University of California
Agriculture and Natural Resources

Integrated Pest Management for Various Insect Pests in Grass and Alfalfa

UCCE-Tom Getts

Some Slides and Data Courtesy of:
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and Brad Hanson UC Davis

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****In the following presentation any mention of pesticide or pesticide trade name is not an recommendation by the University of California. Pesticides are mentioned by trade name for informational purposes only. Mention of any pesticide is not a guarantee of their effectiveness or an endorsement of other pesticides not mentioned. When ever using a pesticide make sure to read and follow the entire label.

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Outline

- Defining Integrated Pest Management
- Principles of IPM
- Pesticide Resistance
- Utilizing IPM for Insect Management
  - Armyworms
  - Grasshoppers
  - Alfalfa Weevils

What is a Pest?

- A organism which you don’t want
- Typically which causes damage
- Insect, Weed, Pathogen, Vertebrate, Nematode, etc.
- All are pests - in the eye of the beholder

Image courtesy of: UC IPM

IPM

- Integrated Pest Management, or IPM, is a process you can use to solve pest problems while minimizing risks to people and the environment. IPM can be used to manage all kinds of pests anywhere - in urban, agricultural, and wildland or natural areas.

A Process....

- Long term system wide approach to pest management
- Dependent on information!
- Know the ecosystem involved
  - Crop, land, soil, water, social aspects, economic aspects, pests, beneficial, lifecycle, etc.
- Not pest control
- Pest management

Photo courtesy of: UC IPM

Step One

- Pest Identification!
  - Books, Internet, People
- Knowledge!
  - Lifecycle
  - Habitat
  - Damage potential
  - Help choose best management options…

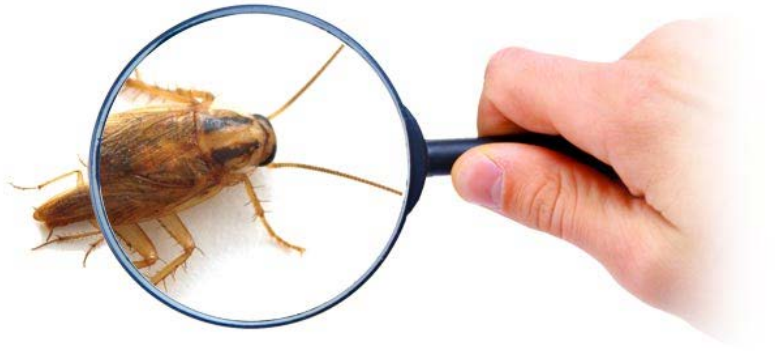


Photo courtesy of: http://acmeexterminating.com/images/free_pest_id.jpg

Step Two

- Monitoring
  - Assess the number of pests
  - Assess damage and potential damage
  - Assess beneficials

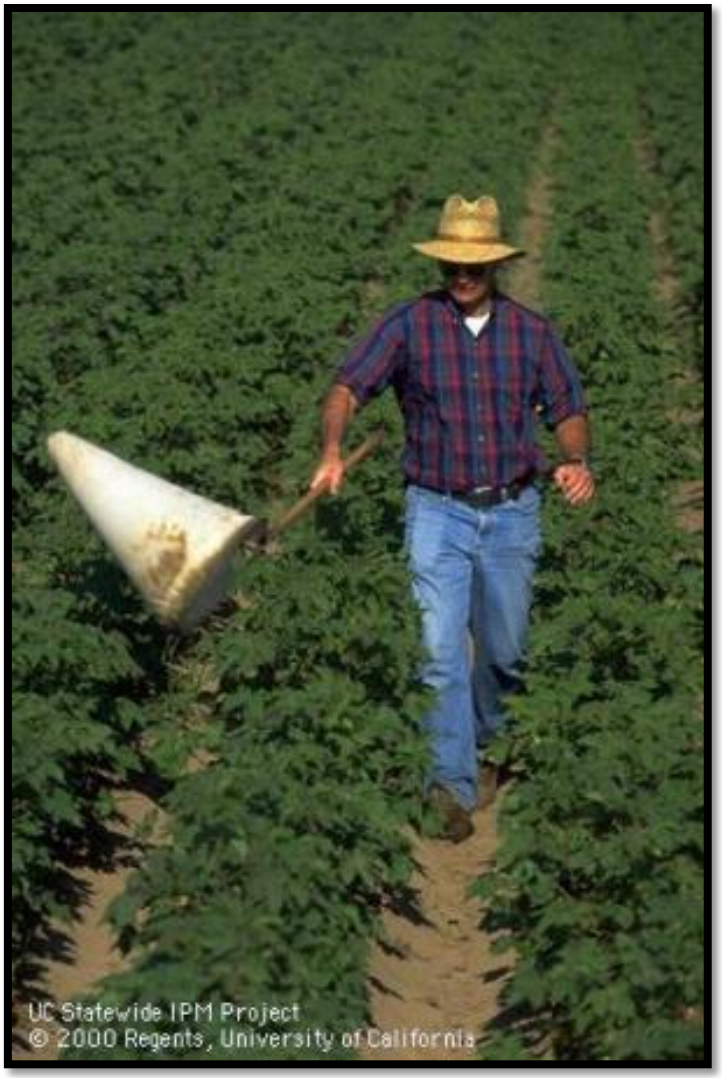


Photo courtesy of: UC IPM

Economic Thresholds

- When is management needed?
- 1 A rated weed = yes
- 1 Armyworm = no
- Monitoring
  - Action number
  - When to treat!
- Developed through research
  - Also experience
  - Know your field/operation

Photo Courtesy of: Google Images

Management

- Multiple approaches
  - Cultural
  - Biocontrol
  - Mechanical
  - Chemical

Photo courtesy of: Deere.com

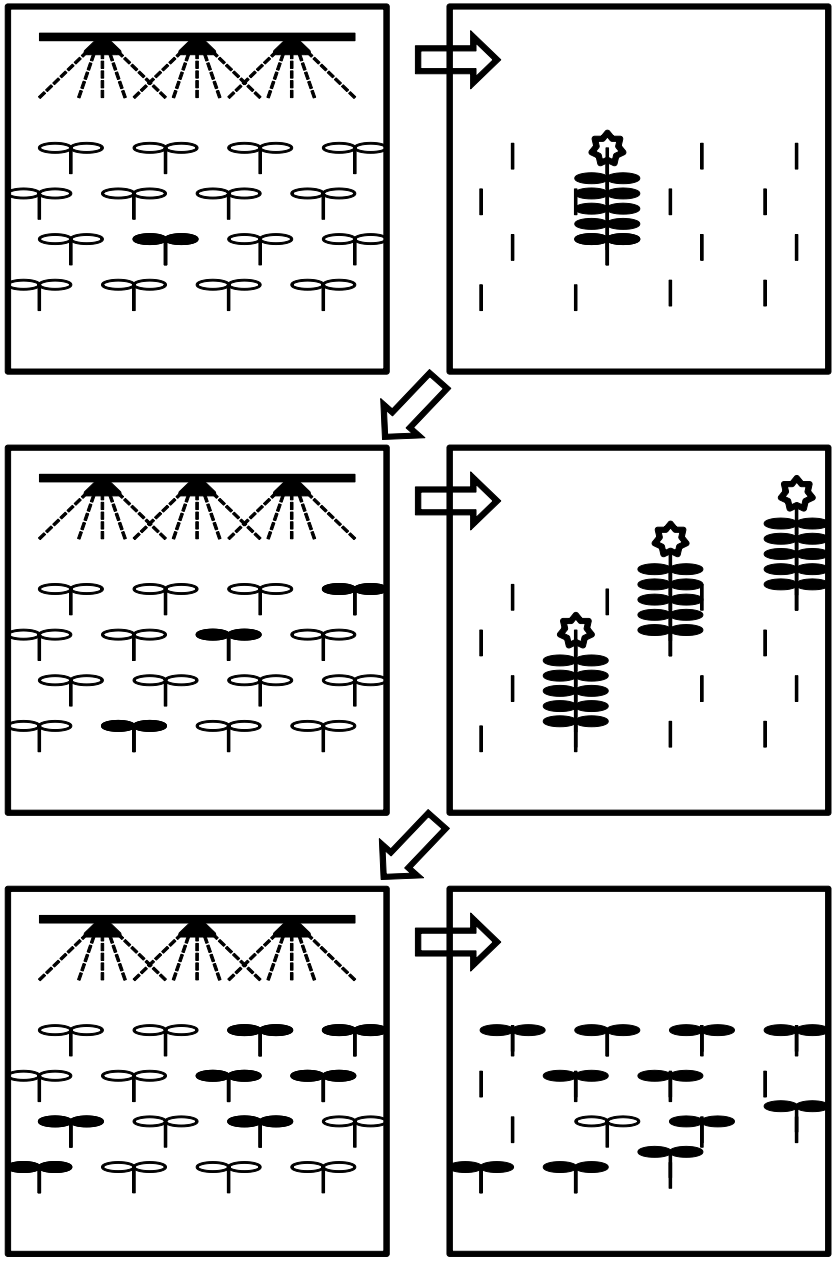
Choosing a Pesticide

- IPM - Choose most selective!
- But also to minimize off target impacts
  - People
  - Crops
  - Organisms
- Spot vs broadcast
- Baits vs sprays
- Also needs to be practical and economical

Photo courtesy of: UC IPM

Pesticide resistance

- Repeated selection pressure
  - Over and over
  - Same active ingredient
- Mode of action



California

- Italian ryegrass resistance
  - 4 modes of action
- Horseweed and Hairy fleabane
  - 2 modes of action
- 30 unique cases of resistance

Armyworm Insecticide Resistance

- Beet Armyworm (Spodoptera exigua)
  - 47 cases USA
  - 14 different active ingredients
  - 525 cases worldwide
  - 39 different active ingredients
- Fall Armyworm (Spodoptera frugiperda)
  - 55 cases USA
  - 23 active ingredients
  - 121 cases worldwide
  - 33 active ingredients

  - https://www.pesticideresistance.org/search.php

Pesticide Resistance

- UC IPM
  - Avoid
  - Delay
  - Reversal
- How?
- Switch up selection pressure!
  - Physically
  - Culturally
  - Chemically
    - Mode of action

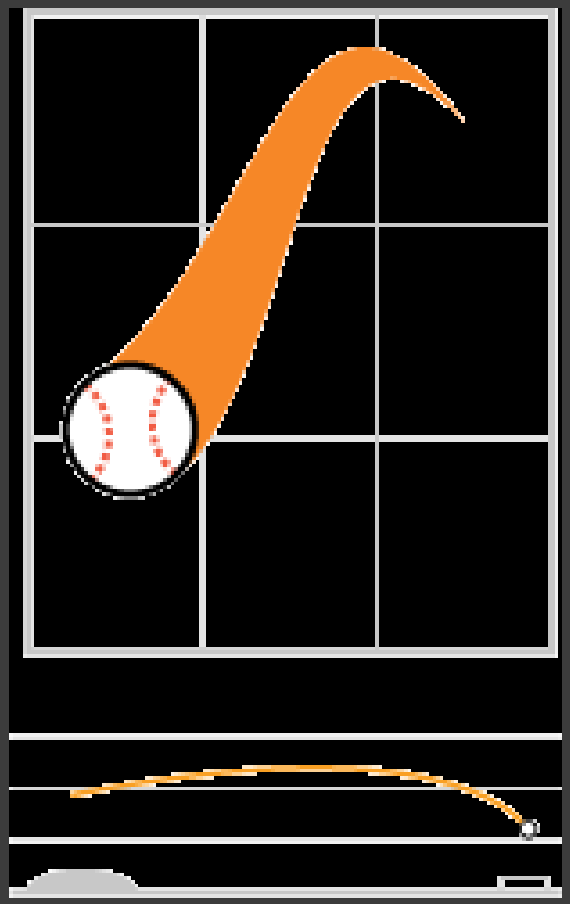


Photo courtesy of: Sports stack exchange

Armyworms!

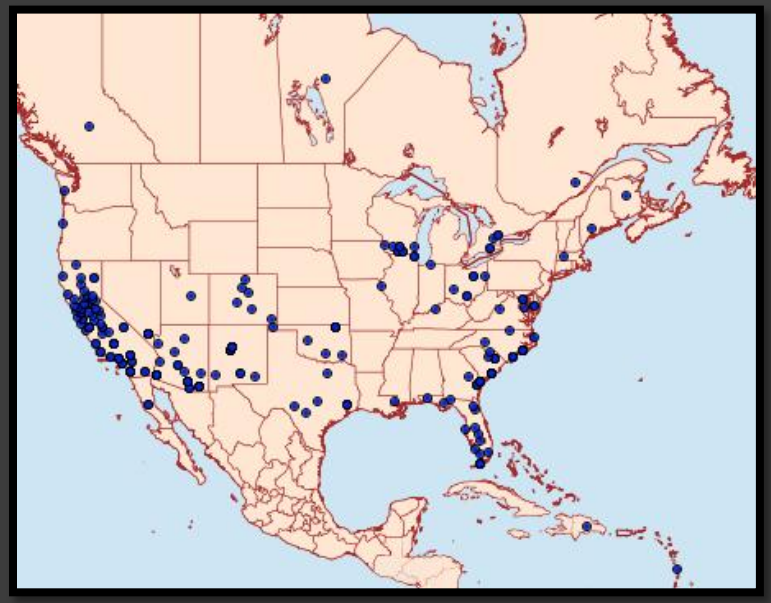
- Lepdopetera Species
- Beet armyworm
- Western yellow striped armyworm
- True armyworm
- Fall Armyworm?

Photos courtesy of: UC IPM

Beet Armyworm

- Native Southeast Asia
- Discovered US 1876
  - Throughout North America

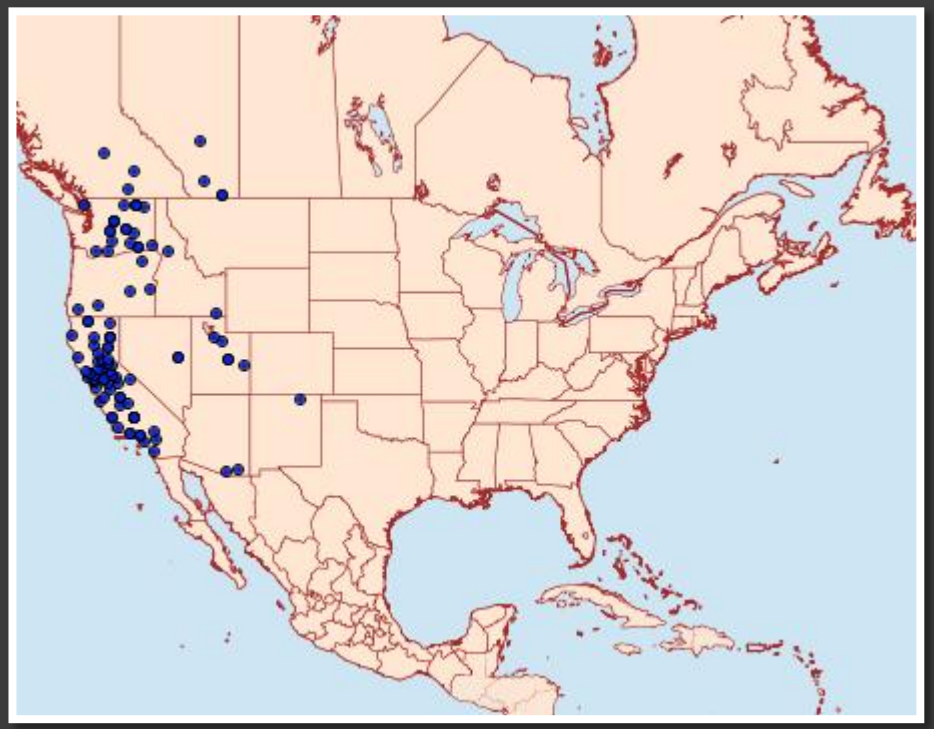
Image courtesy of: Byrain at https://bugguide.net/node/view/693747



Map courtesy of: http://mothphotographersgroup.msstate.edu/large_map.php?hodges=9665

Western Yellow Striped Armyworm

- Mainly Western US
- Native Species



Map courtesy of: Moth photographers group

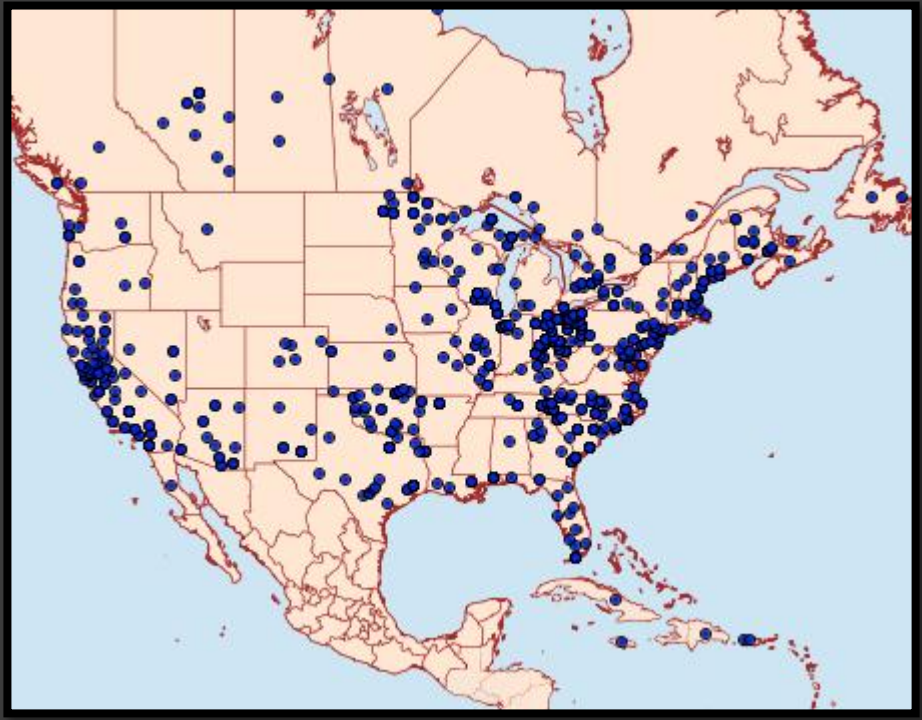
Image courtesy of : John Davis bugguide.net

Image courtesy of: Oregon State

True Armyworm

- All throughout world and North America

Image courtesy of: Clay Nichols bugguide.com



Map courtesy of Moth photographers group

Image courtesy of: Ilona L. bugguide.com

Fall Armyworm?

Image courtesy of: Carol wolf at the moths photographers group

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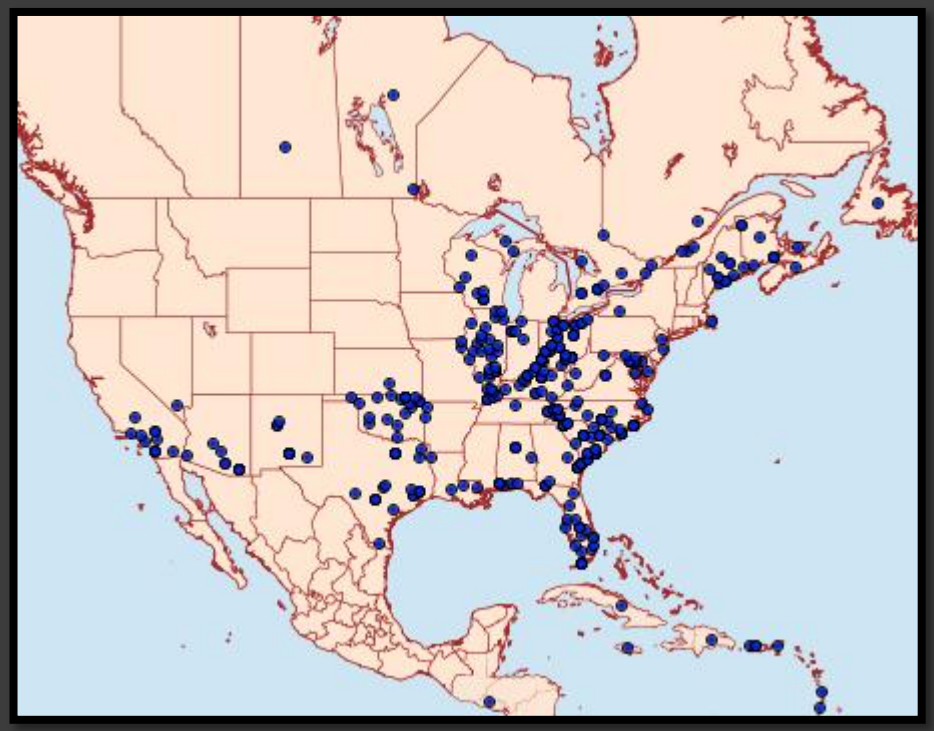

Image courtesy of: the moths photographers group

Image courtesy of: Ken Childs at the moths photographers group

Biology

- Moths - Nocturnal
- Lay eggs 20-400 in mass
- Up to 2,000 eggs per female
  - Beet armyworm and Western yellow striped upper side of leaf. Cottony covering.
  - True Armyworm - rolled in grass
- Typically hatch 1-2 weeks

Image courtesy of: Oregon State, and UC IPM

Image courtesy of: UC IPM

Biology continued

- Western Yellow Striped and Beet Armyworm
  - 2-3 weeks until mature
- True Armyworm
  - Typically 3-4 weeks until mature
- Central Valley
  - Up to 5 generations
- Intermountain Region
  - Only 2 maybe 3 generations

Photo courtesy of: UC IPM

Biology continued

- Appears in Intermountain Region July and August
- Second generation causes most damage
- Damage typically arises 2-3 weeks after second cutting
- Full life cycle can be from 4-6 weeks depending on temperature
- Generations can be concurrent!

Winter

- Do not overwinter in harsh climates
  - No definition of “harsh” climate in literature
  - Migrates in from warmer areas
  - Overwinters as pupa in soil

Damage

- Defoliation of the crop
- Skeletonize alfalfa leaves
  - Cause flagging in field
- Grass eaten often avoids midvein
- Voracious feeder

Damage

- Study looking at fall armyworm feeding
- 80% of total foliage consumed in last instar

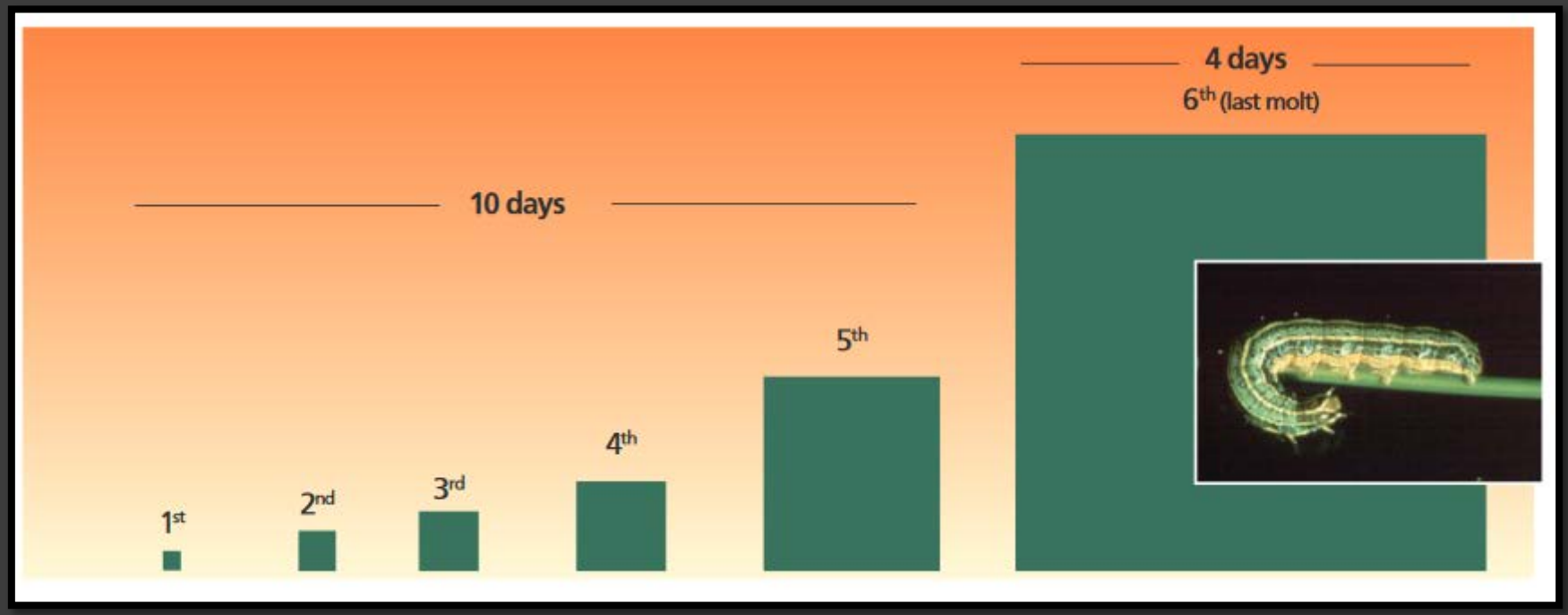

Figure courtesy of: Kathy L. Flanders Auburn University

Management

- Populations are cyclic
- Not a pest every year
- Not typically a large pest in the Intermountain Region
- Often controlled by natural predators!
- Warm winter, wet spring can lead to increased populations

Predators

- Big-eyed bugs
- Spiders
- Minute pirate bug
- Damsel bugs
- Lacewings

Image courtesy of: Southern Utah Entomology

Image courtesy of: Oregon State

Viruses

- Infected Armyworm

Photo Courtesy of: WSU

Parasites

- At least 10!
- Parasitic wasp (H*yposoter exigaue*)
- Often manages population
- Doesn't kill young instars….
- But kills larva before last instar

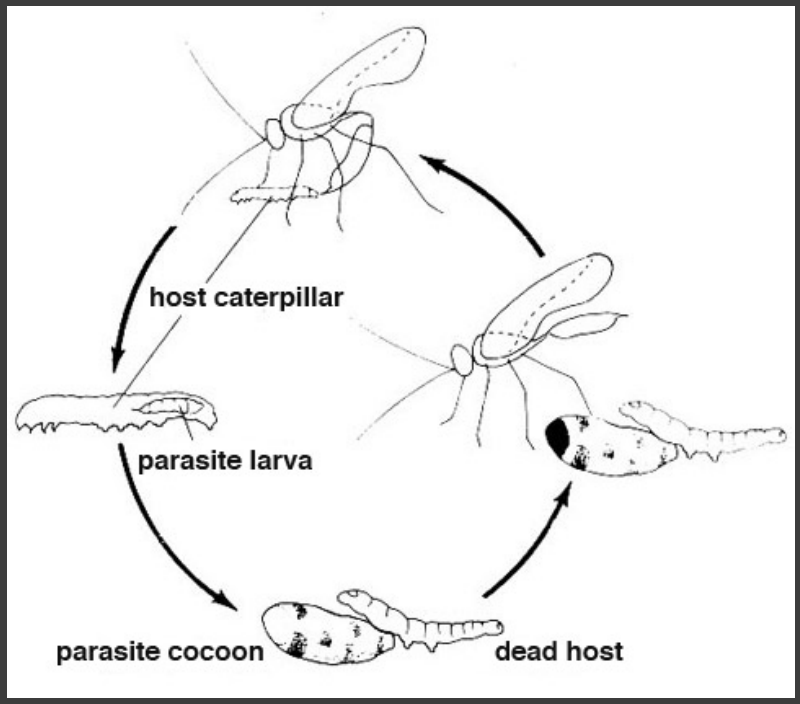

Image courtesy of: http://ipm.ucanr.edu/PMG/NE/hyposoter_exigua.html

Photo courtesy of: UC IPM

Management

- HIGH populations this year!
- Look for “frosting” on fields
- Look for birds
- Moths flying
- Ultraviolet/backlight traps
- And MONITOR!

Photo courtesy of UC IPM

Monitoring Pasture/Grass

- Ground Search!
  - Late July through fall
  - 15 sites/30 acres pasture
  - Every 5-7 days
  - Under grass, around crowns, in cracks
  - Economic threshold
    - Oregon State 5-10 /sq. ft.
    - Other states 2-4/sq. ft.
    - California no established threshold
    - Use judgment

Photo courtesy of: UC IPM

Monitoring Alfalfa

- Sweep 15 inch net
  2-3 times/week
  - 4 sections each field
  - 5 sweeps per section
- Evening and early mornings
- Identify
- Determine if parasitized!
- Threshold
  - 15 or more non-parasatized Armyworms longer ½ inch/sweep

Photo courtesy of: UC IPM

Parasitized Video

- http://ipm.ucanr.edu/PMG/r1900711.html

Image courtesy of: UC IPM

Control options

- Cut the field
  - Creates inhospitable environment
  - If worms are large - may be problem after cutting
  - Under windrows feeding can occur
  - If threshold reached cut within 2 days or spray

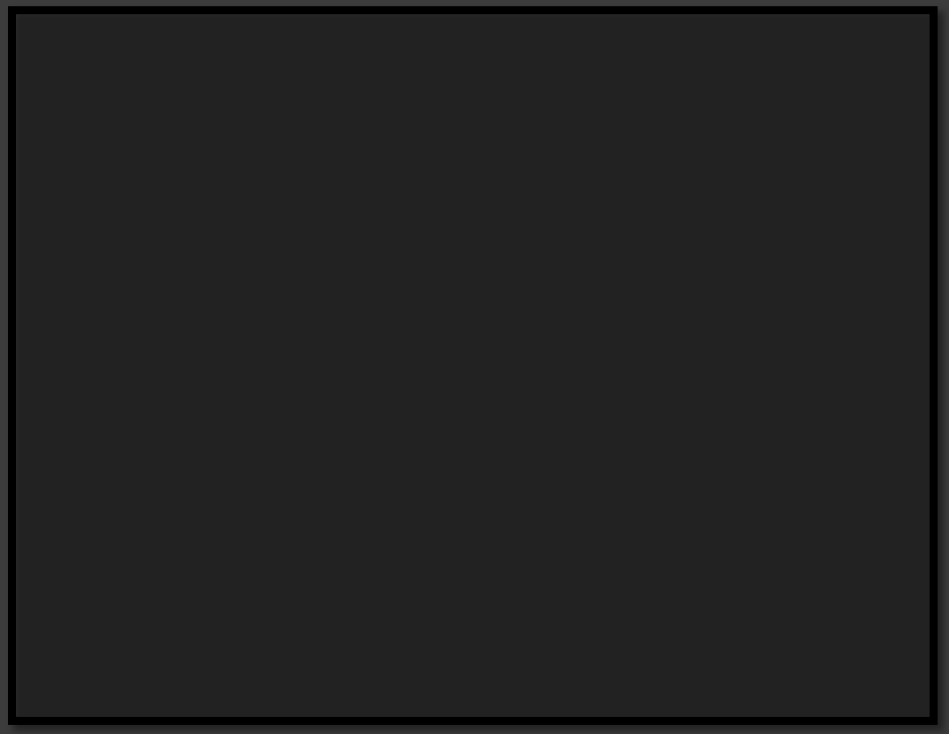

Image courtesy of: Steve Orloff

Insecticide options

- Organic
- BT (bacillus thuringiensis)
  - Agree WG or Xentari DF
  - Apply to first two instars
    - Multiple applications may be needed
  - Does not harm beneficial insects

Photo courtesy of: UC IPM

Select Insecticides for Armyworms (product/acre)

Insecticide	Active	MOA Group	Alfalfa	Grasses	Rangeland
Sevin 4F	Carbaryl	1-A	1-1.5 Quarts	1-1.5 Quarts	NO
Malathion 57	Malathion	1-B	2 pints	2 piints	3 pints
Besiege	chlorantraniliprole and lambda cyhalothrin	28+3	6-10 oz	6-10 oz	6-10 oz
Baythroid XL	cyfluthrin	3	1.6-2.8 oz	1.6-1.9 oz	1.6-1.9 oz
Warrior 2	lambda cyhalothrin	3	1.28-1.92 oz	1.28-1.92 oz	1.28-1.92 oz
Mustang	zeta-cypermethrin	3A	3-4.3 oz	3-4.3 oz	3-4.3 oz
Dimilin 2L	diflubenzuron	15	NO	2oz	2oz
Intrepid 2F	Methoxyfenozide	18	4-8oz	4-8 oz	4-8 oz
Coragen	Chlorantraniliprole	28	3.5-7.5 oz	3.5-7.5 oz	3.5-7.5 oz
Steward	Indoxacarb	22	9.2-11.3 oz	NO	NO
Xentari	BT		.5-1.5 lb	.5-2 lb	.5-2 lb

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Grasshoppers

- Over 200 species in California
- Huge legs!
- Easy to identify
- Sporadic pest, with boom and bust population dynamics

Biology

- Eggs laid in pods during the fall (not in tilled fields)
- 1-4 pods/female
- 20 to 100 eggs per pod
- Top 2 inches soil
- Most overwinter as eggs, some as nymphs
- Hatch in spring
- 5 to 6 molts before maturity (30-40 days)
- Adults live 2-3 months
- One generation per year

Photo courtesy of: https://rstorage.filemobile.com/storage/6829995/15

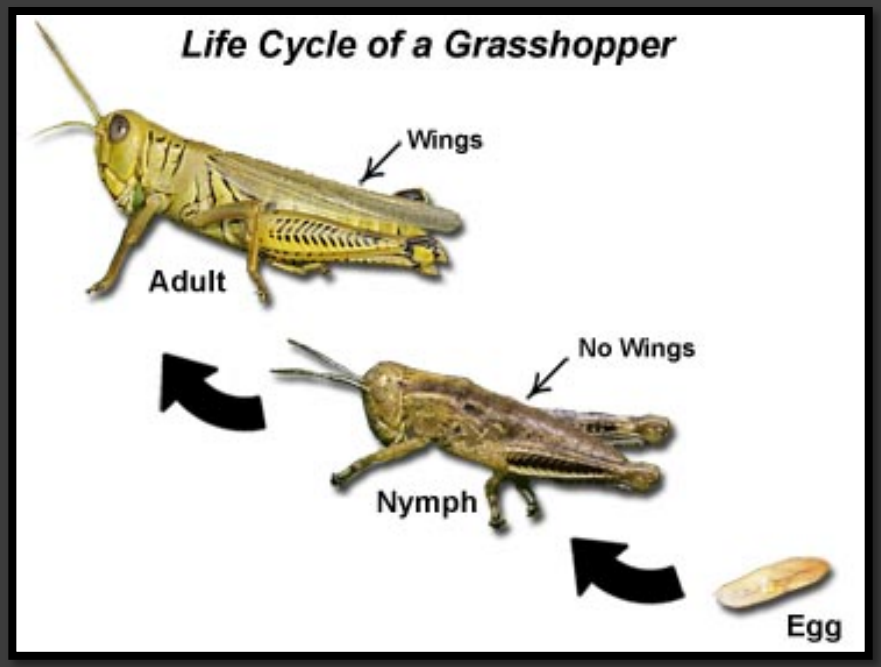

Photo courtesy of: https://targetstudy.com/nature/animals/grasshopper.html

Instar Sizes

General Sizes of Grasshopper Stages

Stage	Size
1st instar	1/4 inch
2nd instar	3/8 inch
3rd instar	1/2 inch
4th instar	3/4 inch
5th instar	1 inch
Adult	1.5 inches

Note: size is approximate, and depending on species, can vary by 1/4 to 1/2 inch.

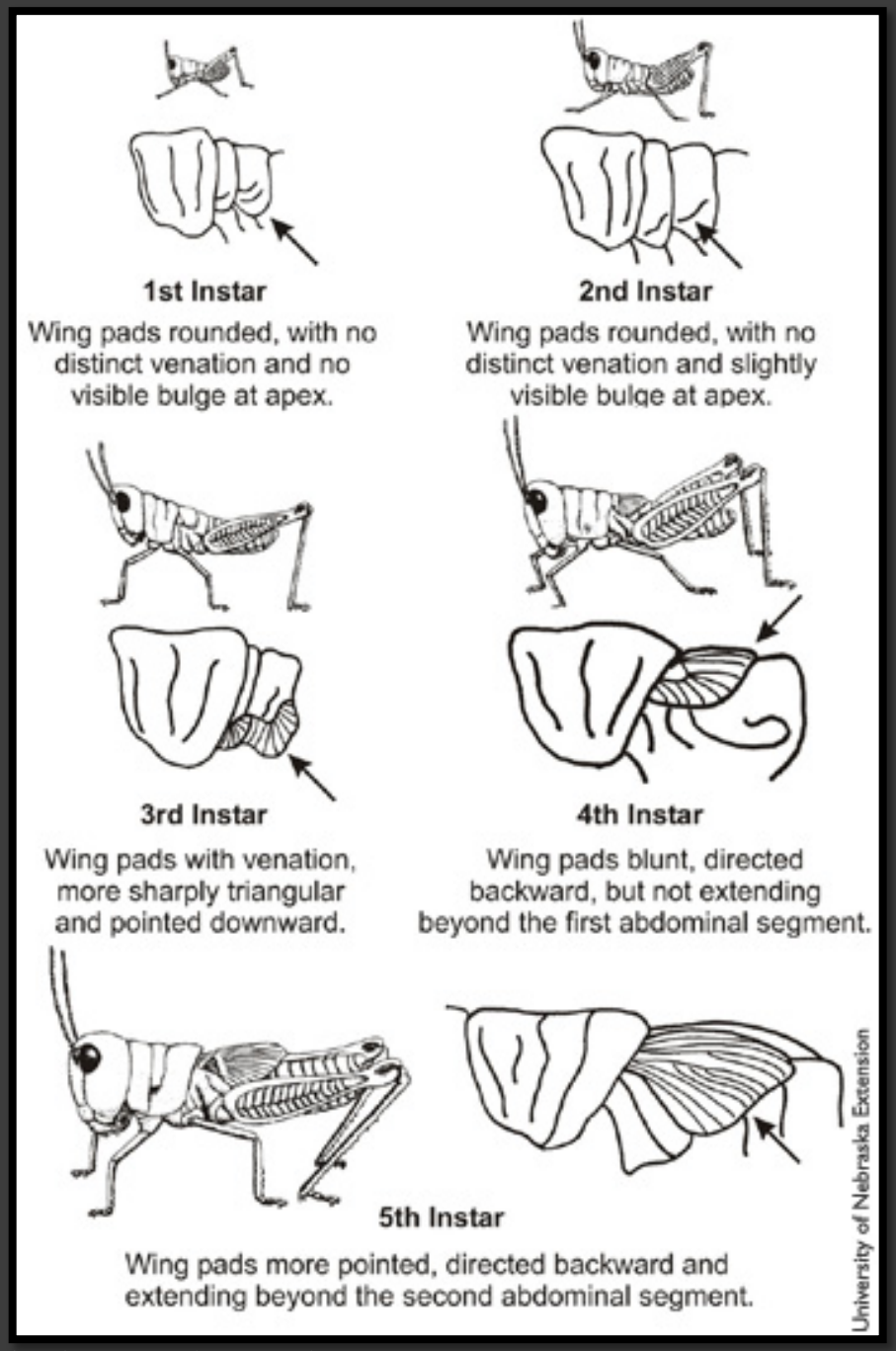

Chart Courtesy of Utah State

Photo Courtesy of: https://utahpests.usu.edu/ipm/agricultural/vegetable/grasshopper-control

Weather Impacts Populations

- Spring
  - Cold - decrease
  - Warm/Dry - increase
  - Wet - fungus
- Fall
  - Warm - more eggs
  - Cold - less eggs
- Drought
  - Negatively impacts populations
  - Can cause movement
- Cold winters - no effect
- Various species impacted differently

Photo courtesy of: http://www.weatherclipart.net/free_weather_clipart/clip_art_illustration_of_a_bright_sun_with_a_rain_cloud_hovering_over_0515-1011-0603-3308_SMU.jpg

Vegetation Consumed

- Some species
  - Grass specific
  - Broadleaf specific
  - Generalist
- Moist vegetation is more palatable
  - Readily move to find food

Photo courtesy of:http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=7743

Movement

- Nymphs will walk to more desirable vegetation
- Adults can fly 15 miles or more
- One source in Wyoming states swarms move over 60 miles
- Adults can “swarm”
- Typically starts in rangeland can move to cropland

Photo courtesy of:
http://www.nydailynews.com/news/national/grasshopper-swarm-spotted-weather-radar-article-1.1812545

Damage

- Consume massive amounts of foliage
- Estimates - 30 to 250% of body weight per day
- Cows - 1.5-2.5% of their body weight
- 30 lb grasshoppers consume the same forage as a 600 lb steer

Photo courtesy of: http://entomology.k-state.edu/images/alfalfa-pests/grasshopper.tif

Management

- Area wide approach
- Coordinated effort
- Monitor
- UC IPM
  - Control on rangeland and field edges before move into crops!

Photo courtesy of: Evan McGlin and National Geographic

Economic Thresholds Range

- Oregon Rangeland
  - 8 or more/square yard
  - USDA Aphis Standard before assistance
- California - no threshold
- Wyoming Rangeland
  - Less than 8/square yard - Not economic
  - 8-15/square yard - Potentially economic
  - 15-20/square yard - Economic
- Economic threshold vary by species, time, developmental stage, crop, cost, etc.

Economic Thresholds Nebraska

Table 1. Treatment guidelines based on number of grasshoppers (nymphs and adults) per square yard.

Grasshopper Population	Within Fields	Field Borders	Treatment necessary?
Non-economic	0-2	5-10	No
Light	3-7	11-20	Uncertain — depends on size, species, type of crop
Moderate	8-14	20-40	Probably
Abundant	15 or more	41 or more	Yes

Grasshopper Control

- Mechanical
  - Cultivation
    - Eggs do not persist in cultivated fields
  - Mowing
    - Eliminates food source
    - Double edge sword

Photo courtesy of: https://www.haugimp.com/

Grasshopper Control

- Biological
  - Birds, spiders, rodents, fungal pathogens (various species)
  - Nolo bait or Semaspore bait, etc.
    - Protazoa infect grasshoppers/Mormon crickets
    - Deformities, slows growth
    - Does not stop feeding immediately!
    - Needs reapplication

Photo courtesy of: https://vignette.wikia.nocookie.net/grasshoppers/images/6/62/Bird_Eating_Grasshopper.jpg/revision/latest?cb=20141205220809

Insecticidal Control Rangeland

- RAAT Treatments (Reduced Area-Agent Treatments)
  - Only treat part of acreage 35-80%
- Rangeland treatments
- Reduce cost of treated acreage
- Insects move from untreated to treated residual activity
- Provide haven for beneficial insects/food for birds
- UC IPM - treat young grasshoppers outside of crops

Wyoming Studies

- Products used in study
  - Carbaryl, Malathion, Dimilin
- Applications made to early instars!!
- Dimilin only effective on first three instars
- Blanket/Broadcast treatments
  - 85-99% grasshopper control
- RAAT Treatments
  - 75-90% grasshopper control
  - 50% of the cost
- Information courtesy of the University of Wyoming
  - Dr. Alex Latchininsky

Insecticides

- Generally much more effective on nymphs
- Dimilin only effective on first three instars - Timing!
- Pyrethroid better on adult grasshoppers
  - Not very selective
  - More non-target impacts

Photo courtesy of: The University of Wyoming

Buffer Zone with Baits

- Non-vegetated zone
  - 60 ft. zone
- Utilize carbaryl baits
- As hoppers migrate to fields eat the baits

Select Insecticides for Grasshoppers (product/acre)

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Besige	chlorantraniliprole and lambda cyhalothrin	28+3	6-10 oz	6-10 oz	6-10 oz
Baythroid XL	cyfluthrin	3	2-2.8	2.6-2.8	2.6-2.8
Warrior 2	lambda cyhalothrin	3	1.28-1.92 oz	1.28-1.92 oz	1.28-1.92 oz
Mustang	zeta-cypermethrin	3A	3-4.3 oz	3-4.3 oz	3-4.3 oz
Dimilin 2l	diflubenzuron	15	NO	.75-1oz	.75-1oz
Coragen	Chlorantraniliprole	28	2-5 oz	2-5 oz	2-5 oz
Steward	Indoxacarb	22	6.7-11.3 oz	NO	NO

Select Insecticides for Grasshoppers (product/acre)

Insecticide	Active	Chemical group	Alfalfa	Grasses	Rangeland
Sevin 4F	Carbraryl	1-A	NO	NO	1 pint
Malathion 57	Malathion	1-B	1.5-2 pints	1.5-2 pints	1.5-2 pints
Besige	chlorantraniliprole and lambda cyhalothrin	28+3	6-10 oz	6-10 oz	6-10 oz
Baythroid XL	cyfluthrin	3	2-2.8	2.6-2.8	2.6-2.8
Warrior 2	lambda cyhalothrin	3	1.28-1.92 oz	1.28-1.92 oz	1.28-1.92 oz
Mustang	zeta-cypermethrin	3A	3-4.3 oz	3-4.3 oz	3-4.3 oz
Dimilin 2l	diflubenzuron	15	NO	.75-1oz	.75-1oz
Coragen	Chlorantraniliprole	28	2-5 oz	2-5 oz	2-5 oz
Steward	Indoxacarb	22	6.7-11.3 oz	NO	NO

Alfalfa Weevils

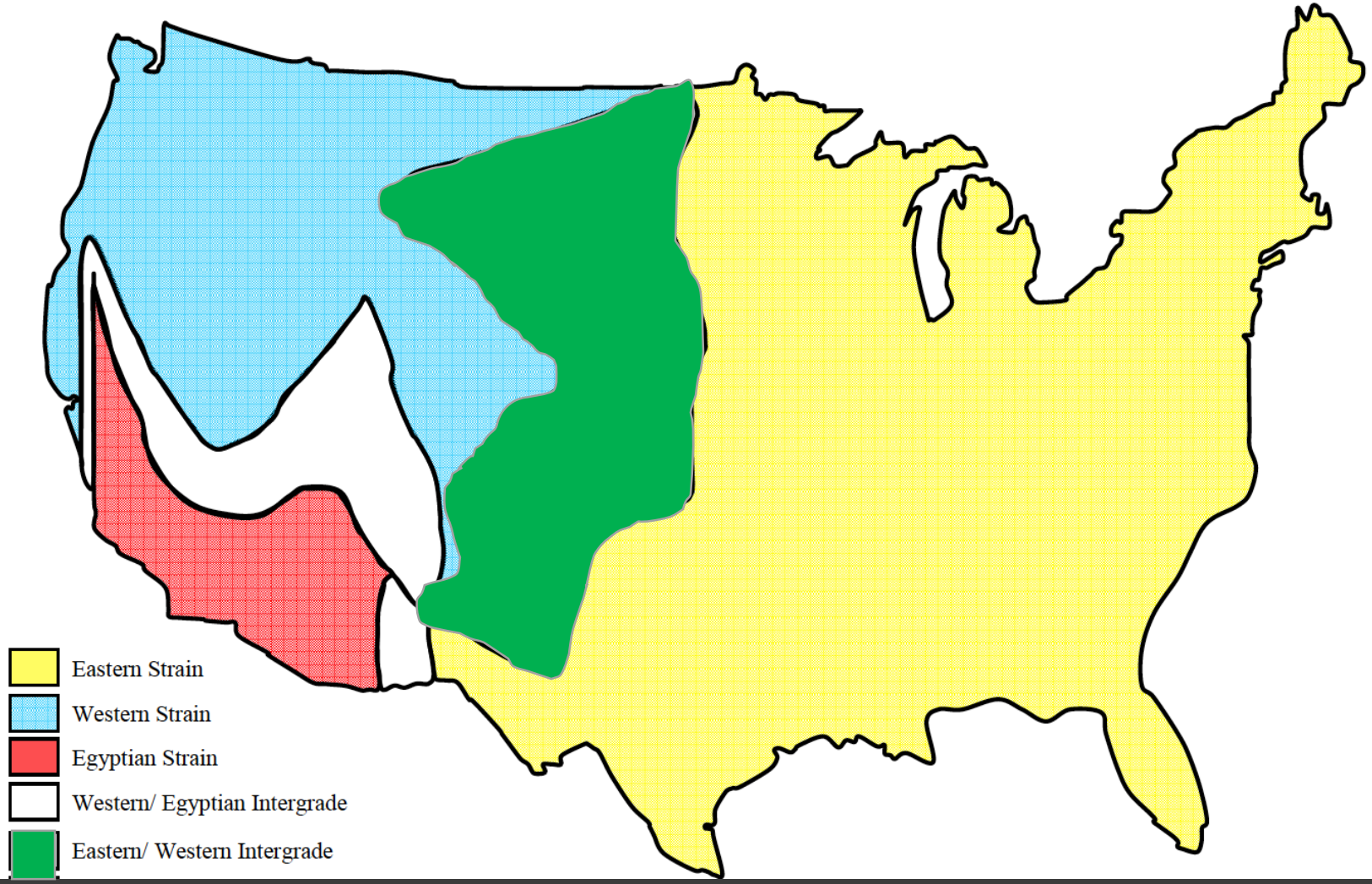
Alfalfa Weevils (Egyptian, Western, and Eastern strains)

- Yield and quality loss, first and sometimes second cutting
- 1 generation/year (sometimes 2)
- Likely all same species (look alike but behavioral differences)
- Introduced pest from Eurasia (early to mid 1900's)

Weevil Biology

- Mating occurs late fall or early spring
  - Eggs laid on stem
  - Hatch late March early April
- 4 instars over 3-4 weeks
  - First pale in color to green
- Spin cocoons 1-2 weeks adults emerge
  - Small amount of feeding
  - Enter resting period

Photo courtesy of: UC IPM


Eastern Strain
Western Strain
Egyptian Strain
Western/ Egyptian Intergrade
Eastern/ Western Intergrade

Alfalfa Weevil Behavioral Differences

Behavior	Western	Egyptian
Climate preference	Cool, cold	Hot, dry
Migrate out of fields	No	Yes
Aggregate during summer aestivation	No	Yes
Pupate	In leaf litter	On plant
Population peak	1-3 weeks later	1-3 weeks earlier
Biocontrol, by parasitoid wasps	Yes	No
Wolbachia, endosymbiotic bacterium*	Yes	No

*May account for behavioral differences

Biocontrol (Surveys in 2004-2005)

Parasitism by wasps:

- Central Valley: 0-14%
- Intermountain Area: 15-17%

Soil dwelling fungus, *Zoophthora phytonomi* (warm, moist conditions)

- Central Valley: <1% in 2004, 30% in 2005
- Intermountain Area: 0% in both years

Management Practices, Cultural:

- Early harvest: Yield loss to first and likely damage under windrows
- Overseeding: Other forages, but changes forage quality (know markets)
- ‘Sheeping-off’: Need sheep and may not reduce to economical levels

Insecticides: 4 MOA's for Weevils in Alfalfa

- OP's: Lorsban, Malathion, Imidan
- Pyrethroids: Mustang, Warrior, Baythroid
- Steward
- Entrust (organic, suppression only, 70%)

Intermountain Area: Resistance to Pyrethroids

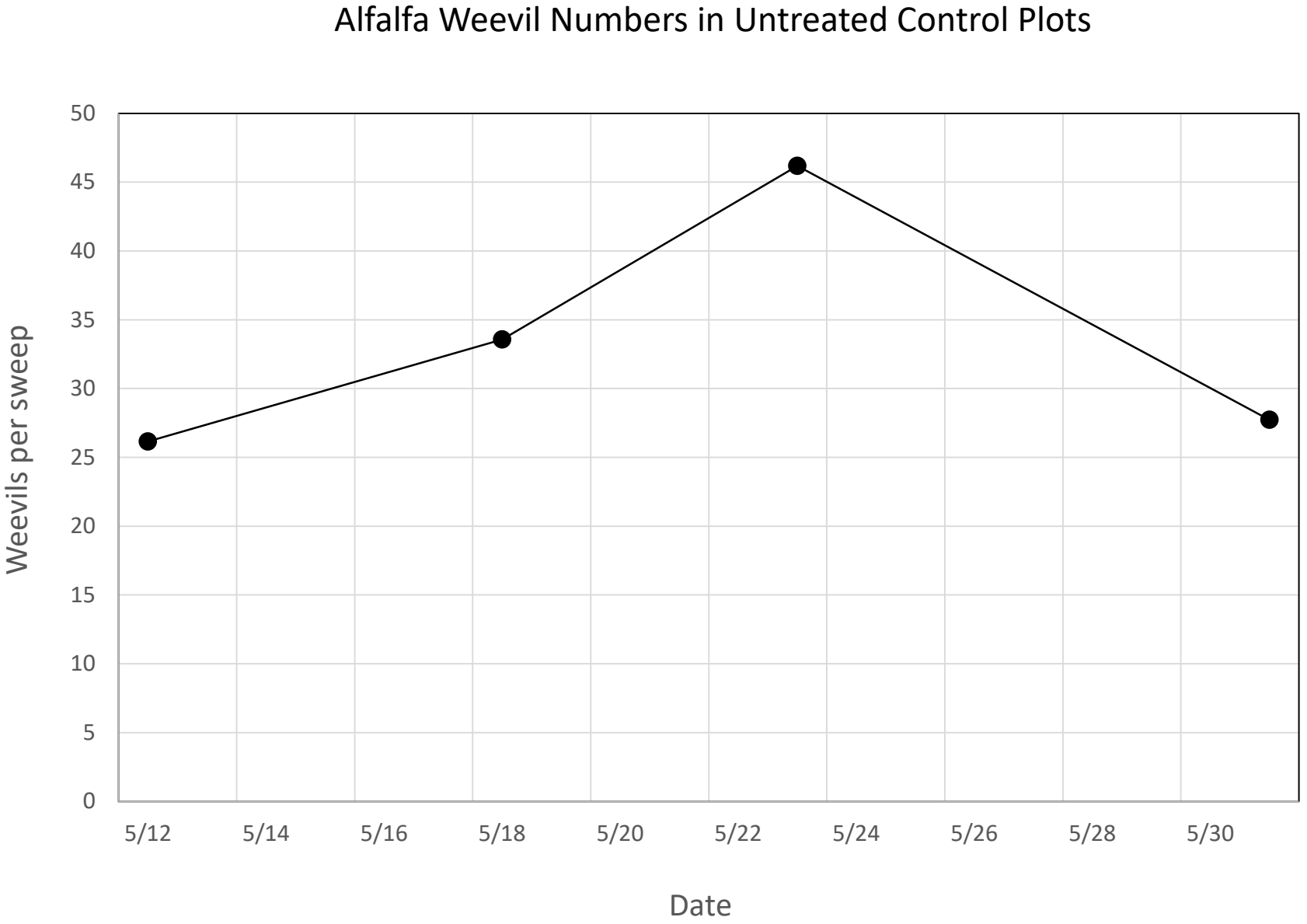
% Alfalfa Weevil Mortality from Baythroid & Warrior	
Field Site	Recommended Rate
Organic field	92%
Conventional Fields 1-4	3-15%

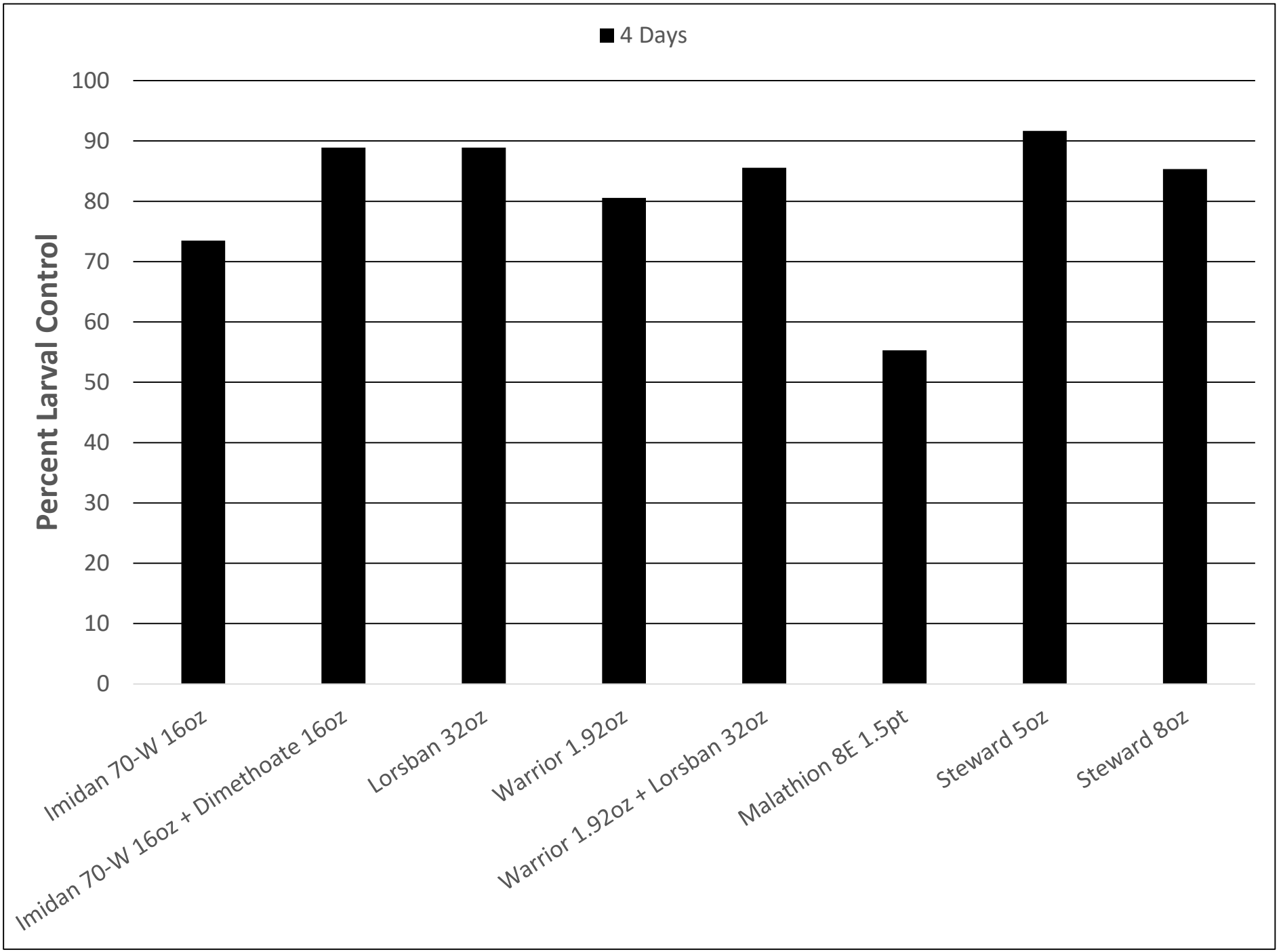
Orloff et al. 2016. Alfalfa and Forage Blog, Alfalfa weevil resistance to pyrethroid insecticides found in Intermountain alfalfa fields.

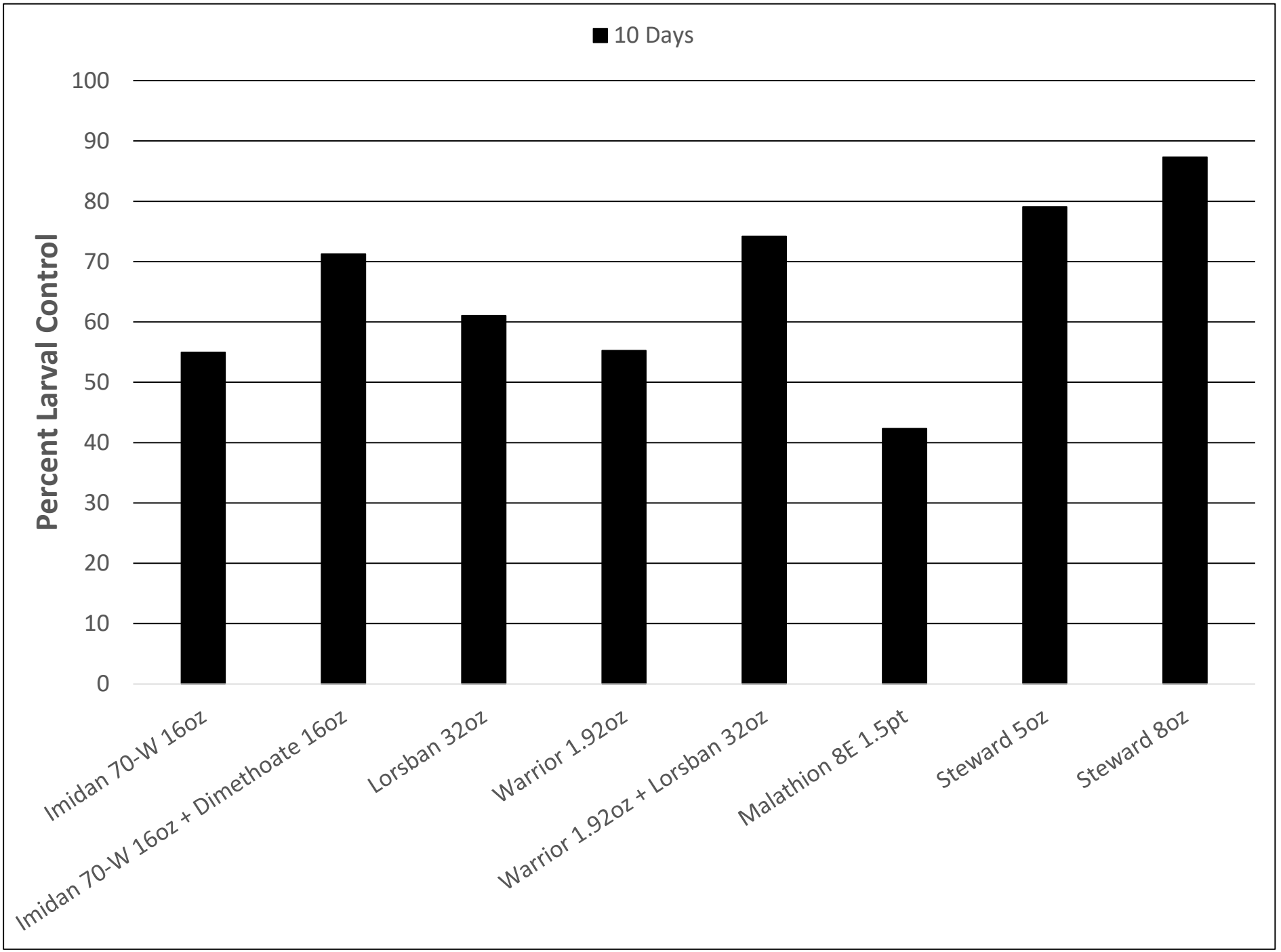
Treatment and Rate	
Control	--
Imidan 70W	16 oz
Imidan 70W+Dimethoate	16 oz+1 pt
Lorsban	2 pt
Warrior II	1.92 oz
Warrior II+Lorsban	1.92+2 pt
Steward	5 oz
Steward	8 oz
Malathion 5E	1.5 pt
Steward+Lorsban	5 oz+1.5 pt
Steward+Warrior II	5 oz+1.92 oz
Steward+Malathion	5 oz +1.5 pt
Steward+Dimethoate	5 oz+1 pt
Steward+Imidan	5 oz+12 oz

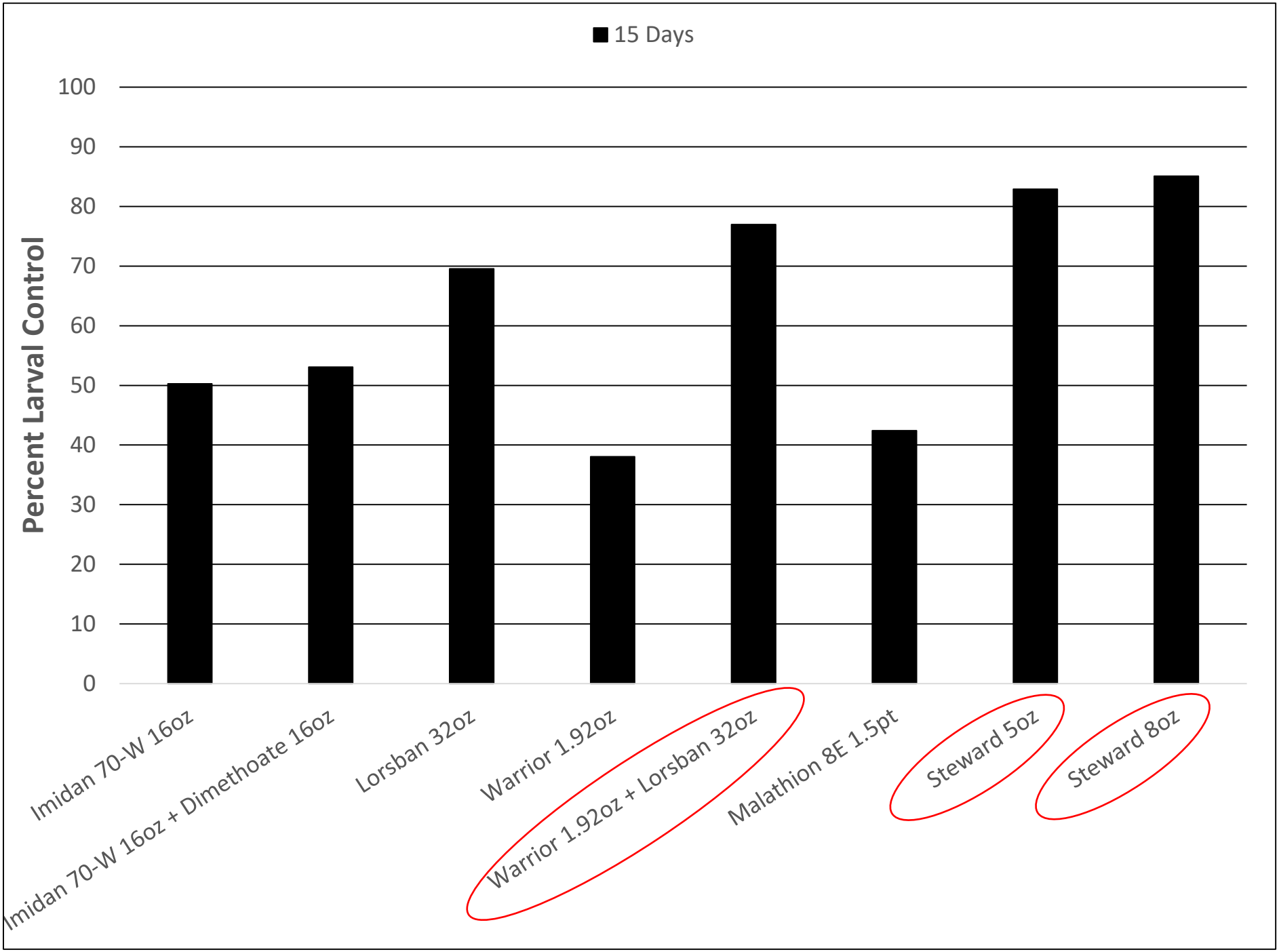
Orloff, 2017, Siskiyou County, Treated 5/8/17

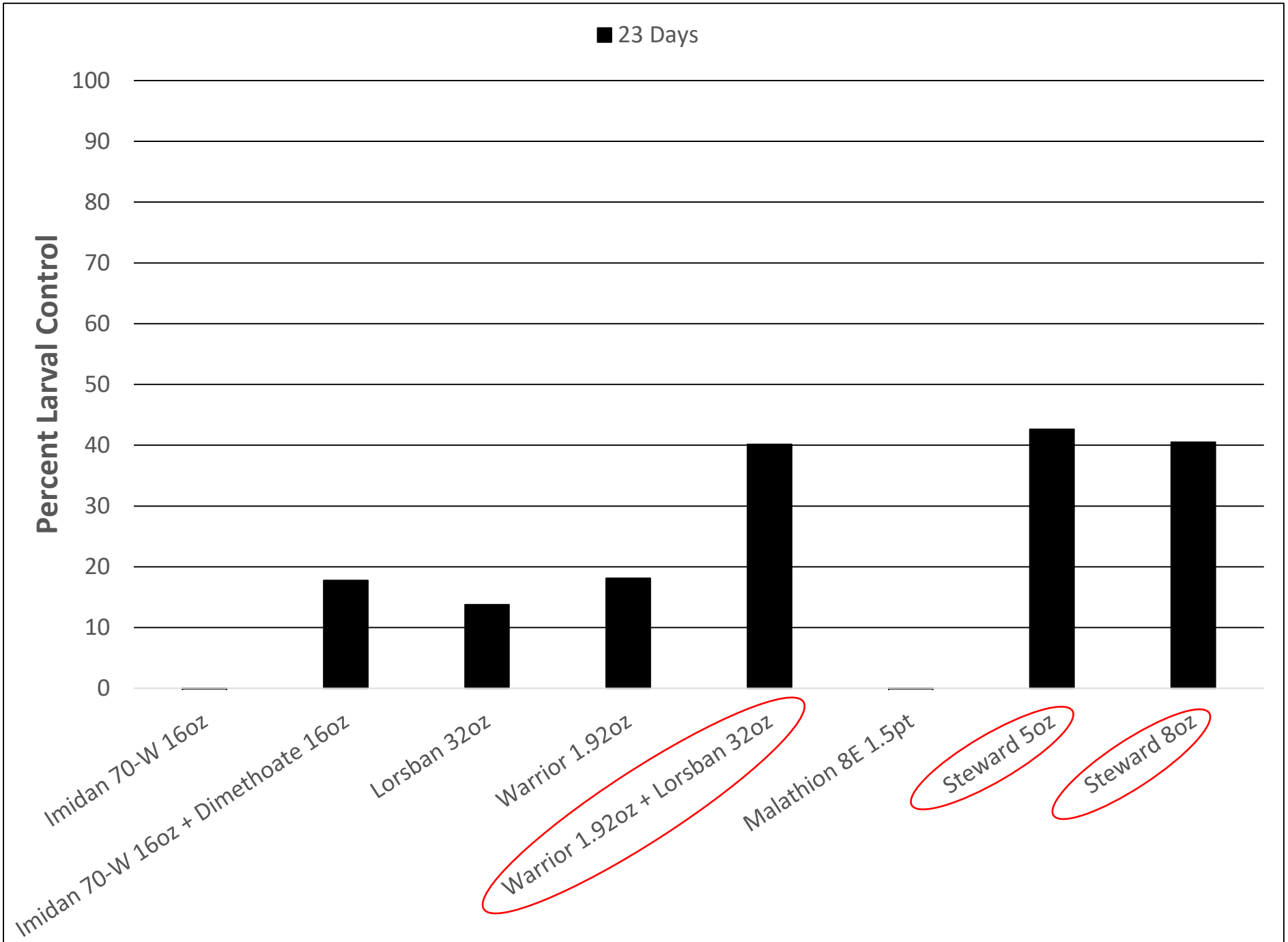
Note: Baythroid and Lannate short residuals for weevil control, Sevin burns foliage

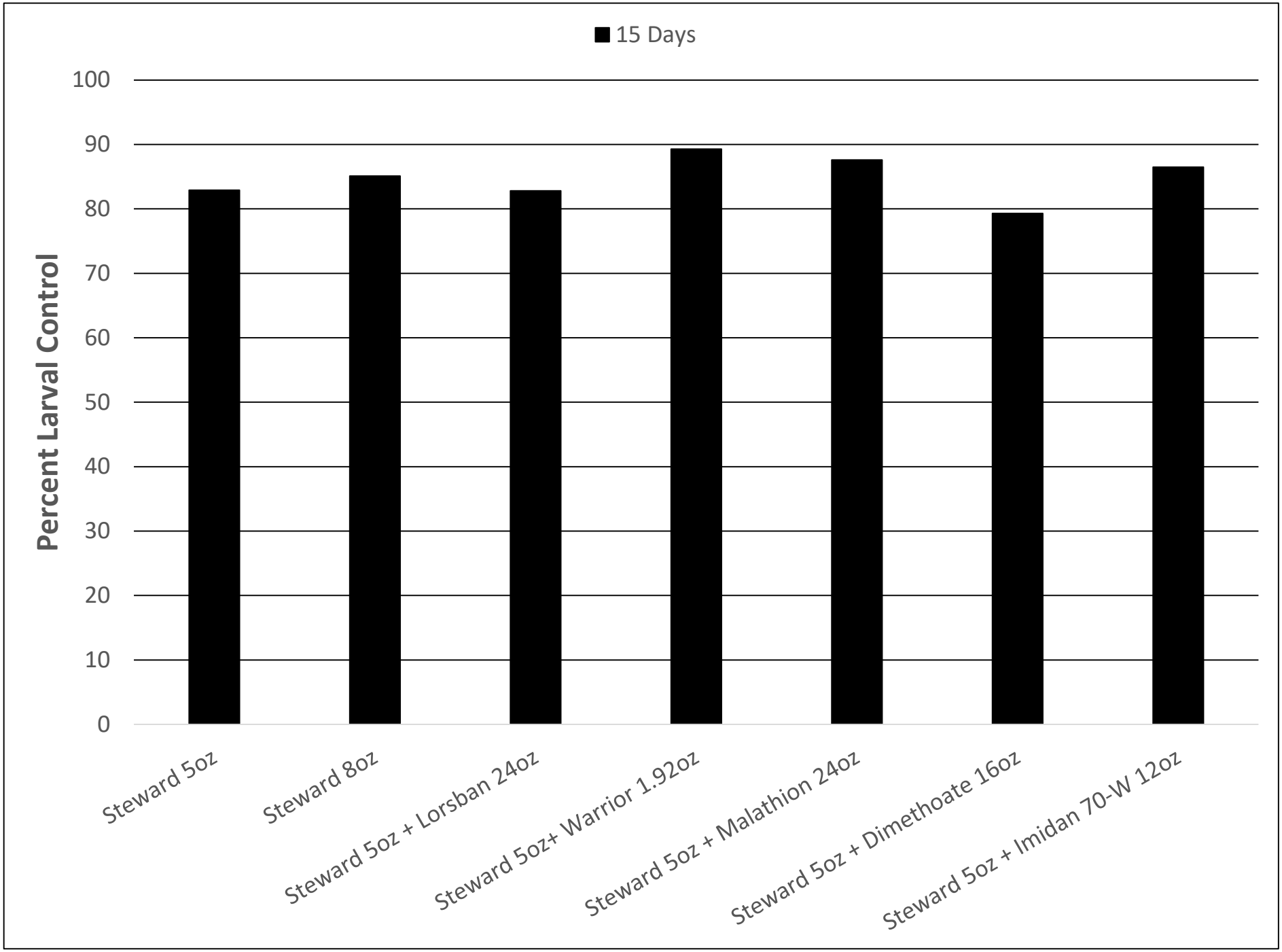

Alfalfa Weevil Numbers in Untreated Control Plots
Weevils per sweep
50
45
40
35
30
25
20
15
10
5
0
5/12
5/14
5/16
5/18
5/20
5/22
5/24
5/26
5/28
5/30
Date

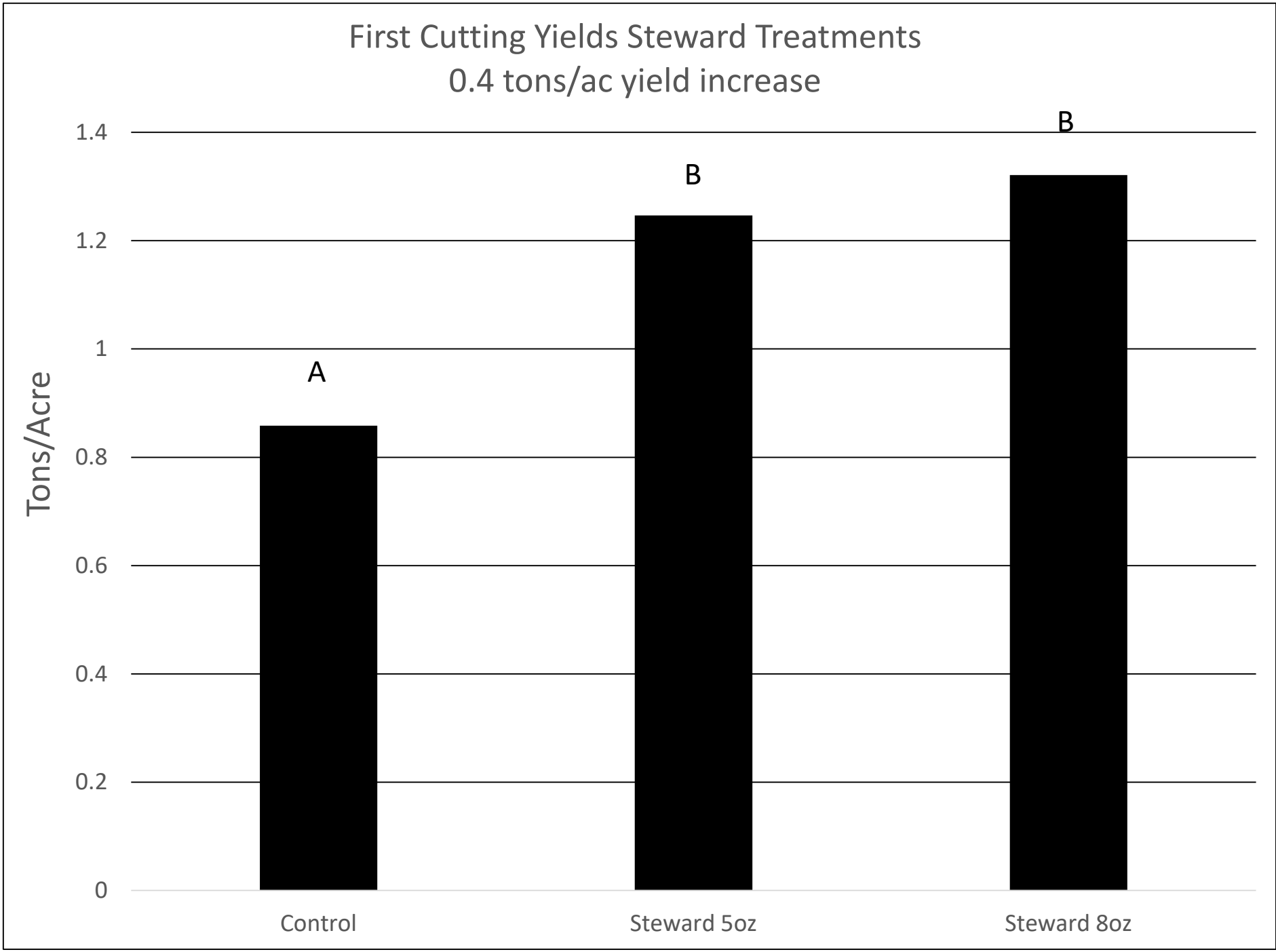

4 Days
Percent Larval Control
100
90
80
70
60
50
40
30
20
10
0
Imidan 70-W 16oz
Imidan 70-W 16oz + Dimethoate 16oz
Lorsban 32oz
Warrior 1.92oz
Warrior 1.92oz + Lorsban 32oz
Malathion 8E 1.5pt
Steward 5oz
Steward 8oz


10 Days
Percent Larval Control
100
90
80
70
60
50
40
30
20
10
0
Imidan 70-W 16oz
Imidan 70-W 16oz + Dimethoate 16oz
Lorsban 32oz
Warrior 1.92oz
Warrior 1.92oz + Lorsban 32oz
Malathion 8E 1.5pt
Steward 5oz
Steward 8oz


15 Days
Percent Larval Control
100
90
80
70
60
50
40
30
20
10
0
Imidan 70-W 16oz
Imidan 70-W 16oz + Dimethoate 16oz
Lorsban 32oz
Warrior 1.92oz
Warrior 1.92oz + Lorsban 32oz
Malathion 8E 1.5pt
Steward 5oz
Steward 8oz

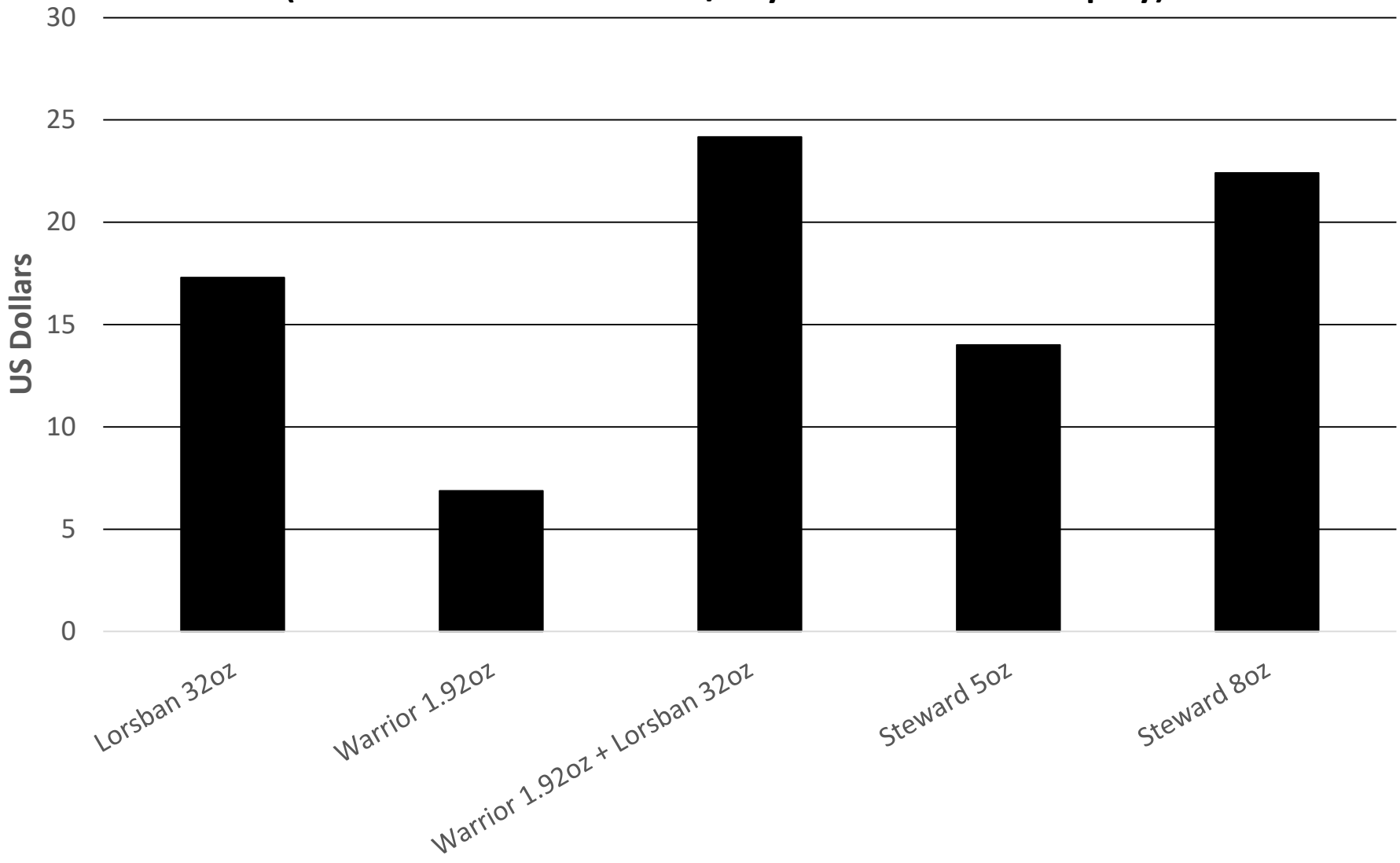

23 Days
Percent Larval Control
100
90
80
70
60
50
40
30
20
10
0
Imidan 70-W 16oz
Imidan 70-W 16oz + Dimethoate 16oz
Lorsban 32oz
Warrior 1.92oz
Warrior 1.92oz + Lorsban 32oz
Malathion 8E 1.5pt
Steward 5oz
Steward 8oz


15 Days
Percent Larval Control
100
90
80
70
60
50
40
30
20
10
0
Steward 5oz
Steward 8oz
Steward 5oz + Lorsban 24oz
Steward 5oz+ Warrior 1.92oz
Steward 5oz + Malathion 24oz
Steward 5oz + Dimethoate 16oz
Steward 5oz + Imidan 70-W 12oz


First Cutting Yields Steward Treatments
0.4 tons/ac yield increase
Tons/Acre
1.4
1.2
1
0.8
0.6
0.4
0.2
0
A
B
B
Control
Steward 5oz
Steward 8oz

Cost of Select Insecticides per Acre for Weevil Control

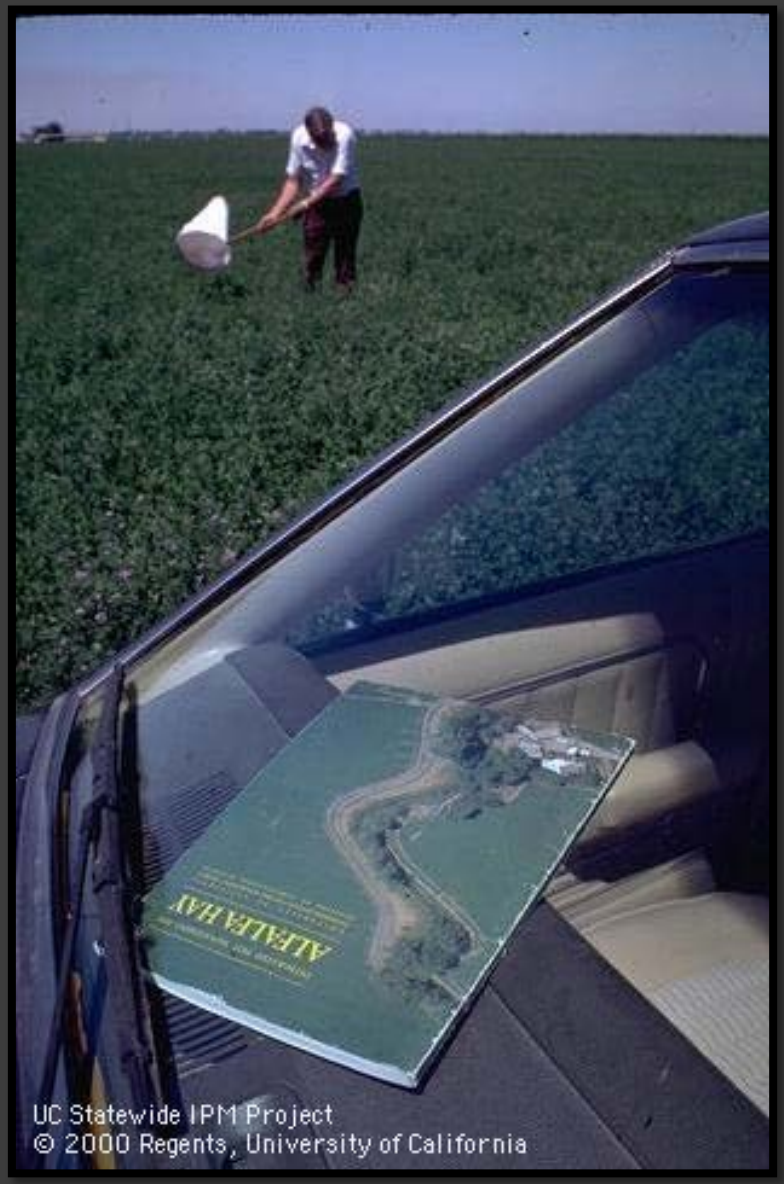
If hay $200/ton and spray costs $20, only need 0.1 tons yield increase to justify spray (Orloff data shows 0.4 tons/ac yield increase from spray)



Economic Threshold Levels

- Spray Timing: Monitor weevils and time sprays to get good control (too early and may have to treat 2x).

- Current threshold: 20 weevils per sweep (likely closer to 8-10 weevils per sweep as value of hay is higher than in 1970's).



- For stubble stands that are too short to sweep, monitor visually for weevil damage.

Alfalfa can recover (regrow) from weevil damage, depending on weevil pressure and time to first cutting (doesn’t stunt growth, except perhaps stubble fields).

Future Research Needs

- New insecticide chemistries (ai's) for alfalfa weevil control
- Re-evaluate weevil threshold levels
- Understand weevil strains in California
- Develop resistant plant varieties: Plant incorporated protectants such as increased tannins for weevil resistance and better feed value (less bloat)

Focus of current work with a CA DPR grant awarded to Dr. Godfrey (now managed by D. Putnam and R. Long, 2016-19).

This presentation is dedicated to our colleague and friend, Steve Orloff.
May you be surfing an eternal wave!

Sources

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