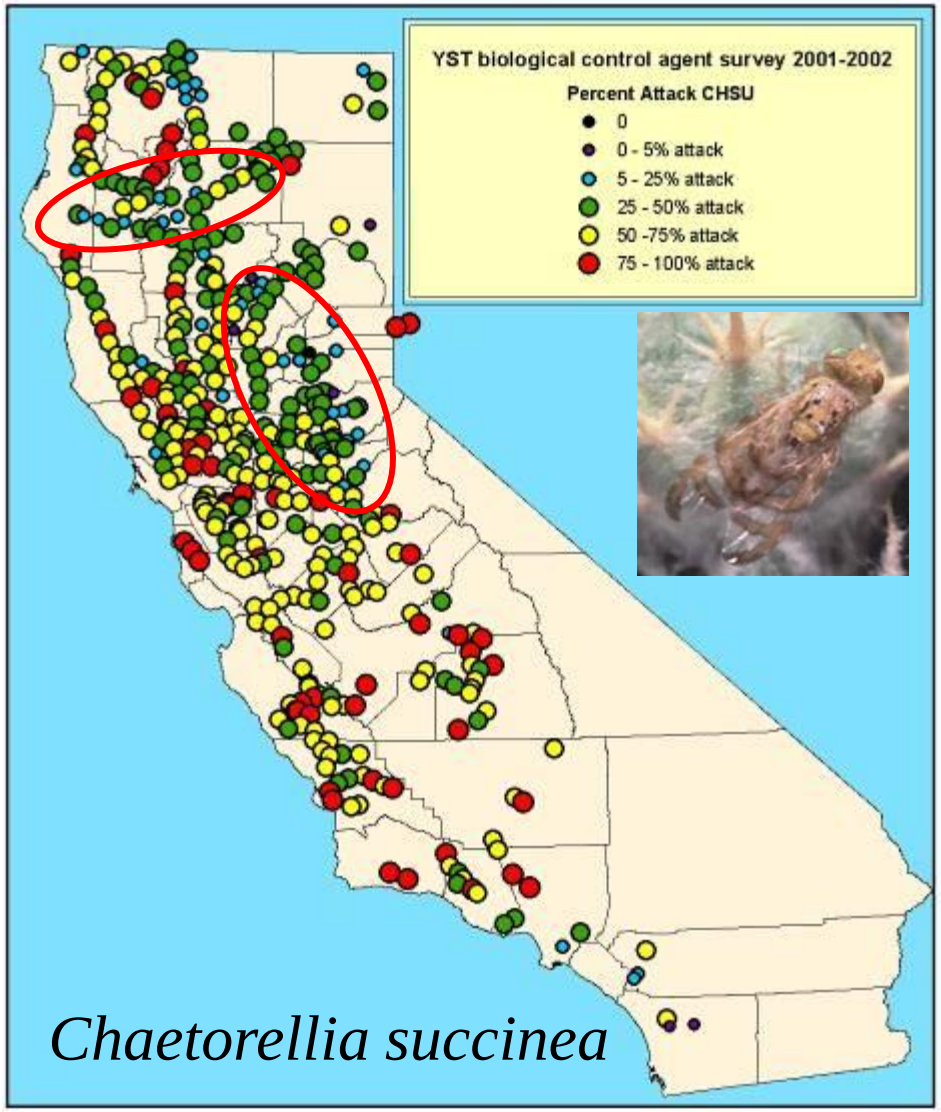
Hairy weevil
Eustenopus villosus

False Peacock Fly
Chaetorellia succinea

Biocontrol distribution and attack rates in California



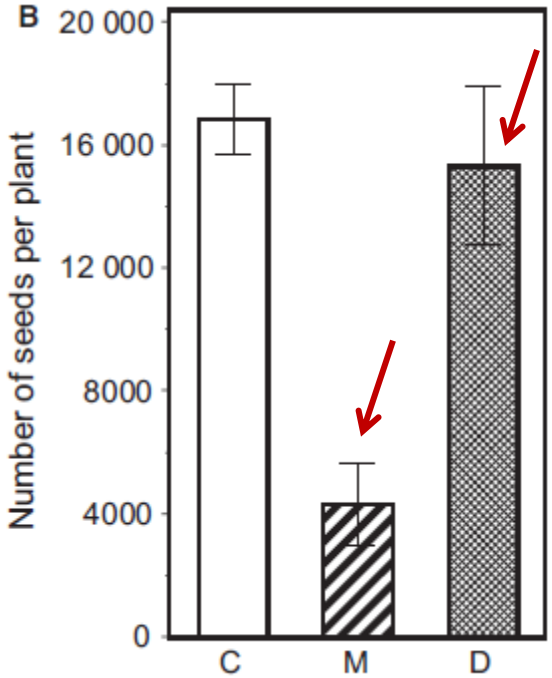


Effect of insect bioagents on YST

Percentage of Heads			
Insect spp.	Cause of damage	Early season	Mid-season
		N=229	N=231
Eustenopus villosus	Feeding/ovipos. Larvae	72 17	9 3
Chaetorellia succinea	Larvae	26	41

Yellow starthistle biomass with simulated biocontrol or mowing

Treatment	Shoot wt (g)	Developed capitulum wt (g)	Undeveloped capitulum wt (g)	Total aboveground wt (g)
Untreated	384.3 ± 15.9 a	130.1 ± 30.1 a	1.05 ± 0.2 a	515.4 ± 15.9 a
Bud damage	390.4 ± 59.3 a	91.6 ± 22.5 ab	5.5 ± 0.9 b	487.4 ± 78.9 a
Mowed	108.9 ± 16.1 b	38.6 ± 9.7 b	0.65 ± 0.2 a	148.1 ± 25.3 b
$P > F$	0.001	0.04	0.008	0.0019



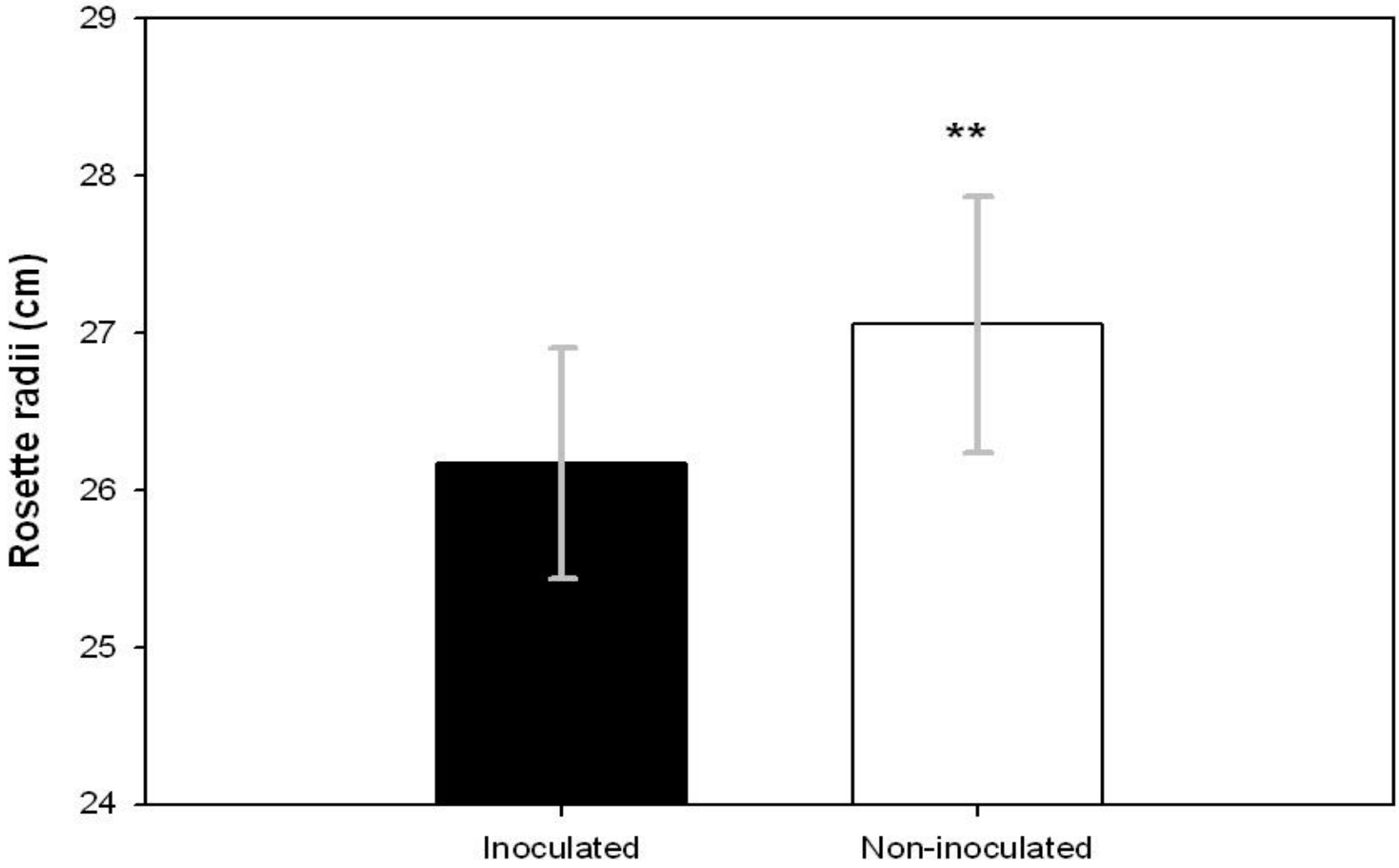
Number of seeds per plant with controls (C), mowed (M), and simulated biocontrol (D)

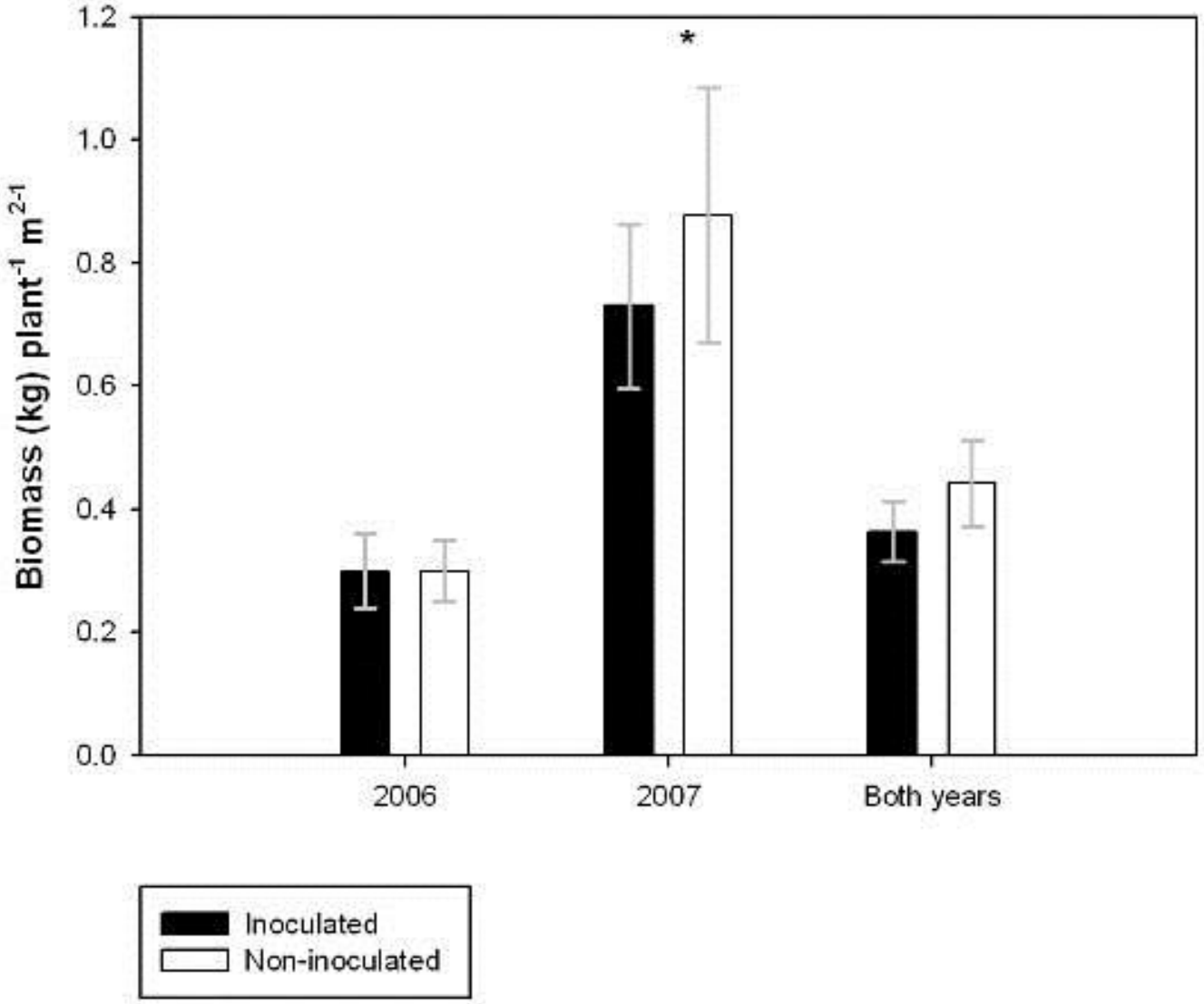
Rust Fungus

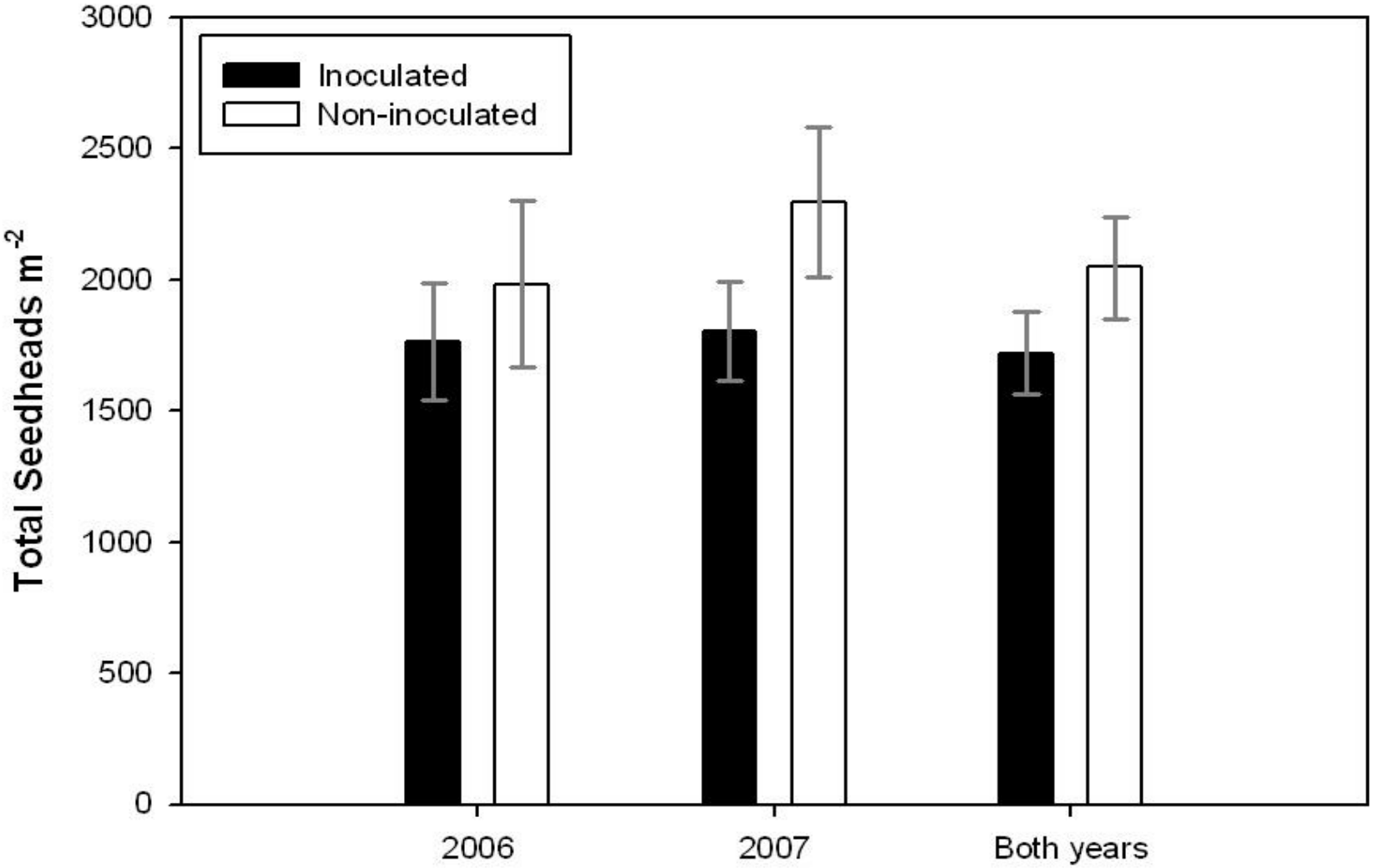
- *Puccinia jaceae* var. *solstitialis*
- Found in Turkey; Approved for released by CDFA in 2003
- Attacks vegetative part of plant

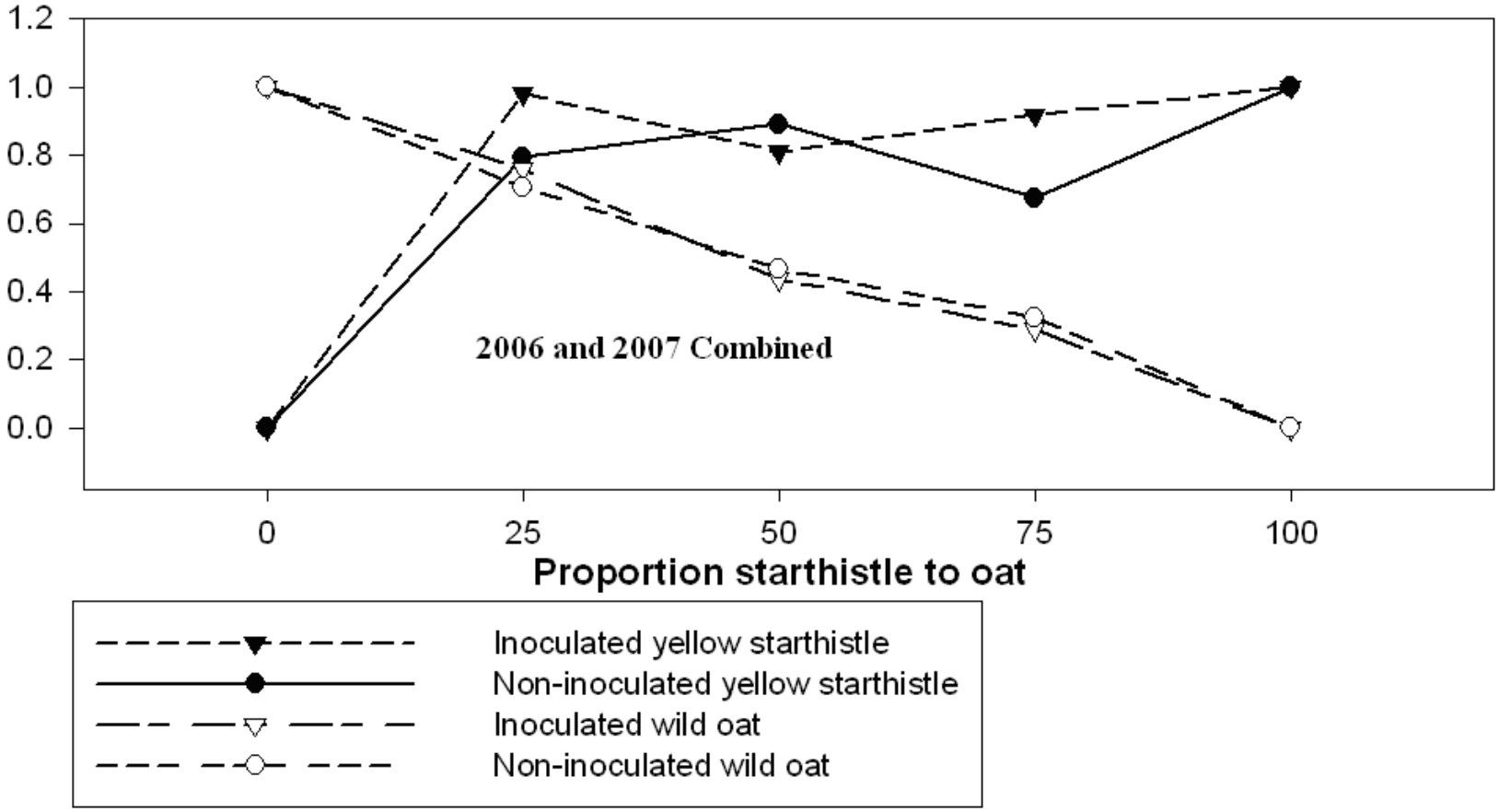
Lee

Field Site


29
28
27
26
25
24
Rosette radii (cm)
**
Inoculated
Non-inoculated


1.2
1.0
0.8
0.6
0.4
0.2
0.0
Biomass (kg) plant-1 m2-1
*
2006
2007
Both years
Inoculated
Non-inoculated


Inoculated
Non-inoculated
Total Seedheads m-2
3000
2500
2000
1500
1000
500
0
2006
2007
Both years


1.2
1.0
0.8
0.6
0.4
0.2
0.0
2006 and 2007 Combined
0
25
50
75
100
Proportion starthistle to oat
Inoculated yellow starthistle
Non-inoculated yellow starthistle
Inoculated wild oat
Non-inoculated wild oat

Grazing

Table 1. Comparison of grazing characteristics of cattle, sheep and goats (Frost and Launchbaugh 2003)

Animal	Digestive systems	Feeding behavior	Classification
Cattle	Large rumens adapted to ferment fibrous material	Best for managing fibrous herbaceous vegetation, prefer grasses but will also graze yellow starthistle at the bolting stage	Grass and roughage eaters
Sheep	Large rumen adapted to ferment fibrous material	Can selectively graze and tolerate high fiber content, diet dominated by forbs, will control yellow starthistle when grazed at bolting stage, but not in rosette stage	Forb and roughage eaters, more easily managed by human herders, used for strategic grazing
Goats	Large liver mass that allows processing of secondary compounds less digestible or more toxic to other grazers	Mouths designed to strip leaves from woody plants and chew branches, will also feed on yellow starthistle in the spiny stage	Browsers used often to control woody species

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Prescribed burning

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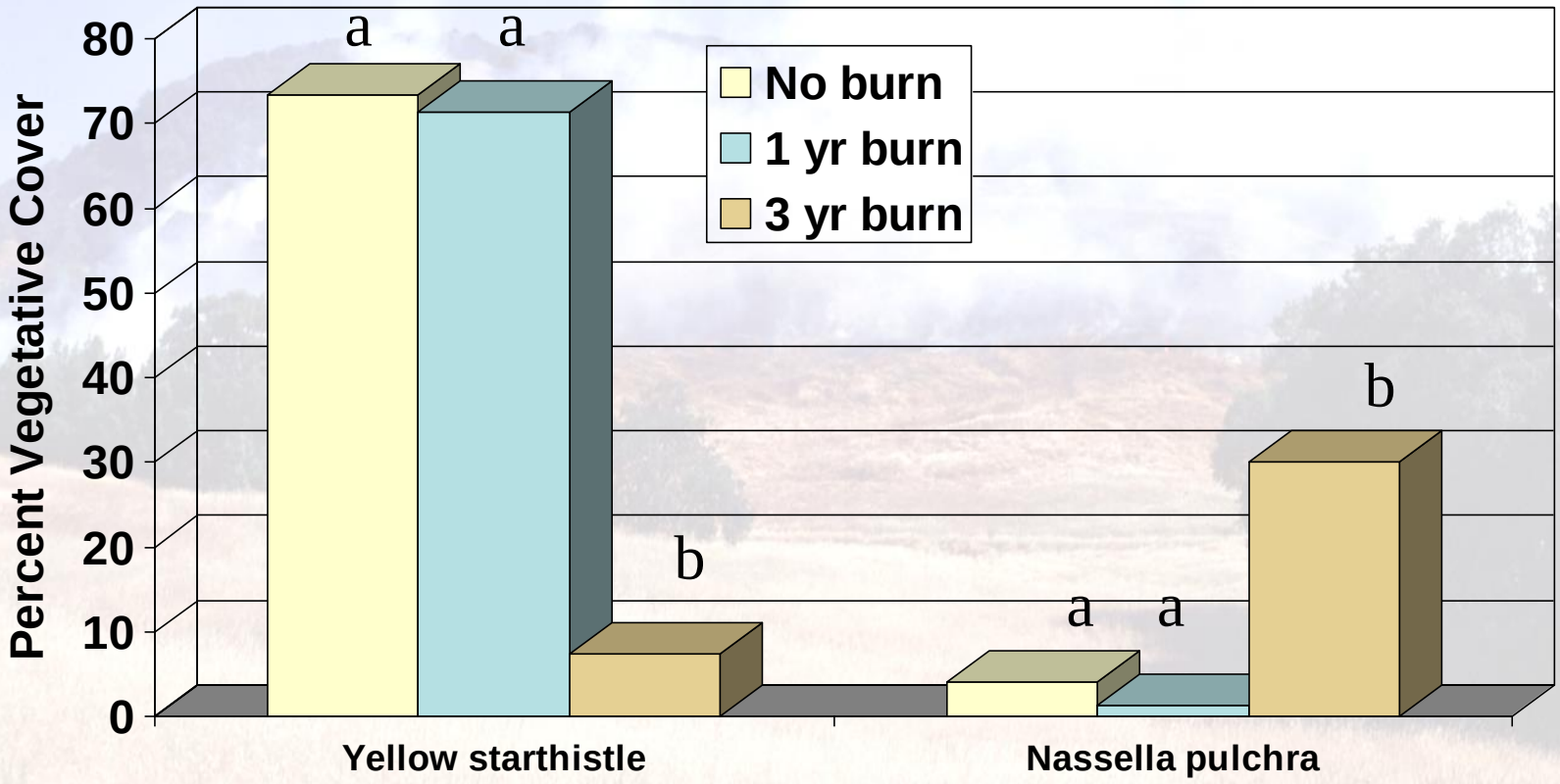
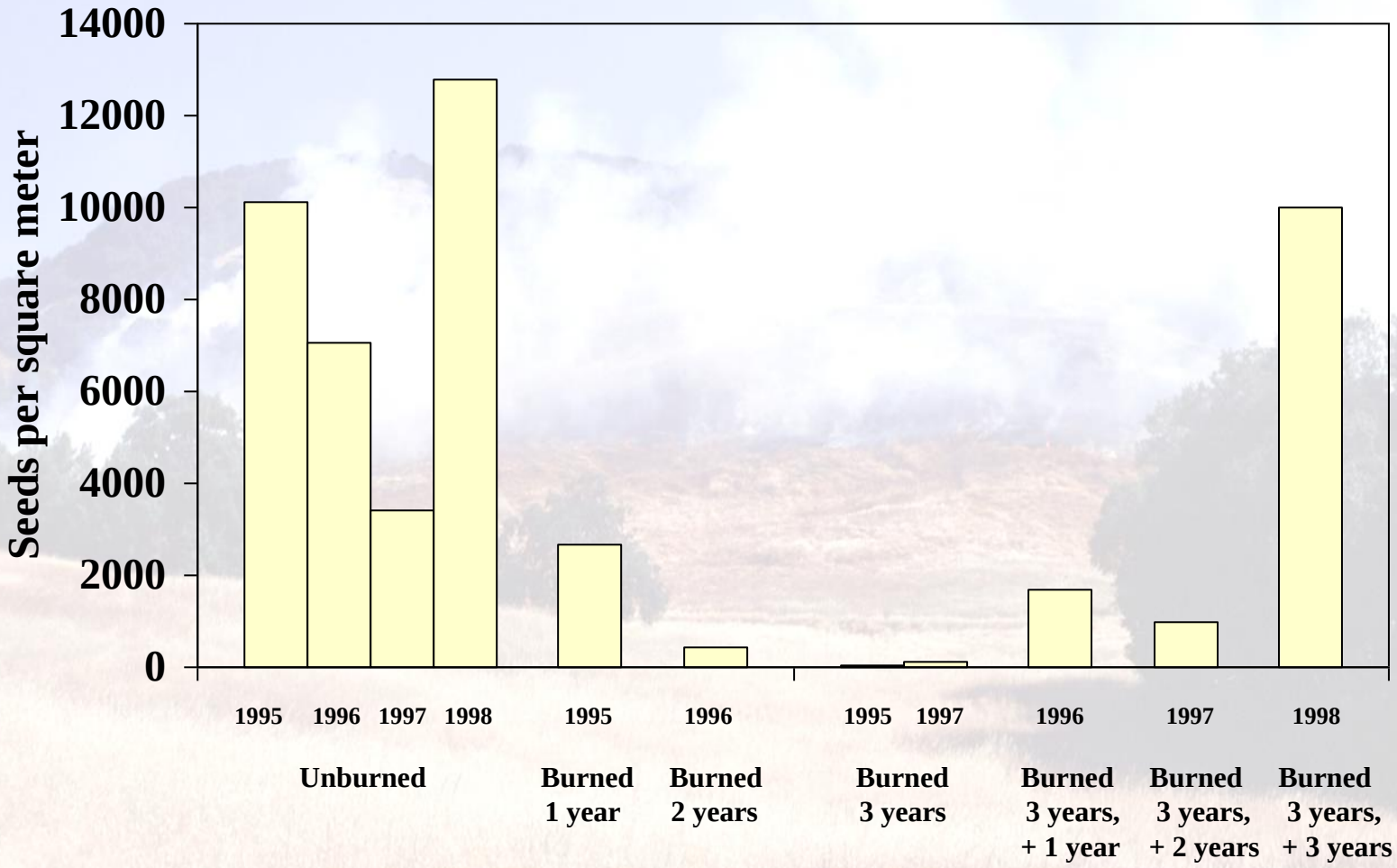
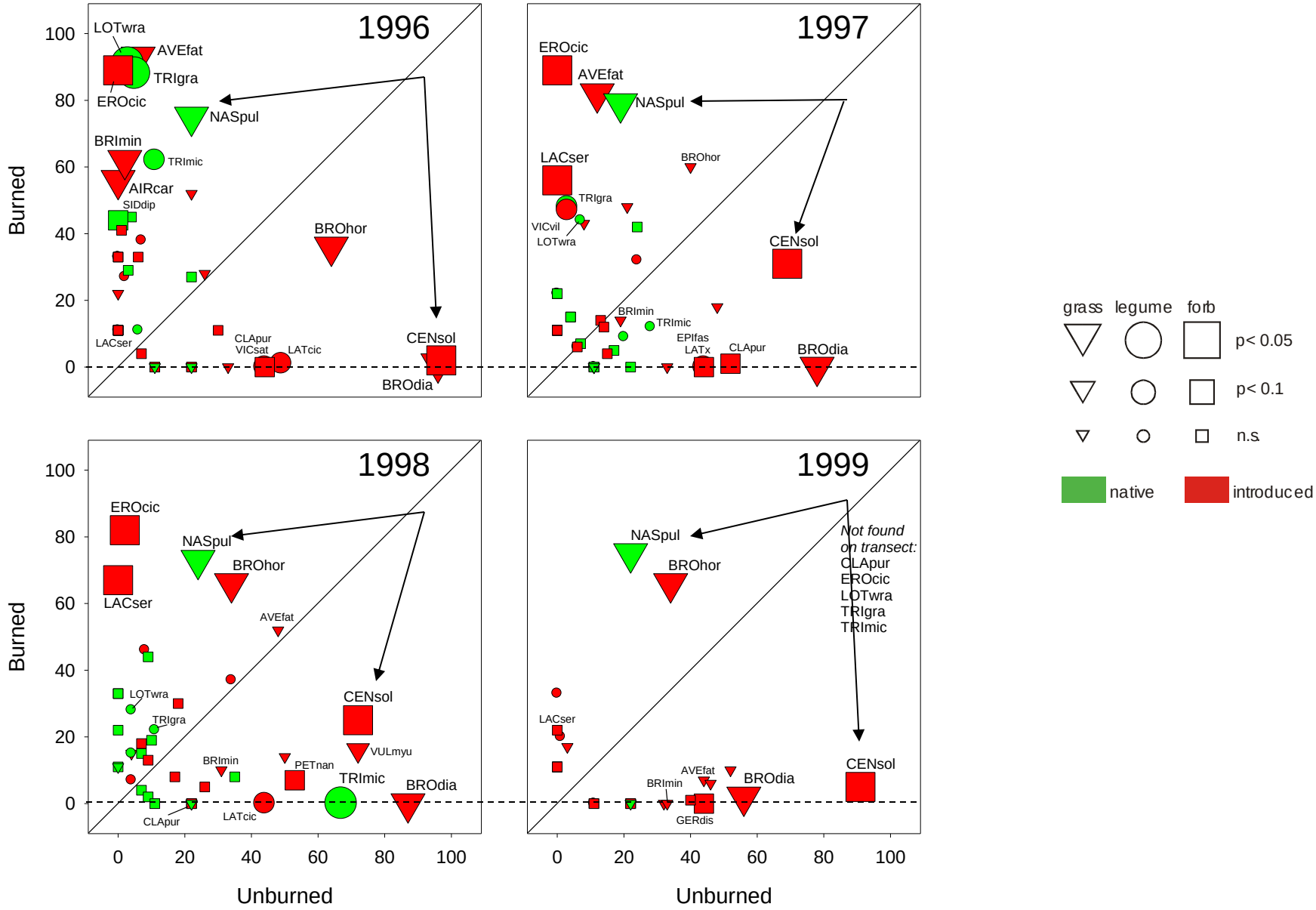
Vegetative cover in July



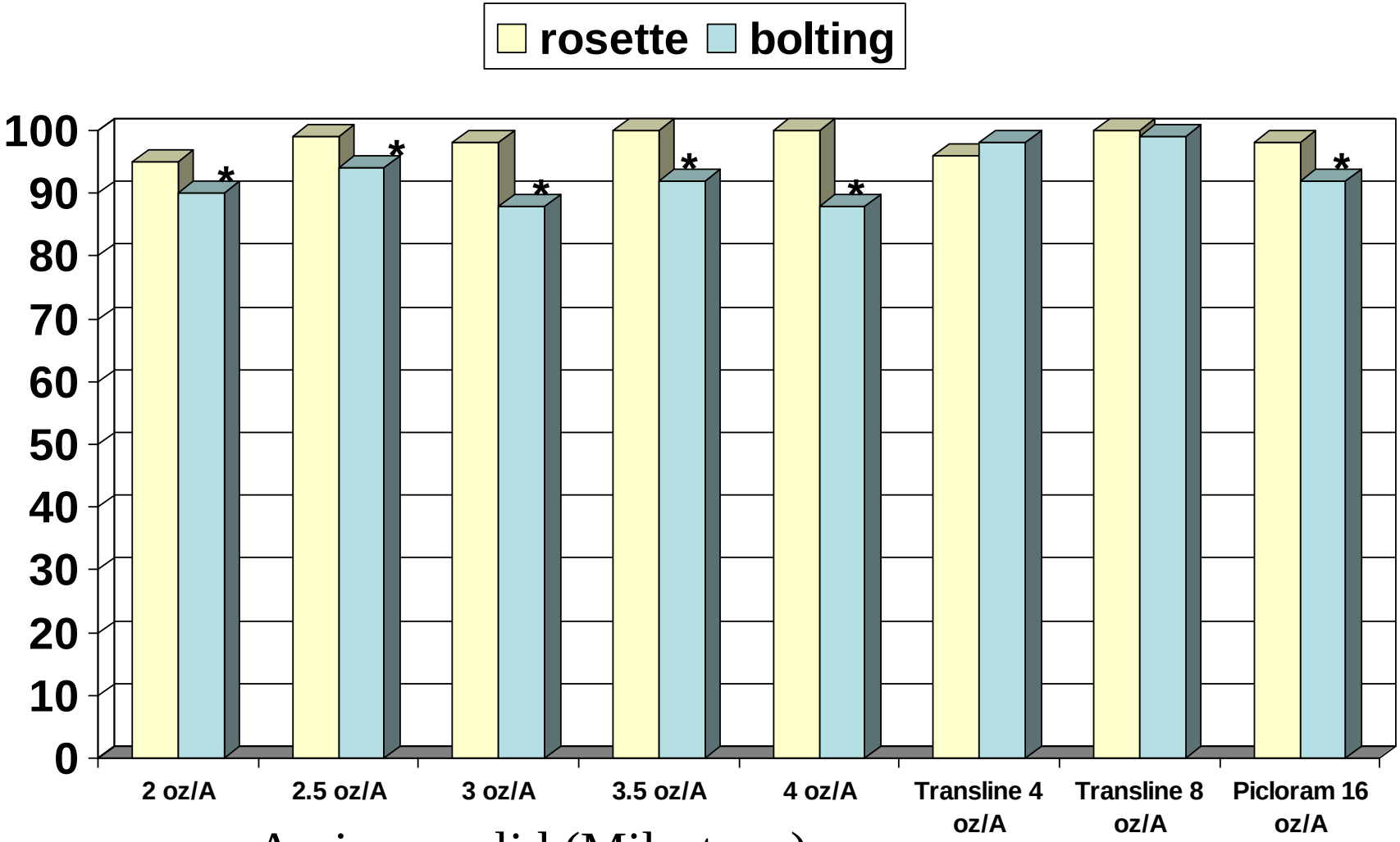
Yellow starthistle seedbank recovery




1996
1997
1998
1999
Burned
Unburned
LOTwra
AVEfat
TRIgra
EROcic
NASpul
BRImin
TRImic
AIRcar
SIDdip
BROhor
LACser
CLApur
VICsat
LATcic
CENsol
BRODia
VICvil
LOTwra
BRImin
TRImic
EPIfas
LATx
CLApur
VULmyu
PETnan
GERdis
Not found on transect:
CLApur
EROcic
LOTwra
TRIgra
TRImic
grass
legume
forb
p< 0.05
p< 0.1
n.s.
native
introduced

Herbicide control

Herbicides on YST control

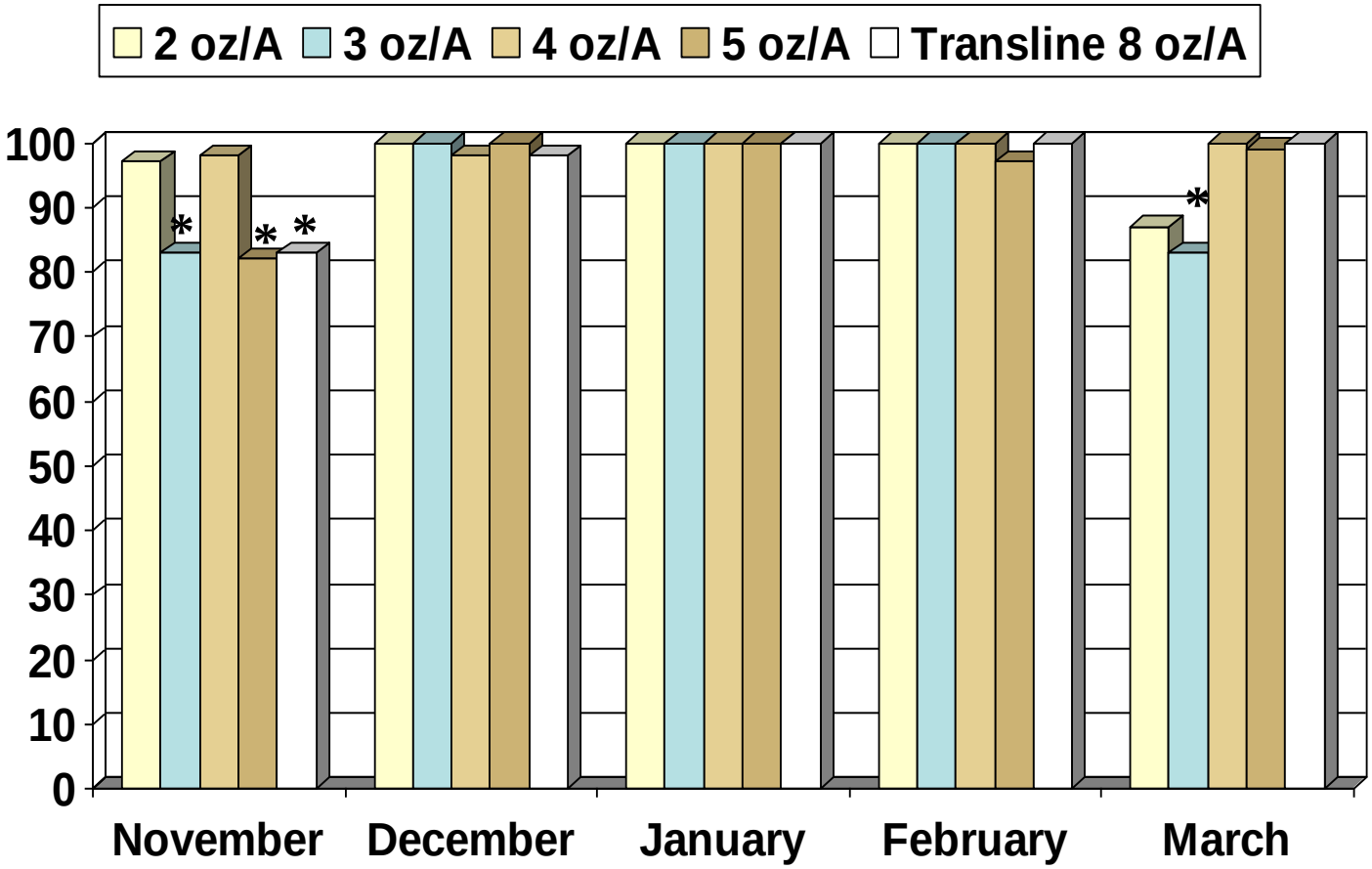


Aminopyralid (Milestone)

*** LSD (P=0.05)**

Transline (clopyralid) treated rangeland on right

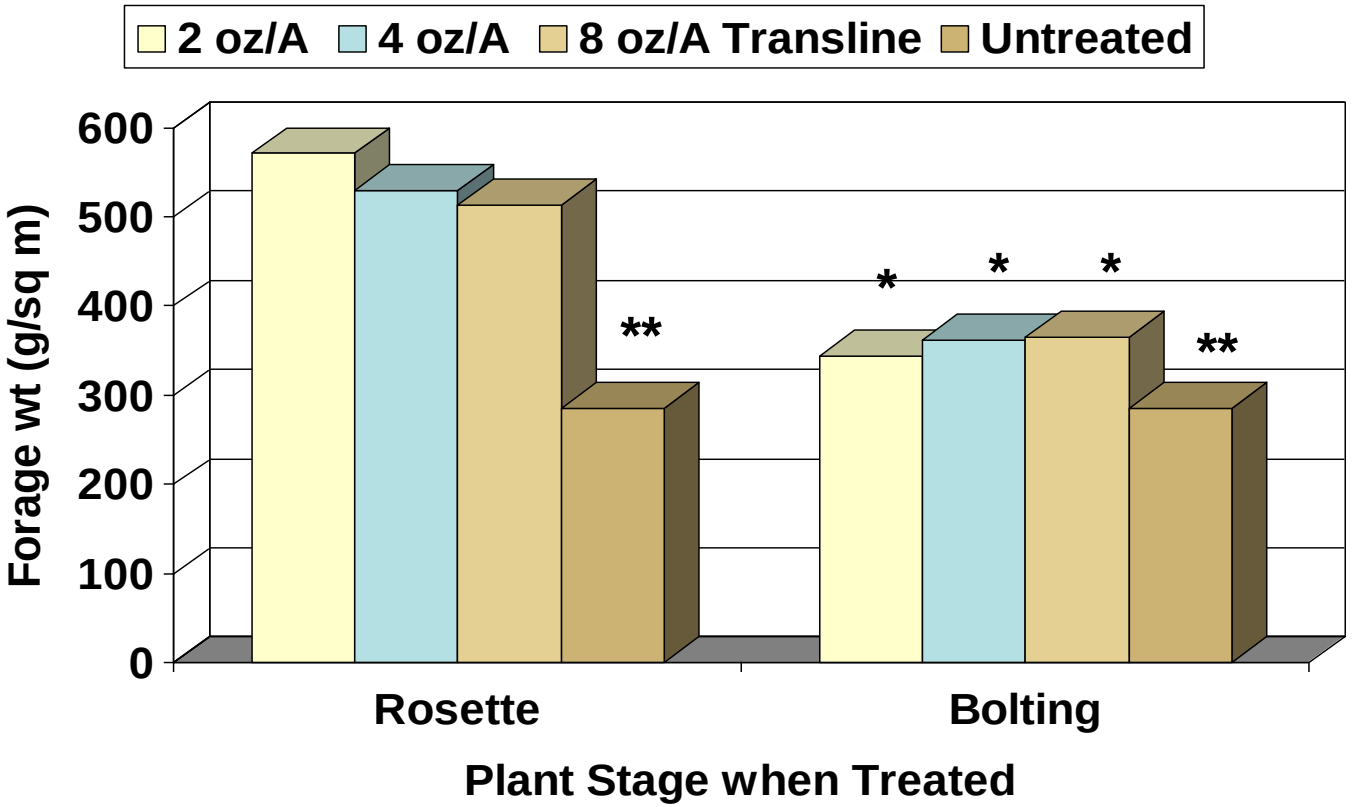
Milestone and Transline on yellow starthistle control



Stage of growth at treatment stage

Aminopyralid 3 oz/A
Untreated

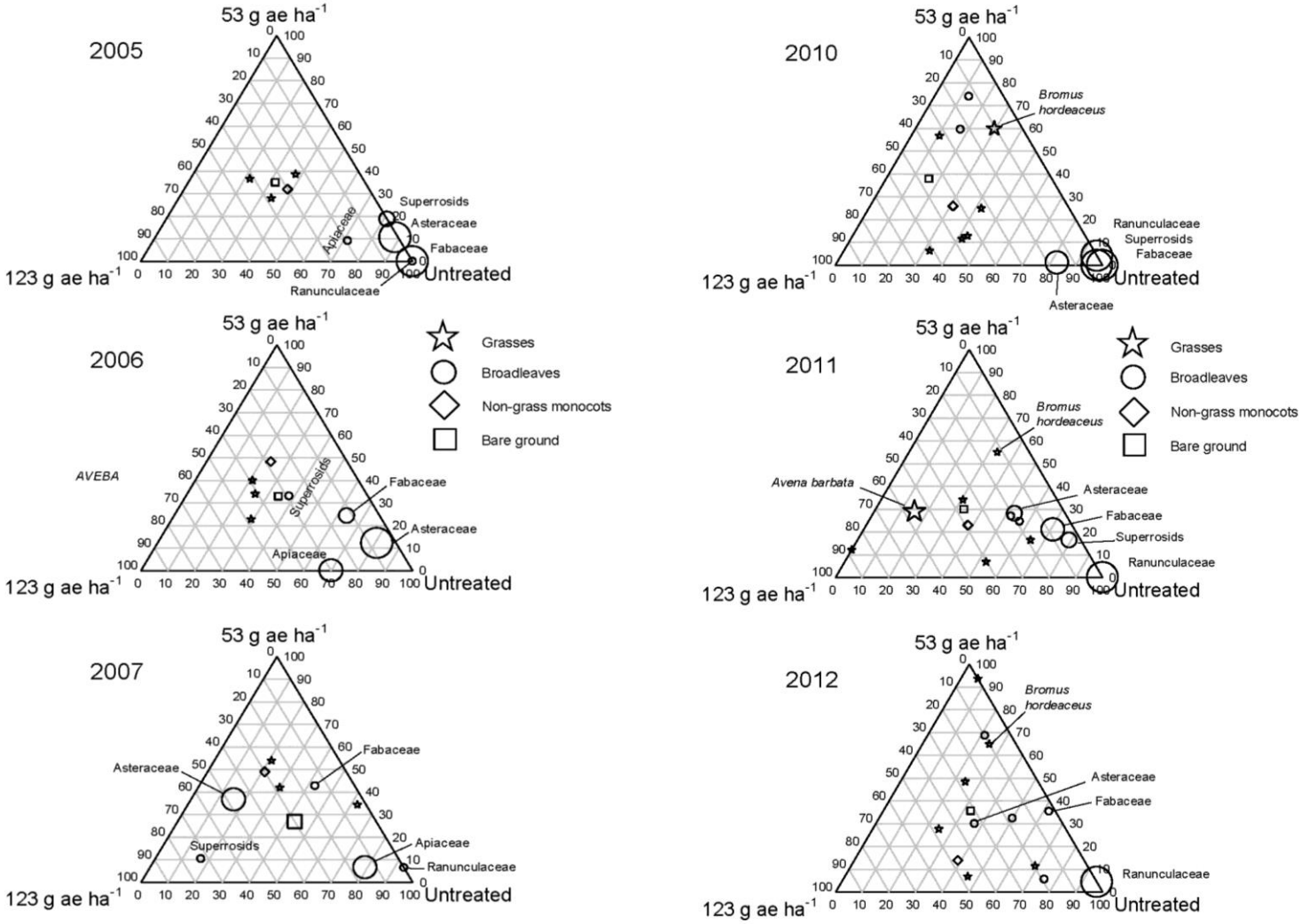
Aminopyralid and clopyralid on grass forage following year

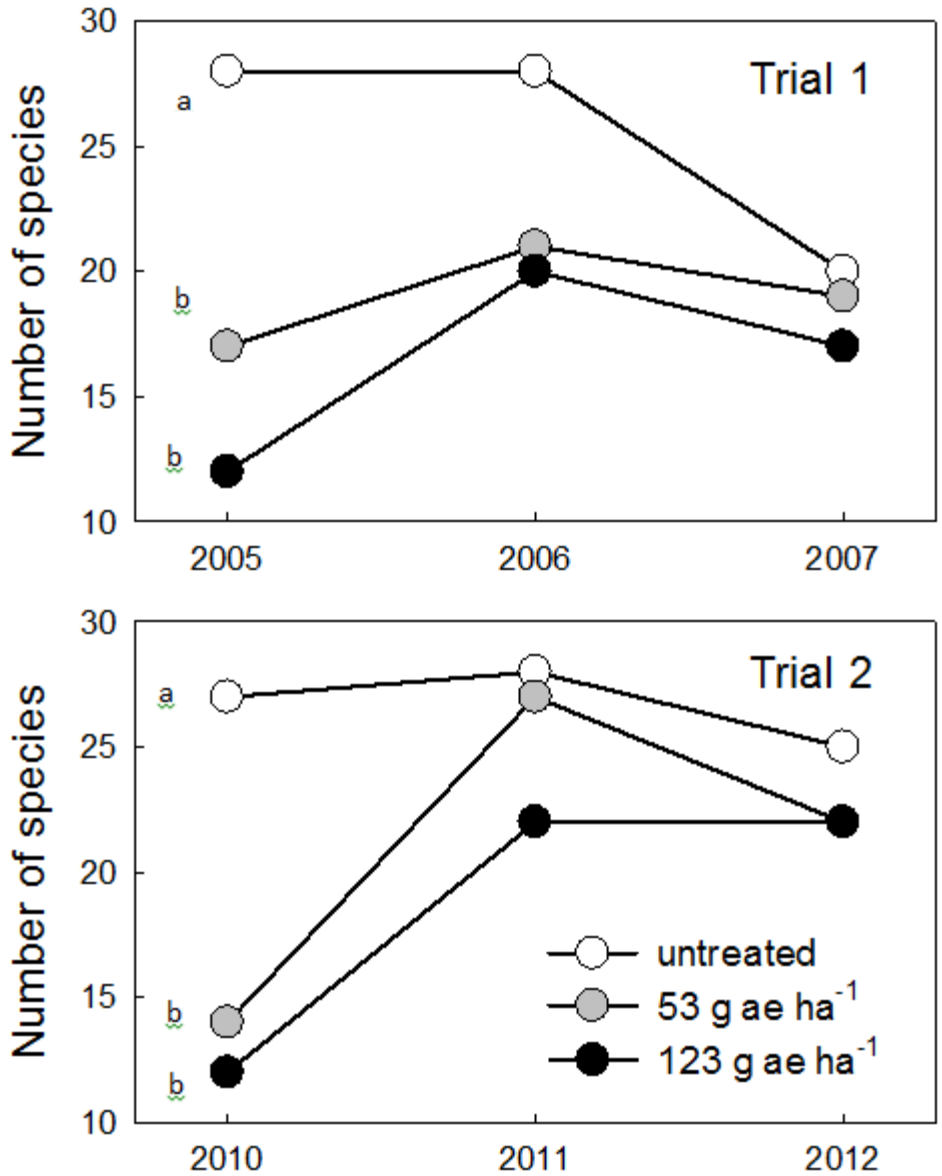


*LSD (P=0.05)
**LSD (P=0.01)

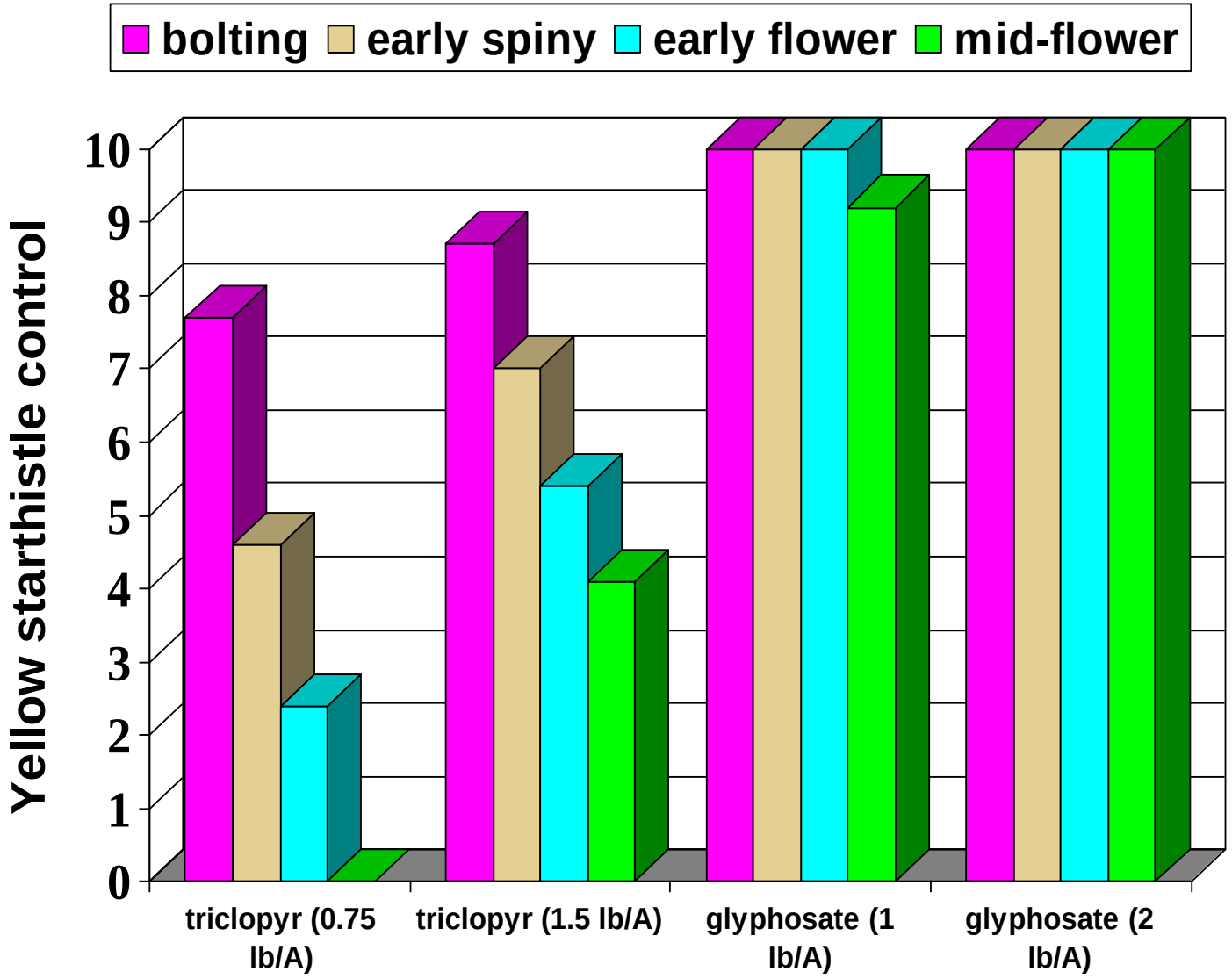
Yellow starthistle control

		Rate		Control 60 DAT	
Treatment	Timing	oz ai/A	product/A	YST	Filaree
aminocyclopyrachlor	rosette	0.5	0.625 oz	67 c	27 bc
aminocyclopyrachlor	rosette	1	1.25 oz	90 b	27 abc
aminocyclopyrachlor	rosette	1.5	1.875 oz	100 a	53 ab
aminocyclopyrachlor	rosette	2	2.5 oz	100 a	47 ab
aminocyclopyrachlor	rosette	2.5	3.125 oz	100 a	57 ab
aminocyclopyrachlor	rosette	3	3.75 oz	100 a	73 a
aminopyralid	rosette	0.75	3 fl oz	100 a	60 ab
aminopyralid	rosette	1.25	5 fl oz	100 a	33 abc
untreated	rosette	- - -	- - -	0 d	0 c


2005
53 g ae ha-1
123 g ae ha-1
Untreated
Superrosids
Asteraceae
Fabaceae
Apiaceae
Ranunculaceae
2006
53 g ae ha-1
123 g ae ha-1
Untreated
AVEBA
Superrosids
Fabaceae
Asteraceae
Apiaceae
Grasses
Broadleaves
Non-grass monocots
Bare ground
2007
53 g ae ha-1
123 g ae ha-1
Untreated
Asteraceae
Fabaceae
Superrosids
Apiaceae
Ranunculaceae
2010
53 g ae ha-1
123 g ae ha-1
Untreated
Bromus hordeaceus
Ranunculaceae
Superrosids
Fabaceae
Asteraceae
2011
53 g ae ha-1
123 g ae ha-1
Untreated
Bromus hordeaceus
Avena barbata
Asteraceae
Fabaceae
Superrosids
Ranunculaceae
Grasses
Broadleaves
Non-grass monocots
Bare ground
2012
53 g ae ha-1
123 g ae ha-1
Untreated
Bromus hordeaceus
Asteraceae
Fabaceae
Ranunculaceae


Trial 1
Number of species
30
25
20
15
10
a
b
b
2005
2006
2007
Trial 2
Number of species
30
25
20
15
10
a
b
b
2010
2011
2012
untreated
53 g ae ha-1
123 g ae ha-1

Late season control of YST



Selective way of using a non-selective herbicide

Rope wick application of Roundup (glyphosate)

ATV or tractor attachment with rope wick applicator

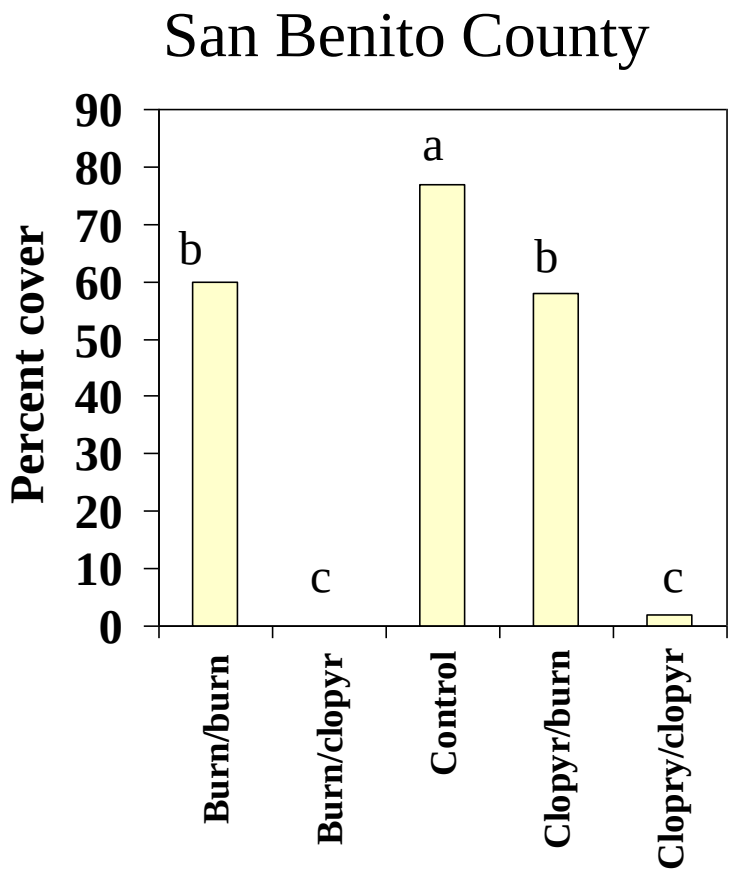
Treated with acetic/citric acid combination

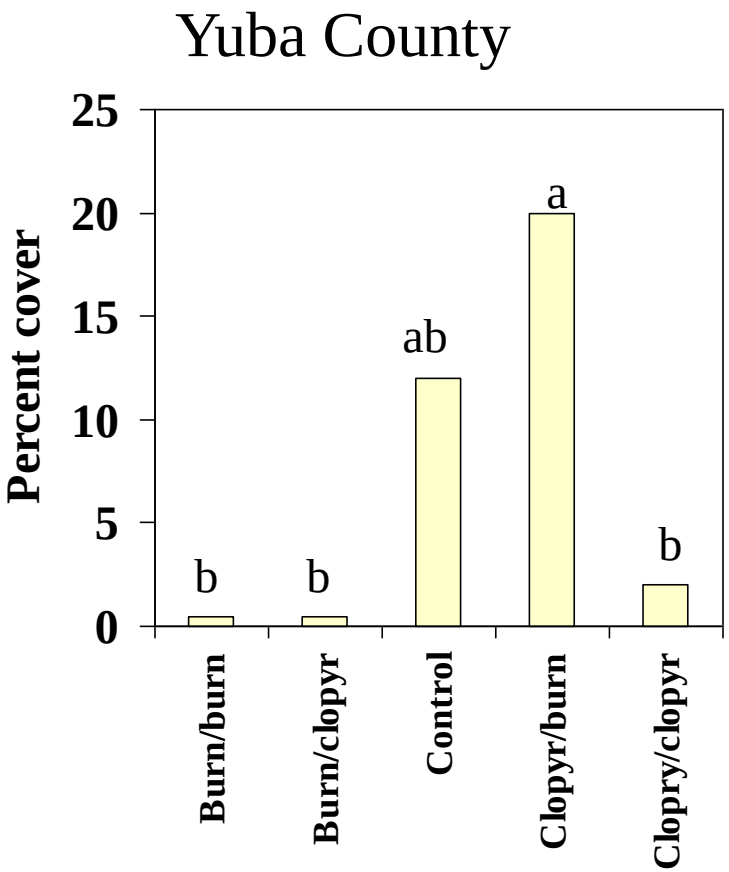
Integrated approaches

- Burning and chemical
- Revegetation and chemical
- Mowing and chemical

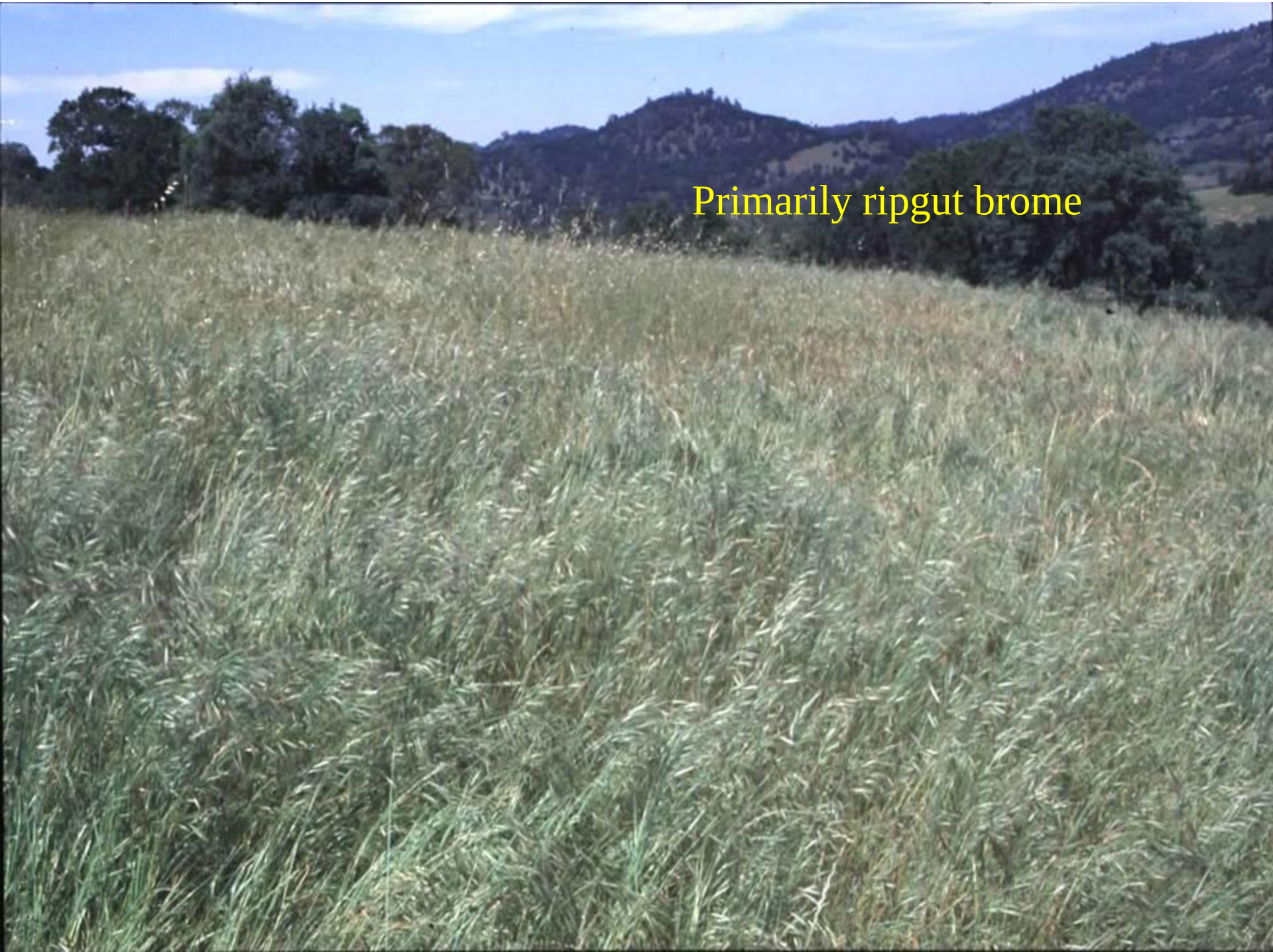
San Benito site following burn in 1999

YST cover following two years of control

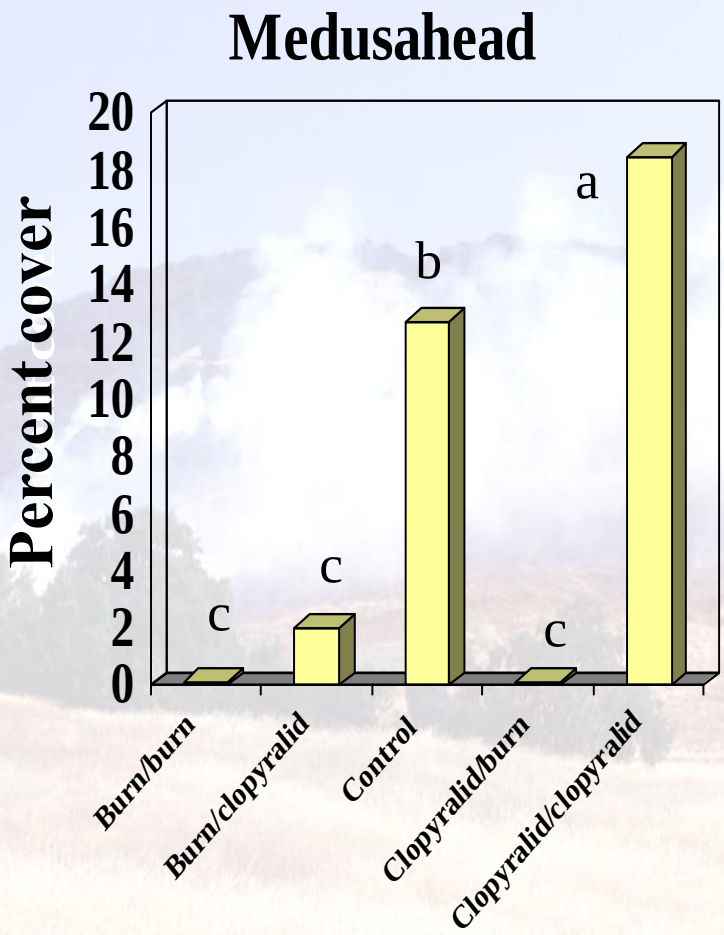


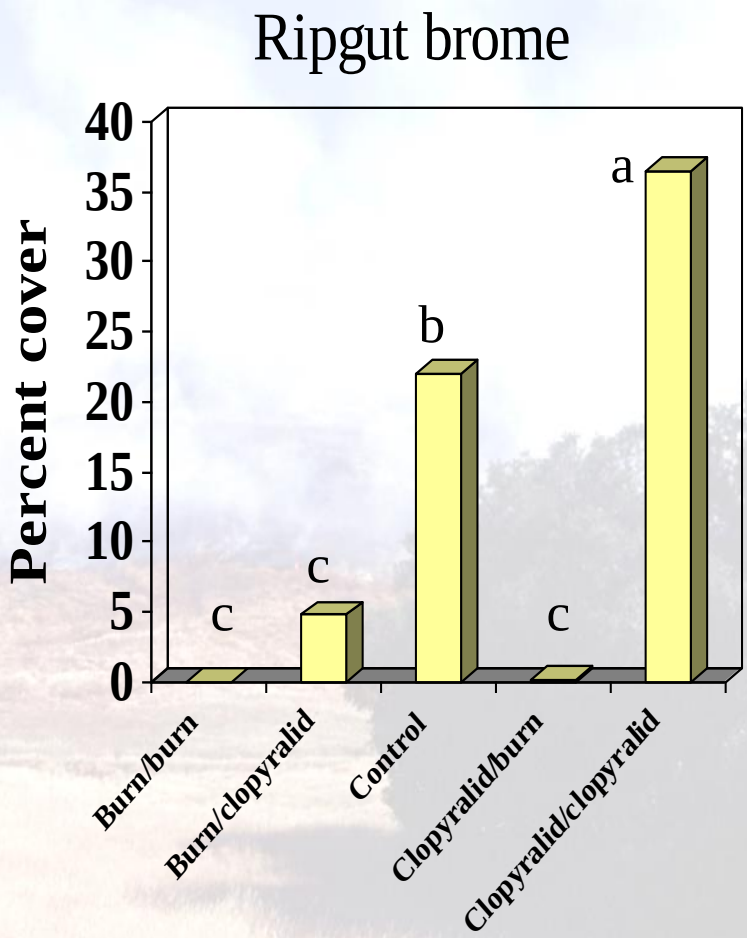


Ripgut brome (*Bromus diandrus*)


Primarily ripgut brome

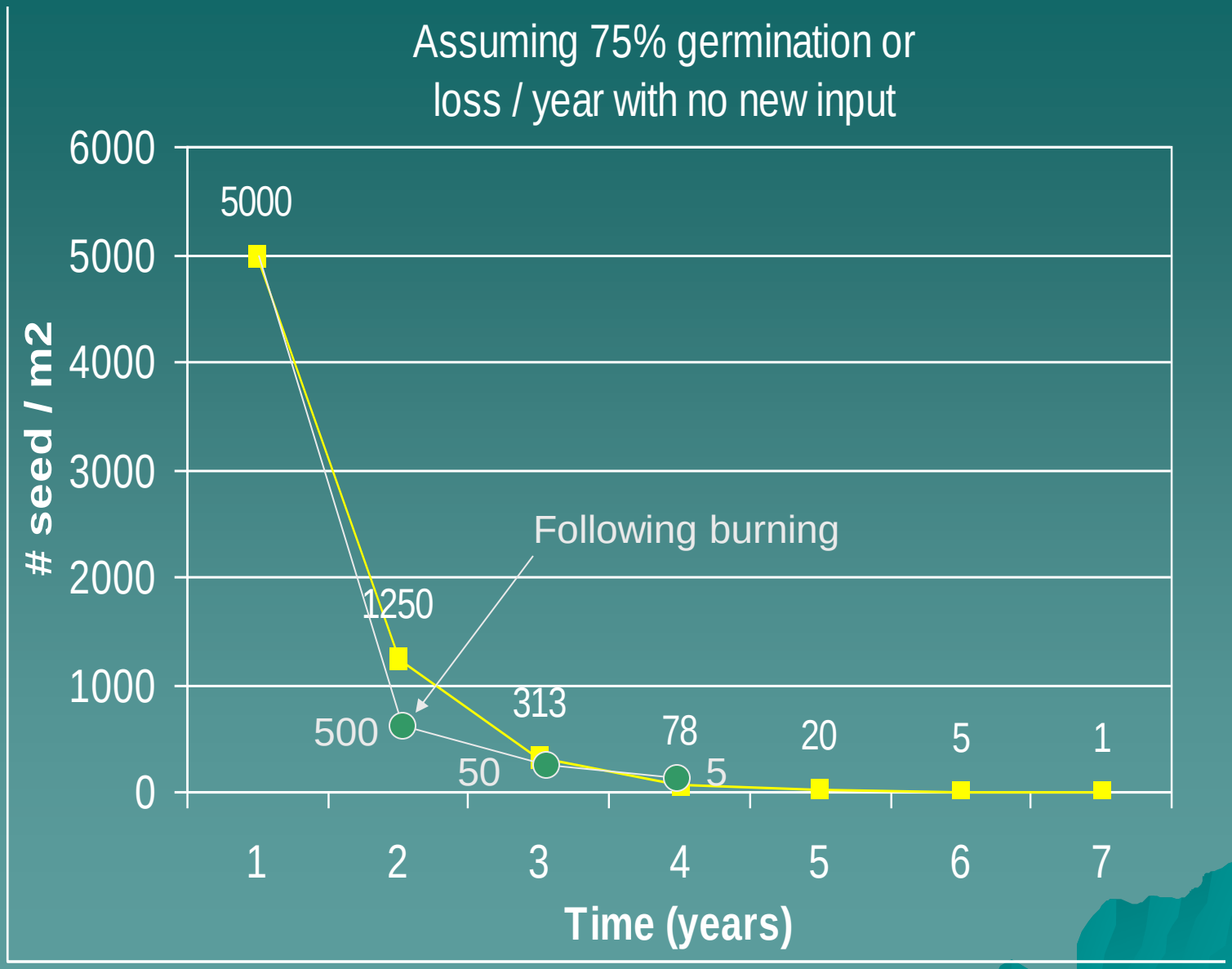
Medusahead
Taeniatherum caput-medusae


Medusahead
Percent cover
20
18
16
14
12
10
8
6
4
2
0
c
c
b
c
a
Burn/burn
Burn/clopyralid
Control
Clopyralid/burn
Clopyralid/clopyralid


Ripgut brome
Percent cover
40
35
30
25
20
15
10
5
0
c
c
b
c
a
Burn/burn
Burn/clopyralid
Control
Clopyralid/burn
Clopyralid/clopyralid

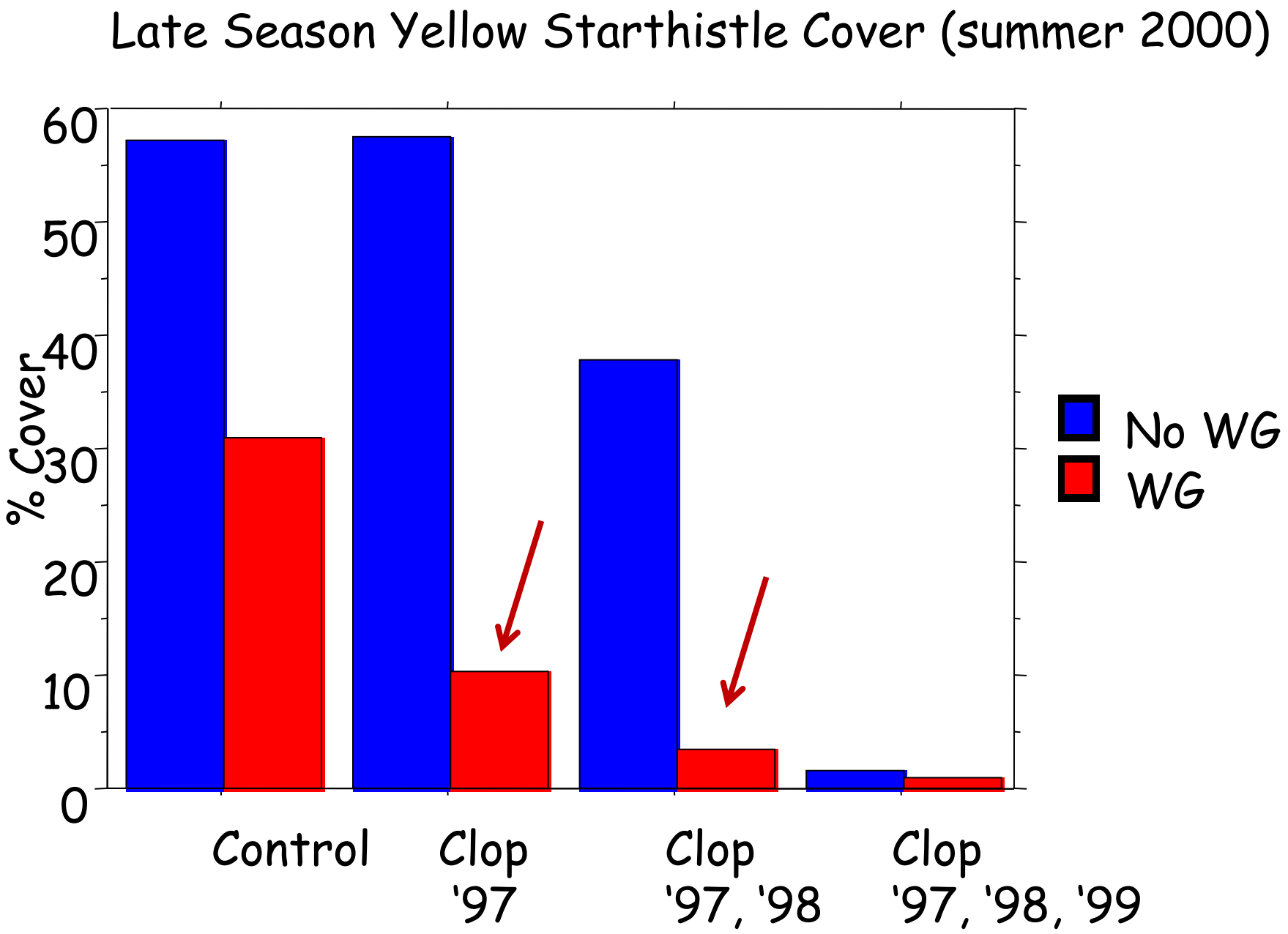
Integrated management of YST at Ft. Hunter Liggett

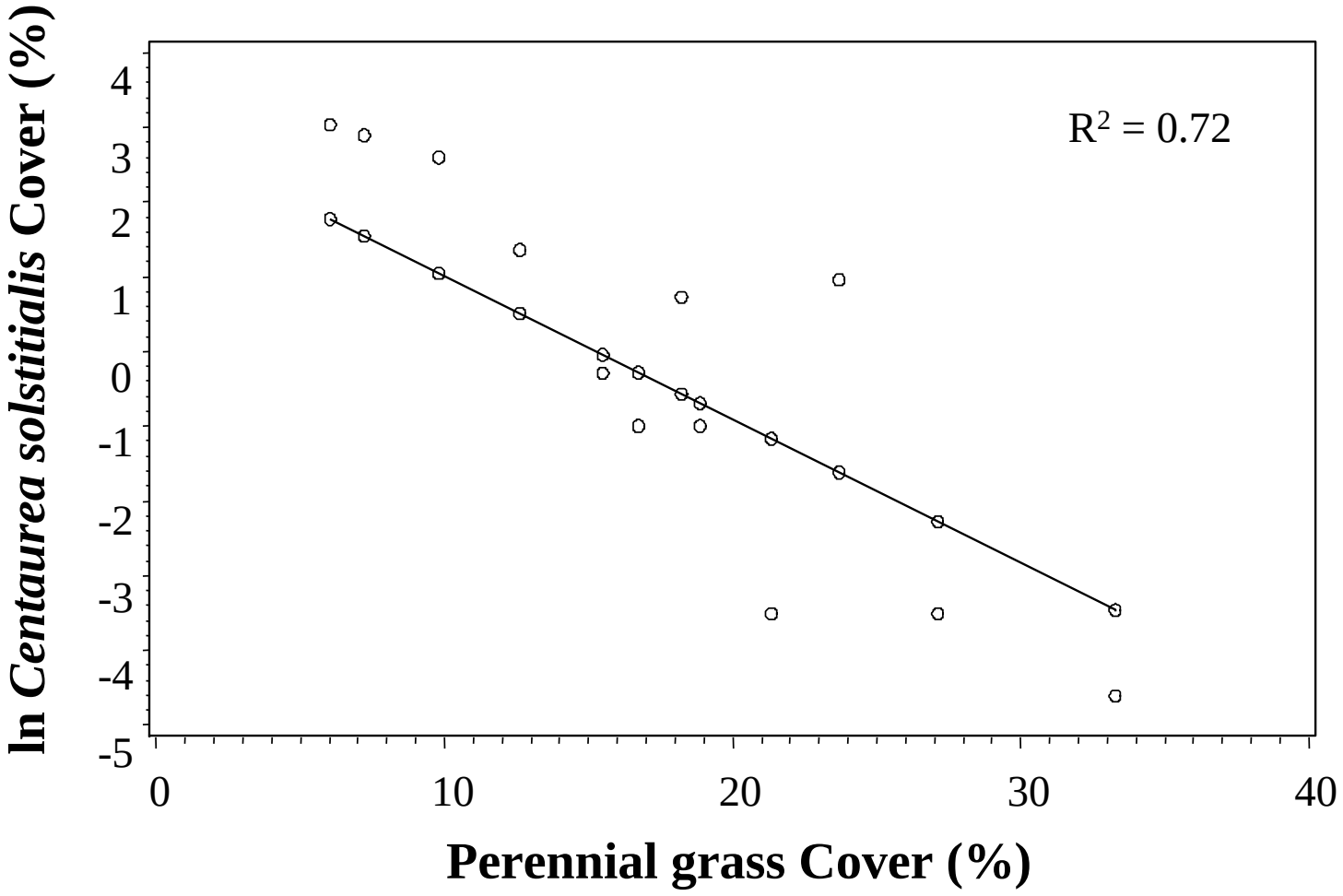
Site	Treatment	Seedlings/m^2 Untreated	Treated (% untreated)
Military use			
2000	Burned 1999	117	271 (232%)
	Clopyr. 2000		
2001		478	2 (0.4%)
Wildland site			
2000	Burned 1999	435	547 (126%)
	Clopyr. 2000		
2001	Burned 2001	1560	6 (0.4%)
2002	No treatment	987	45 (5%)


Assuming 75% germination or
loss / year with no new input
6000
5000
4000
3000
2000
1000
0
seed / m2
5000
1250
313
78
20
5
1
500
50
5
Following burning
1
2
3
4
5
6
7
Time (years)

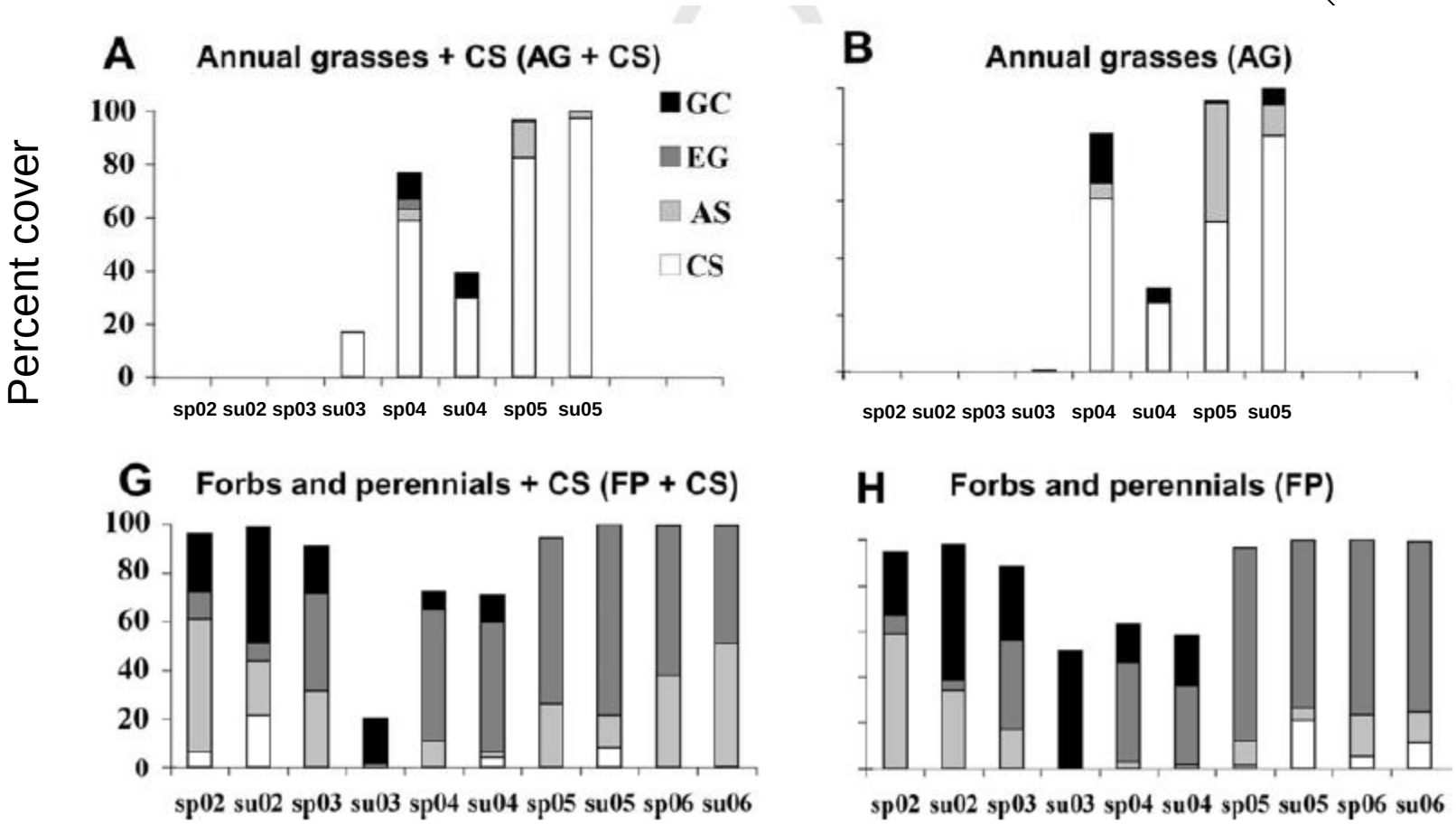
Brown Brush Monitor

Foreground: Annual grass community
Background: Perennial grass community


Late Season Yellow Starthistle Cover (summer 2000)
% Cover
60
50
40
30
20
10
0
Control
Clop '97
Clop '97, '98
Clop '97, '98, '99
No WG
WG


ln Centaurea solstitialis Cover (%)
4
3
2
1
0
-1
-2
-3
-4
-5
R2 = 0.72
0
10
20
30
40
Perennial grass Cover (%)

Native perennial grass (*Elymus glaucus*)



Black = *Grindelia*, perennial native forb
White = yellow starthistle
Light gray = annual species
Dark gray = *Elymus glaucus*, native perennial grass

Best timing of aminopyralid for control of yellow starthistle

		Yellow starthistle cover at each evaluation date			
		July 2010	May 3, 2011	August 1, 2011	May 23, 2012[a]
Site	Time of application	%			
Mission	November 2009	17.3 b	32.3 b	52.8 a	0
	January 2010	0.3 c	1.3 c	11.7 b	0
	March 2010	0 c	0.1 c	0.7 b	0
	None	43.4 a	50.0 a	47.4 a	0
	Probability F	< 0.0001	< 0.0001	< 0.0001	—
Back	November 2009	20.8 b	15.0 b	89.4 b	0
	January 2010	0.3 c	0.6 c	12.9 c	0
	March 2010	0.2 c	0.2 c	4.6 d	0
	None	84.3 a	50.7 a	100.0 a	0
	Probability F	< 0.0001	< 0.0001	< 0.0001	—

Stipa cernua was the most successful seeded species to establish, but establishment required 3 yr. January or March aminopyralid treatment integrated with perennial grass drill seeding in January was most successful.

		Stipa cernua cover			
		Aminopyralid application timing			
		November	January	March	untreated
Year of evaluation	Drill seed timing	%			
2010	December	0 b	0 b	0.6 b	0 b
	January	0.6 b	2.7 ab	4.6 a	1.1 ab
	March	0 b	2.8 ab	0.3 b	0 b
	unseeded	0 b	0 b	0 b	0 b
2011	December	0 b	0 b	0 b	0 b
	January	0 b	0.6 ab	5.0 a	0.2 b
	March	0 b	0.6 ab	2.2 ab	0 b
	unseeded	0 b	0 b	0 b	0 b
2012	December	1.2 de	3.3 de	3.5 cde	1.0 de
	January	23.5 a	18.8 a	10.8 abc	13.2 ab
	March	4.0 bcde	6.8 bcd	2.0 de	3.7 cde
	unseeded	0 e	0 e	0 e	0 e

Summary of YST management

- Numerous successful control options
  - Timely mowing, grazing, burning, herbicides
- Keys to long term success
  - Deplete the seedbank
  - Prevent new seed recruitment
    - Off site recruitment
      - Livestock, vehicles, wind
    - On site escapes
      - Skips, fringe areas, fencelines, satellite populations
  - Monitoring and detection of YST
  - Spot treatment or follow-up program

Thanks for your attention
Questions?