Reduced Area+Agent Treatments (RAATs): Do More With Less

“The purpose of grasshopper management is to keep good stewards on the land - to keep those people who live with the Land, on the Land.” - National Grasshopper Management Board motto

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ESM Dept., College of Agriculture

[Image of University of Wyoming logo]
Rangeland forage is hard to value!

The forage it produces isn’t “worth” much unless you can’t replace it to keep your livestock…
WY Historic Grasshopper Outbreak Frequency Map
1944-1994
A typical grasshopper eats vegetation equaling its weight daily. Some grasshopper species can “waste” 6 times more than they eat.

Adult male migratory grasshopper
Adult male and female average body mass = 0.6 grams
At 30/yd ~ 100lbs of grasshoppers per acre
Impact on Species of Concern

Insects, including grasshoppers, are part of important component in the early diet of sage grouse chicks.
Grasshopper outbreaks can also be a detriment to wildlife

Migratory grasshopper (*Melanoplus sanguinipes*) feeding on silver sagebrush (*Artemisia cana*) in Whalen Canyon, Platte Co., WY circa 1992
Reduced Area+Agent Treatments strategy (RAATs)

Integrated Pest Management (IPM)
For Grasshoppers
Grasshopper Treatment Application Strategies:
Conventional/Blanket/100% VS. RAATs
How RAATs Works:

- Grasshoppers killed directly in the treated swaths
- More grasshopper predator insects survive insecticide in untreated swaths
- Grasshoppers continue to move into treated strips
- Nesting birds continue to feed on grasshoppers

*Side benefit - Less disruption to bio-control agents of weeds (APHIS has this data on Aphthona spp. beetles on leafy spurge in Montana)*
## Blanket vs. RAATs: Control

Control can be 5 to 15% lower than conventional blanket methods.

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>oz./coverage%</th>
<th>Method</th>
<th>% Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbaryl</td>
<td>16/100</td>
<td>Standard</td>
<td>85-95</td>
</tr>
<tr>
<td></td>
<td>8/50</td>
<td>RAAT</td>
<td>75-85</td>
</tr>
<tr>
<td>Malathion</td>
<td>8/100</td>
<td>Standard</td>
<td>90-99</td>
</tr>
<tr>
<td></td>
<td>4/80</td>
<td>RAAT</td>
<td>75-85</td>
</tr>
<tr>
<td>Diflubenzuron</td>
<td>2/100</td>
<td>Standard</td>
<td>95-99</td>
</tr>
<tr>
<td></td>
<td>0.75/50</td>
<td>RAAT</td>
<td>80-90</td>
</tr>
</tbody>
</table>
Some Comments on Efficacy

• It costs a lot to kill them all when you don’t need to.

• Don’t need immediate kill on rangeland.

• Surviving grasshoppers provide a prey base for the predators and parasitoids. This helps to keep grasshoppers at normal densities in future years.

• We haven’t observed any resurgence the following year in RAATs protected areas.
Major Pest Species
Hatch Mid-May Thru June

Optimal for treatments
Minimum Recommended Treatment:
0.75 oz of diflubenzuron - RAAT- 50% Coverage
with at least 8 oz of water, 3 oz canola oil and 1 oz C.O.C.
per treated acre

Spray Swath 100 -150ft
Vegetable oils and grasshoppers: Used as spray adjuvants, canola oil can help increase control and/or take the place of some insecticide.
Diflubenzuron  
(Dimilin® 2L and Cavalier® 2L)  
Insect Growth Regulator class (chitin synthesis inhibitor)

PROS: Safety (honey bees, people, etc.)  
Long Residual (better for RAATs)  
Reliable Results  
Temperature Range

CONS: Timing!!! (only kills nymphs outright)  
Potential harm to aquatic insects*  
  (*Safe for fish directly but, like all insecticides, it will kill insects living in water)
Insects are killed when they grow to a next developmental stage.

Normal molt

Unsuccessful molt after Dimilin application
Grasshopper Crop Pest Nymphs

Migratory

Differential

Twostriped

Redlegged

Extended hatching period, up to 52 days!
Pest grasshoppers often lay their eggs in un-tilled field borders. However, no-till, minimum till, and some implements like sweeps may allow grasshopper eggs to survive in crop fields. Protect the crop before grasshoppers get into it by treating these areas early and often as necessary!
Crop Pest Grasshopper Management

Differential grasshopper egg pods avg. 45-194 eggs
Density 40/yd²
20 females out of 40
Each female – 1 avg. egg-pod = 900 eggs/yd²

Egg density in field borders can be VERY HIGH!
Let’s put this in perspective

- 40 acre crop field with a 15 ft border
- = 38.2 acres of crop and 1.8 acres of pest grasshopper habitat
- If just 200 gh eggs per sq. yard are laid in border
- And all hatch and survive and spread over field, that is 9.5 grasshopper per sq YARD!
Current UW Recommendation for Row Crop Protection

- Spray that 1.8 acres once between May 20-31, Scout it and spray again, if nymphs are present, June 20-30, repeat if necessary, around July 20-31.
- I would use diflubenzuron (Dimilin 2L, Cavalier 2L) at the label maximum for non-crop with volume and adjuvant matching my spray equipment and plant cover.

NON-CROP AREA RESTRICTIONS: See Grassland section for restrictions

GRASSLAND RESTRICTIONS: Do not exceed a total of 2 fl oz per acre per cutting. Do not exceed a total of 6 fl oz per acre per year. Allow at least 1 day after treatment before cutting grass. Apply only when the potential for drift to adjacent sensitive areas (e.g. residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g. when wind is blowing away from the sensitive areas).-
Ways to treat small areas

ATV Boomless nozzle spray pattern
## 2004 ATV-RAAT Adjuvant Trial

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pre. Density #/m²</th>
<th>21d Post Density #/m²</th>
<th>Corrected Mortality %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimilin w/ Only Water</td>
<td>39</td>
<td>6</td>
<td>79%</td>
</tr>
<tr>
<td>Dimilin w/ Mo-Bait</td>
<td>37</td>
<td>4</td>
<td>86%</td>
</tr>
<tr>
<td>Dimilin w/ C.O.C</td>
<td>33</td>
<td>3</td>
<td>89%</td>
</tr>
<tr>
<td>Dimilin w/ Canola oil</td>
<td>36</td>
<td>2</td>
<td>93%</td>
</tr>
</tbody>
</table>
Many different spray setups

Many products including poison bait for grasshoppers
Accurate and Timely Survey is Critical for Efficient Control

- Grasshopper density assessment
- Species composition
- Developmental stages (age structure of population)
- Acreage infested
- USDA-APHIS-PPQ can help
“Typically, 14 grasshoppers per square equals a 30% forage loss on northern mixed grass prairie in the course of a growing season.”

Rangeland is a resilient “crop” with a low value per acre unless, you can’t replace the forage lost.

(Some rangeland pest grasshopper species may move into cropland)

Economic Injury Level = Damage > Treatment cost

Typical Economic Threshold ≈ 15-20 grasshoppers per square yard*

*Variation with timing, species, efficacy, cost, etc.
Diflubenzuron
(Dimilin® 2L and Cavalier® 2L)
Benzoyl-Urea; IGR class (chitin synthesis inhibitor)

PROS: Safety (honey bees, people, etc.)
   Residual (RAATs)
   Reliable Results
   Temperature Range

CONS: Timing!!! (only kills nymphs outright)
   Harm to aquatic insects*

(*Safe for fish directly but, like all insecticides, it will kill insects living in water)
TOXICITY to MAMMALS
3 most common rangeland insect insecticides

*Oral LD$_{50}$ of active ingredients for rats (in mg/kg):*

- Malathion - 2,100 (1,000-10,000)
- Carbaryl - 450 (250-850)
- Diflubenzuron - $>4,640$

*Dermal LD$_{50}$ of active ingredients for rats (in mg/kg):*

- Malathion - $>4,000$
- Carbaryl - $>2,000$ (rabbit)
- Diflubenzuron - $>10,000$
HAZARD to GAME BIRDS

Malathion: \( \text{LD}_{50} 167 \text{ mg/kg} \)
Carbaryl: \( \text{LD}_{50} 2,000 \text{ mg/kg} \)
Diflubenzuron: \( \text{LD}_{50} 3,763 \text{ mg/kg} \)

Applied at labeled dose rates, the area of 1 square foot will receive:

- Malathion: 5.3 mg
- Carbaryl: 2.3 mg
- Diflubenzuron: 0.16 mg

To pick up a 50% lethal dose, a 2 ¼ lb bird would have to consume all the pesticide applied to:

- 32 square feet with Malathion:
- 900 square feet with Carbaryl
- 21,780 square feet (½ acre) with Diflubenzuron:
## HAZARD to FISH
(brown, rainbow, and cutthroat trout)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Malathion <em>Fyfanon</em></th>
<th>Carbaryl <em>Sevin</em></th>
<th>Diflubenzuron <em>Dimilin</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toxicity (LC$_{50}$ mg/L)</strong></td>
<td>0.1</td>
<td>1.3</td>
<td>240</td>
</tr>
<tr>
<td><strong>Relative Toxicity</strong></td>
<td>2,400x</td>
<td>184.6x</td>
<td>1.0x</td>
</tr>
<tr>
<td><strong>Exposure (oz and [g a.i./ac])</strong></td>
<td>8 [227]</td>
<td>16 [100]</td>
<td>1 [7]</td>
</tr>
<tr>
<td><strong>Relative Exposure</strong></td>
<td>32.4x</td>
<td>14.3x</td>
<td>1.0x</td>
</tr>
<tr>
<td><strong>Hazard (Rel. Tox. x Rel. Exp.)</strong></td>
<td>77,760</td>
<td>2,639.8</td>
<td>1</td>
</tr>
<tr>
<td><strong>Hazard relative to Diflubenzuron</strong></td>
<td>~80,000x</td>
<td>~2,600x</td>
<td>1x</td>
</tr>
</tbody>
</table>
Diflubenzuron and Honey Bees

Multiple studies early in product development:

Repeated exposure of bee colonies to six or eight, consecutive Dimilin applications of 57 to 140 g a.i./acre presented no hazard to adult honey bees or to their brood. (454 grams = 1 pound)

For comparison:
In grasshopper control, a single Dimilin application at a rate of 7 g a.i./acre is used. This reduces the already low hazard by 8 to 20 times.

Resources from Oregon State University
http://extension.oregonstate.edu/catalog/abstract.php?seriesno=PNW+591
“How to Reduce Bee Poisoning from Pesticides” - PNW 591, December 2006
RAATs Exceptions

Higher rates or coverages may be needed if:

- treatments are applied to **late instar nymphs** (especially if using diflubenzuron {Dimilin 2L and equivalent generics},
- grasshopper densities are extreme
- forage cover is tall or dense, or terrain is extremely rough (more surface area effectively reduces insecticide rate).

You can use grasshopper management software (**CARMA** or **HOPPER**) should be used to assess a program. Apply insecticides in accordance with label directions and established guidelines for buffers around water, bees, and human habitations.
CARMA: The CAse-based Range Management Advisor

Version: 4.0 Jan 27, 2004

Copyright © 1996-2004 University of Wyoming and University of Nebraska

Program development: John D. Hastings and L. Karl Branting
Concept & design: John D. Hastings, L. Karl Branting, Jeffrey A. Lockwood
Entomological & pest management expertise: Jeffrey A. Lockwood, Alexandre V. Latchininsky, Scott P. Schell

What is it?

CARMA produces advice about the most economical responses to Wyoming grasshopper infestations. For rangeland infestations, CARMA does this by predicting the proportion of available forage that will be consumed by grasshoppers and estimating the economic returns of various treatment options. The information required to make the forage loss prediction includes the date, the infestation location on a Wyoming map, the range value and infestation history of the location, the number of grasshoppers per square yard, the grasshopper type and age distribution, the relative recent precipitation and temperatures, and the total area infested (including adjacent neighbors’ lands). CARMA also includes a prototype crop protection module that gives advice about cropland grasshopper infestations using accepted cropland protection rules.

Access the CARMA Program at:
carma.unk.edu
The newest version of CARMA can be run from Prof. Hasting's website: http://carma.unk.edu/

The following table contains treatment data. Ensure the correctness of the data before continuing. Click OK to exit and accept any changes, or Restore to revert back to the initially shown settings. Click Add to add a new treatment to the bottom of the table (you may need to use the vertical scroll bar to see the new treatment row) and enter its settings, or Remove to remove a treatment highlighted by clicking in its leftmost column. Sort rows by right-clicking on a column header and left-clicking of the sort widget above the vertical scroll bar.

<table>
<thead>
<tr>
<th>#</th>
<th>Treatment name</th>
<th>Rate of agent (fl. oz. or lbs. per acre)</th>
<th>Carrier</th>
<th>Non-aqueous carrier rate (fl. oz. or lbs. per acre)</th>
<th>Coverage (% of infestation)</th>
<th>Agent cost ($ per gal. or lb.)</th>
<th>Cost of non-aqueous carrier ($ per gal. or lb.)</th>
<th>Cost of application ($ per acre)</th>
<th>Efficacy % (low)</th>
<th>Efficacy % (high)</th>
<th>Exclude it</th>
<th>Total cost ($ per protected acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Carbaryl RAATs-water</td>
<td>8 oz</td>
<td>water</td>
<td>8 oz</td>
<td>50</td>
<td>30.00</td>
<td>0.00</td>
<td>1.25</td>
<td>80</td>
<td>90</td>
<td>...</td>
<td>1.56</td>
</tr>
<tr>
<td>4</td>
<td>Carbaryl RAATs-canola</td>
<td>4 oz</td>
<td>canola oil</td>
<td>8 oz</td>
<td>50</td>
<td>30.00</td>
<td>3.30</td>
<td>1.25</td>
<td>80</td>
<td>90</td>
<td>...</td>
<td>1.21</td>
</tr>
<tr>
<td>5</td>
<td>Carbaryl bait</td>
<td>0.5 lb</td>
<td>wheat bran</td>
<td>2.0 lb</td>
<td>100</td>
<td>0.94</td>
<td>0.10</td>
<td>3.60</td>
<td>70</td>
<td>85</td>
<td>...</td>
<td>4.17</td>
</tr>
<tr>
<td>6</td>
<td>Dimilin</td>
<td>1 oz</td>
<td>crop oil (w/ twice as much water)</td>
<td>8 oz</td>
<td>100</td>
<td>215.00</td>
<td>3.80</td>
<td>1.25</td>
<td>90</td>
<td>95</td>
<td>...</td>
<td>3.17</td>
</tr>
<tr>
<td>7</td>
<td>Dimilin RAATs-crop oil</td>
<td>0.75 oz</td>
<td>crop oil (w/ twice as much water)</td>
<td>4 oz</td>
<td>50</td>
<td>215.00</td>
<td>3.30</td>
<td>1.25</td>
<td>90</td>
<td>95</td>
<td>...</td>
<td>1.17</td>
</tr>
<tr>
<td>8</td>
<td>Dimilin RAATs-canola oil</td>
<td>1 oz</td>
<td>canola oil (w/ twice as much water)</td>
<td>8 oz</td>
<td>33</td>
<td>165.00</td>
<td>3.90</td>
<td>1.25</td>
<td>90</td>
<td>95</td>
<td>...</td>
<td>0.92</td>
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<tr>
<td>9</td>
<td>Malathion</td>
<td>0 oz</td>
<td>none</td>
<td>0 oz</td>
<td>100</td>
<td>6.00</td>
<td>0.00</td>
<td>1.25</td>
<td>65</td>
<td>95</td>
<td>...</td>
<td>1.62</td>
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<td>10</td>
<td>Malathion RAATs</td>
<td>4 oz</td>
<td>none</td>
<td>0 oz</td>
<td>80</td>
<td>6.00</td>
<td>0.00</td>
<td>1.25</td>
<td>80</td>
<td>90</td>
<td>...</td>
<td>1.15</td>
</tr>
<tr>
<td>11</td>
<td>Nosema bait</td>
<td>1 lb</td>
<td>wheat bran</td>
<td>1 lb</td>
<td>100</td>
<td>5.00</td>
<td>0.10</td>
<td>3.50</td>
<td>50</td>
<td>70</td>
<td>...</td>
<td>6.60</td>
</tr>
</tbody>
</table>
Apply insecticides in accordance with label directions and established guidelines for buffers around water, bees, and human habitations.
2019 Grasshopper forecast

50% chance of grasshoppers!
Alfalfa Hay Fields?

diflubenzuron (Dimilin 2L, Cavalier 2L) has alfalfa hay label

ONLY grasshopper nymphs are killed (IGR)! Slow acting.

We never did any research with it as alfalfa was considered a high value crop that warranted full coverage treatment with fast acting pesticide.
If the grasshoppers are in the crop see the:
High Plains IPM website

or Google “HPIPM”

For current labeling on these crops:
Alfalfa, Alfalfa Seed
Camilena, Canola, Carrot, Cole Crops
Cucurbits, Dry Beans, Pepper, Tomato
Field Corn, Lettuce, Millet, Safflower, Amaranth
Mint, Onion, Potato, Pulse Crops, Range / Pasture
Small Grains, Sorghum, Spinach,
Sugarbeets, Sunflower, Sweet corn
Favoring Grasshoppers

- Many eggs are in the ground, even if hatching/spring survival is low we may have outbreak levels again.

- Long mild fall probably allowed all eggs to develop to the stage that can over-winter
Abbreviated History of RAATs Strategy

1995 – 2002: UW and Cooperators: 240 40 acre+ plots and 16 large plots

1998 – 1999: APHIS conducts successful RAAT tests in South Dakota

1997 – 2001: Used in Russia and central Asian countries

2001 - Tested versus blanket coverage in CA on extreme grasshopper densities

1999 – 2001: Used in Utah and Nevada on grasshoppers and Mormon crickets

2000 – 2001: Used on large outbreaks in Oregon

1999 – 2018: Millions of acres protected in Western US
Aerial chemical crop protection [1945]

Treated swath: 75-90 ft
Untreated swath: 135-150 ft

UW RAATs brochure

Treated swath: 100 - 150 ft
Untreated swath: 100-150 ft
Canola oil - Is it worth it?

Canola was lower in price than petroleum based crop oil concentrate (C.O.C.) in the late 1990s.

A few years ago Platte Co. Weed & Pest was quoted these prices:

- Canola - $6.25/ gallon
- C.O.C - $5.69/ gallon

Per 1,000 acres treated, it will be $15 more expensive to use the canola-C.O.C oil mixture for the carrier at that price difference.

MSO – Methylated Seed Oil is also a viable, NON-attractive oil spray adjuvant. However, it won’t take canola oil into solution.
Why were the “grasshoppers late” in 2018?

Little spurthroated species – *(Melanoplus infantilis)* in collections

Intermediate hatching species – up to 21 days later than migratory

Grass and forb feeding pest at high densities
THE RAATs CONCEPT:

Environmental Motivation

1) Exploiting grasshopper behavior allows effective IPM.

2) The untreated swaths allow the survival and re-colonization of beneficial and non-target species.

3) Less insecticide means less risk to human and environmental health.
THE RAATs CONCEPT:

Economic Motivation

1) Assume 50% of cost is insecticide and 50% is application. (This varies year to year with cost of insecticides, fuel, and size of treatment program)

2) Example total cost of a program is $4.60 per treated acre

3) Results:
   Application = $2.30/2 = $1.15
   Insecticide = $2.30/2 = $1.15

Total cost per protected acre = $2.30