USDA Animal and Plant Health Inspection Service
U.S. DEPARTMENT OF AGRICULTURE

Grasshopper: Ecology & Economics

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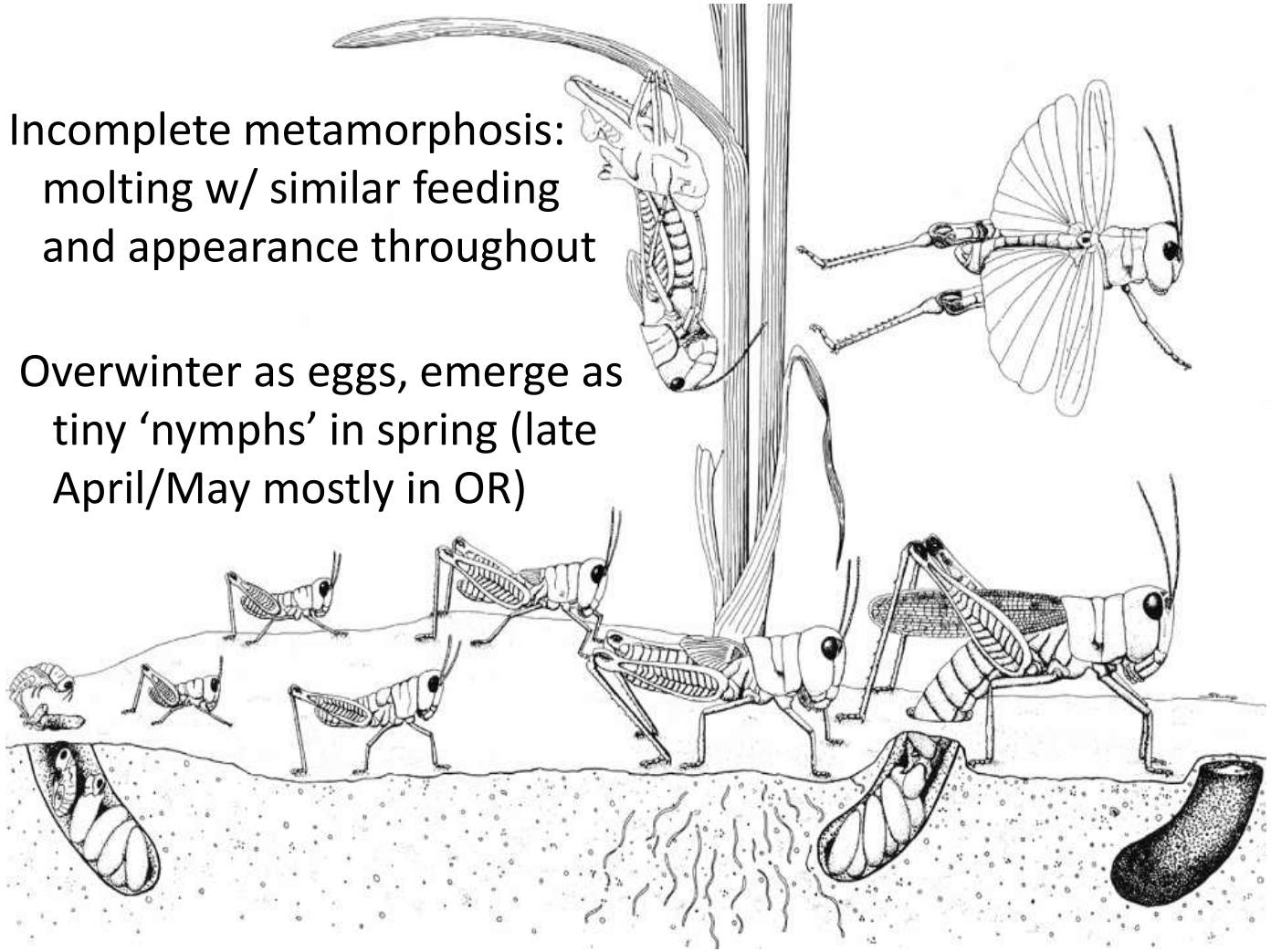
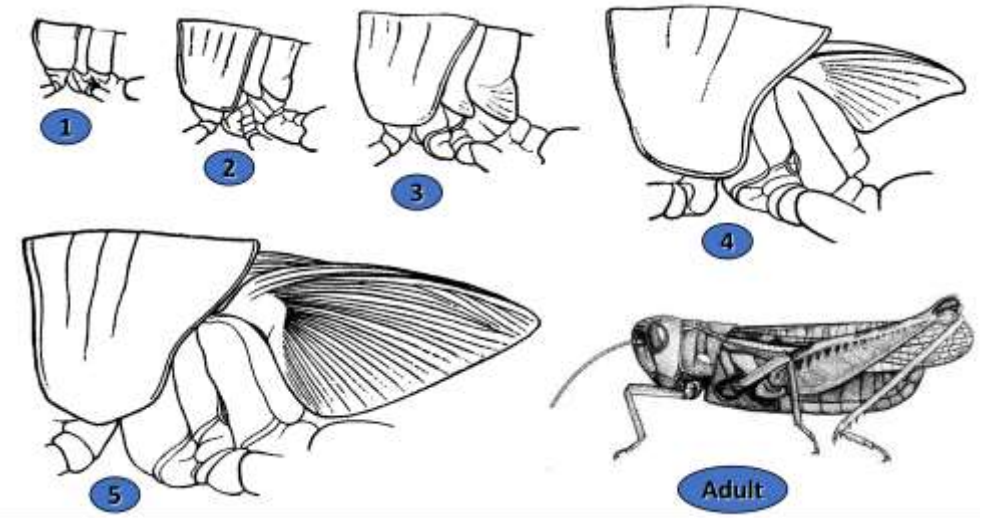
Grasshopper Biology: Life-Cycle

One generation per year. Most stages quite mobile, with migration during season common

Incomplete metamorphosis: molting w/ similar feeding and appearance throughout

Overwinter as eggs, emerge as tiny ‘nymphs’ in spring (late April/May mostly in OR)





Several nymphal stages or ‘instars’ with molting between each: developing ‘wing-pads’, increased size and mobility

Nymphal stages typically 30-40 days total, followed by 40-60 days more as Adults

Sexual reproduction and ‘ovipositing’ 1-4 egg-pods of <80 eggs per female

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Grasshopper Biology: Morphology

Melanoplus sanguinipes

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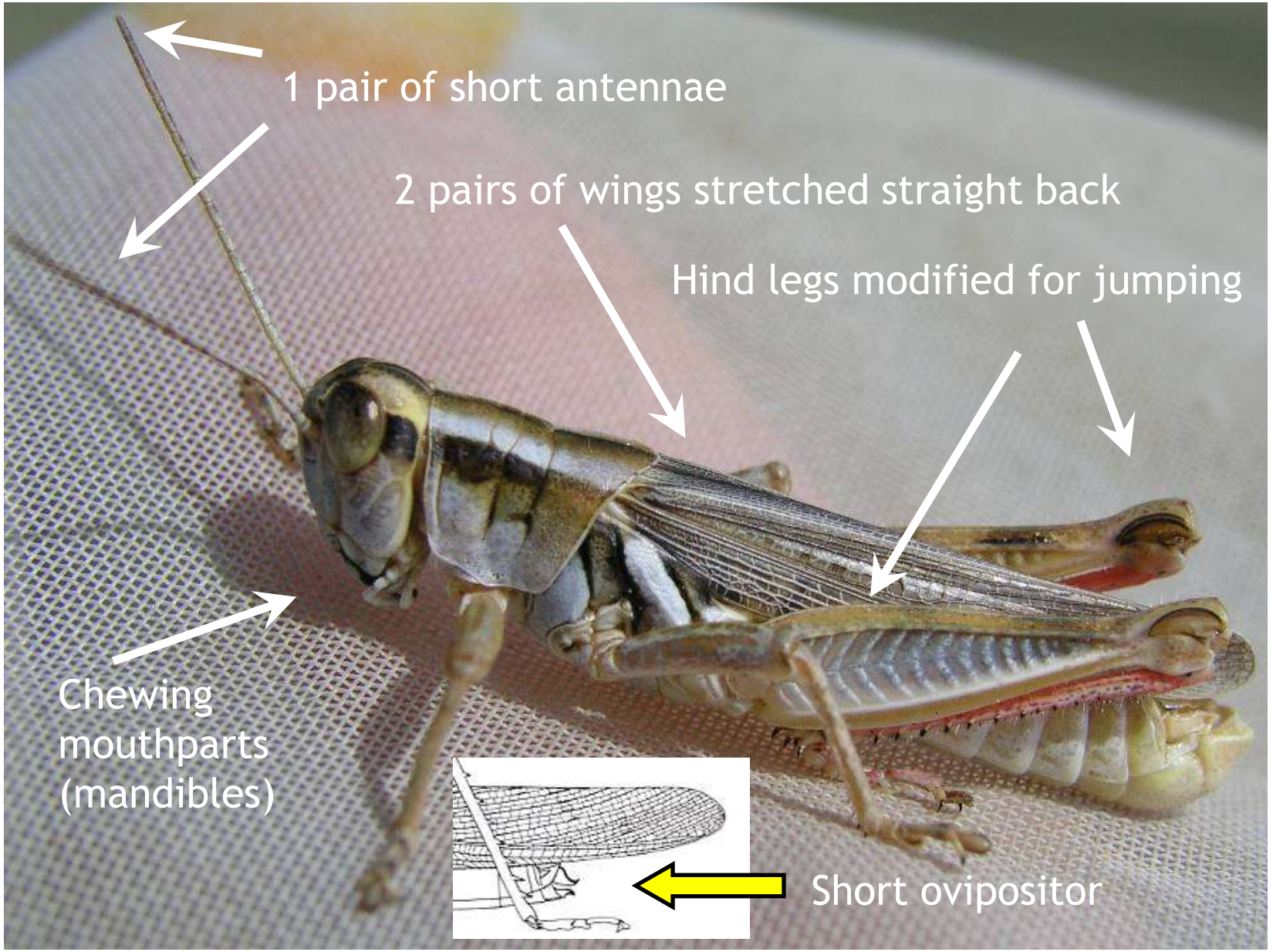
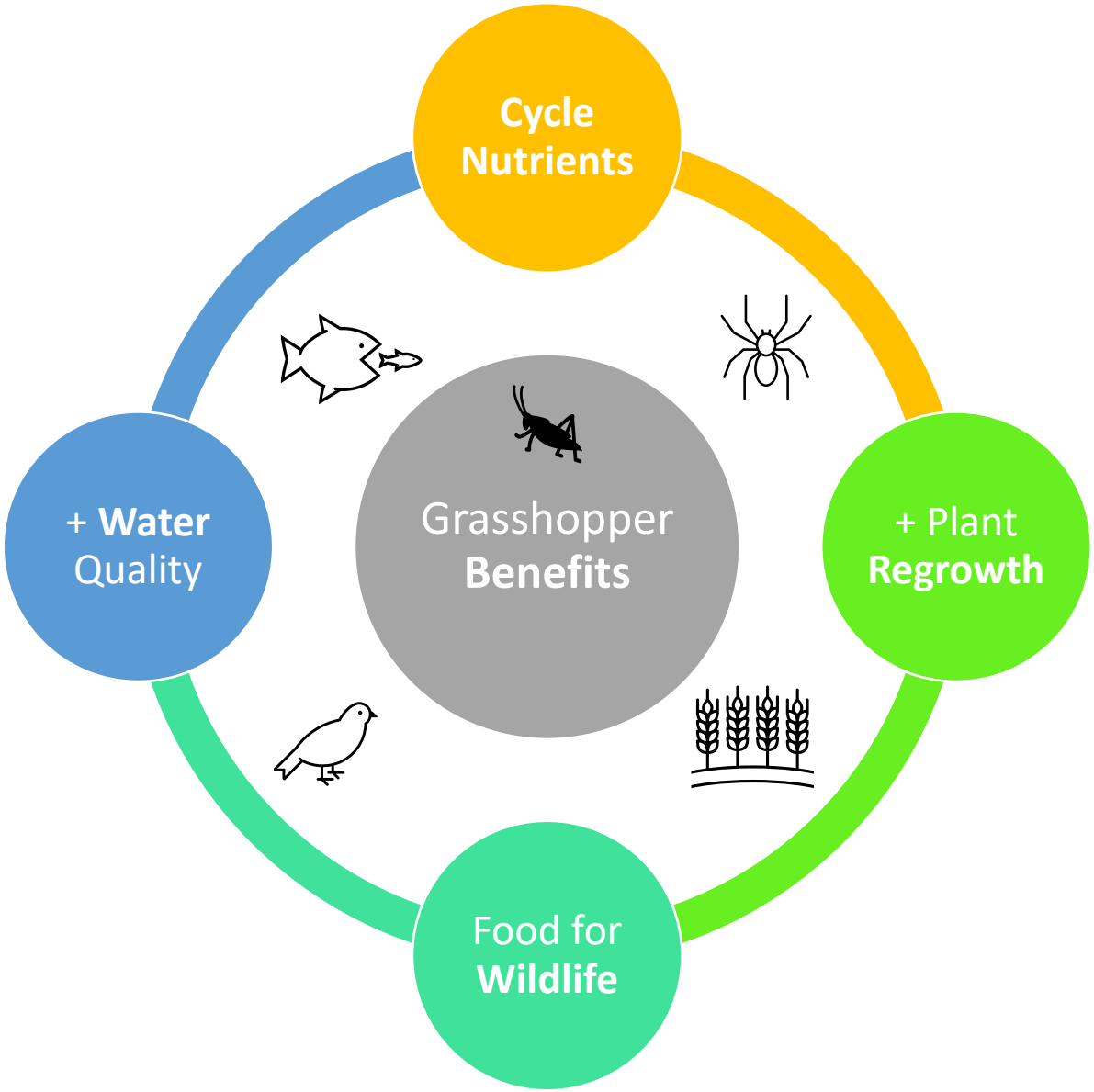
Grasshopper Biology: Morphology





100s of species!

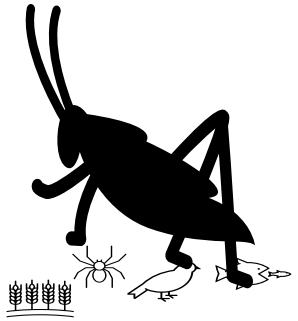
<10% economic pests

Coevolved / Native

A few eat *only* economic weeds

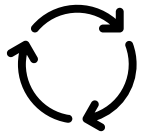
Grasshopper (GH) Pest Economics

Pest? If/when damage *out-weighs* benefits

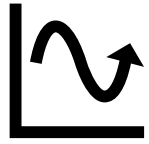


World-wide: GH among top economic pests…

during **Outbreaks** (population booms)



Cyclical pests



Grasshopper Pest Species in Oregon (ranked by economic impact):

Melanoplus sanguinipes		Migratory
Camnula pellucida		Clear-winged
Aulocara elliotti		Big-headed
Oedaleonotus enigma		Valley
M. bivittatus		Two-striped
M. femurrubrum		Red-legged
Ageneotettix deorum		White-whiskered
M. packardii		Packard
M. foedus		Striped sand

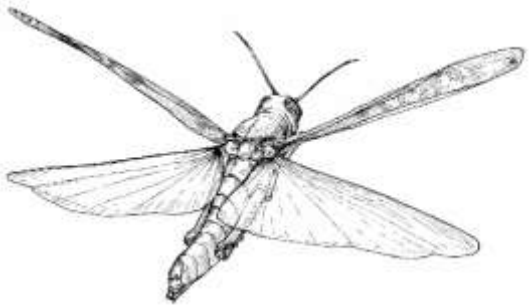
 Dryland prairie adapted but boosted by bare ground / erosion

 Boosted by lush growth / irrigated crops

 Boosted by ‘weeds’

IPM Handbook: Field Guide to Common Western Grasshoppers

Favor mesic sites (seasonal wetlands) in drought, pop. grow rapidly with long lush growing seasons, excellent fliers.



Clearwinged Grasshopper

***Camnula pellucida* (Scudder)**

Distribution and Habitat

The clearwinged grasshopper, *Camnula pellucida* (Scudder), is distributed widely in North America. It inhabits a variety of grasslands including the northern mixedgrass prairie, the bunchgrass prairie, and mountain meadows. A resident population lives in a mountain meadow at 10,800 feet in Colorado, just below timberline.

Economic Importance

The clearwinged grasshopper is a severe pest of small grains and grasses. It is most destructive early in the season when it often completely destroys spring wheat. Outbreaks on rangelands may devastate grass forage in areas as large as 2,000 square miles. A population with a density of 20 adults per square yard will consume the entire available yield of forage grasses on rangelands of British Columbia. Cage plot tests on native grassland of interior British Columbia showed that the feeding of this grasshopper during its nymphal life reduced the yield of Kentucky bluegrass by 5.1 pounds (dry weight) per acre for each grasshopper per square yard. An infestation of one young adult per square yard reduced yield 1 pound per day over 1 acre. Swarms may invade vegetable crops and feed preferentially on onions, lettuce, cabbage, and peas. The clearwinged grasshopper is a small species. The live weight of males collected from an open, grassy area of the Big Horn Mountains, Wyoming averaged 201 mg, and of females 605 mg (dry weight: males 55 mg, females 105 mg).

Geographic range of *Camnula pellucida* (Scudder)

Food Habits

The clearwinged grasshopper feeds mainly on grasses. It prefers succulent plants of western wheatgrass, reed canarygrass, barley, and wheat. Field observations at several locations show that it feeds heavily on many species of grasses, including fescues (Idaho fescue and red fescue), bluegrasses (Sandberg bluegrass and Kentucky bluegrass), wheatgrasses (western wheatgrass and crested wheatgrass), bromes (downy brome, smooth brome, and soft brome), and slender hairgrass. These grasses are not equally nutritious. The most favorable diets of single species consist of red fescue, three species of bluegrass, wheat, crested wheatgrass, and intermediate wheatgrass. In its natural habitat, the clearwinged grasshopper consumes small amounts of forbs such as fireweed and several species of legumes.

Migration and Dispersal

Myriads of the clearwinged grasshopper hatch in egg beds that may contain as many as 3,000 to 100,000 eggs per square foot. Pressure of high densities and depletion of food result in movement of the young nymphs away from egg beds to the nearest green vegetation. Immature grasshoppers continue to disperse through all of the nymphal stage. The older instars march in cohesive bands.

Adults may migrate long distances in huge flying swarms at either low or high altitudes, but in recent years only small swarms in flights of short duration have been observed. These flights may occur in the afternoons of hot, sunny days. Masses take off into a gentle wind and fly distances of one hundred to several hundred yards. When egg laying begins, migration ceases but females fly back and forth between feeding grounds and egg beds. They move to the egg beds during the heat of the day for oviposition. After a particular female deposits a clutch of eggs, she flies back to the feeding grounds in the evening or the next morning and stays there until another batch of eggs is mature. The males appear to remain on the egg beds outnumbering and attending the females as they oviposit. Males eventually die on the egg beds.

Migratory behavior is not characteristic of all populations of the clearwinged grasshopper. Individuals infesting sodded pasture near Harney, Minnesota, exhibited little movement. Nymphs developed to maturity close to where they had hatched and the adults showed little tendency to migrate, flying only short distances.

Instar 1

1. BL 4.2-5.5 mm FL 2.4-2.7 mm AS 11-13.

Instar 2

2. BL 5-7.1 mm FL 3.4-3.8 mm AS 14-16.

Instar 3

3. BL 7.3-8.9 mm FL 4.7-5.2 mm AS 18.

Instar 4

4. BL 10-14.15 mm FL 6-7.2 mm AS 20-22.

Instar 5

5. BL 14-20 mm FL 8.4-9.9 mm AS 22-25.

Figures 1-5. Appearance of the five nymphal instars of *C. pellucida* - their sizes, structures, and color patterns. Notice progressive development of the wing pads. BL = body length, FL = hind femur length, AS = antennal segments number.

Mating and egg laying occurred in the same area where eggs had been deposited the previous year.

Identification

Adults of the clearwinged grasshopper are of medium size, yellow to brown, and possess mottled forewings and transparent hindwings (Fig. 8). The forewings have along their angles light stripes that in the resting grasshopper with closed wings converge near the middle. The male (Fig. 6) is noticeably smaller than the female (Fig. 7). First instar nymphs are strikingly colored cream, tan, and black (Fig. 1).

The nymphs (Fig. 1-5) are identifiable by their color patterns and external structures:

(1) Head with lateral foveolae triangular (Fig. 9). Usually a dark bar crosses transversely across front of head under antennal sockets, across lower part of compound eyes, and onto sides of head.

(2) Pronotum with median carina low but uniformly elevated; median carina entire (without notch) in early instars, notched once in front of middle in the older instars (Fig. 9). Pronotum with lateral carinae clearly defined (Fig. 9).

(3) Hind tibia fuscous in [illegible] instar, fuscous or tan in fourth and fifth instars.

[No Title]

Hatching

The clearwinged grasshopper is an early-hatching species. Eggs begin embryonic growth in the summer of deposition and continue until they attain 50 percent of development (Stage 19). To reach the advanced stage, they require 400 day-degrees of heat at which point diapause stops further summer development. Lack of soil moisture may retard this initial development.

Diapause in eggs is broken during winter. At 41°F eggs require a minimum of 70 days of chilling. The rise of soil temperatures above a threshold of 55°F the following spring starts the final stages of embryonic development. After experiencing 150 day-degrees of heat, the eggs are ready to hatch. Emergence begins when soil temperature reaches 80°F and air temperature 65°F. Hatching of all eggs in an individual pod may be completed on the same day but this process generally lasts two to four days. A warm spring and favorable soil moisture shorten the hatching period of all the eggs in a bed. Because the hatching period may be completed in 12 days, the nymphs seem to appear en masse on bed

Locusts?

Not all grasshoppers are locusts but

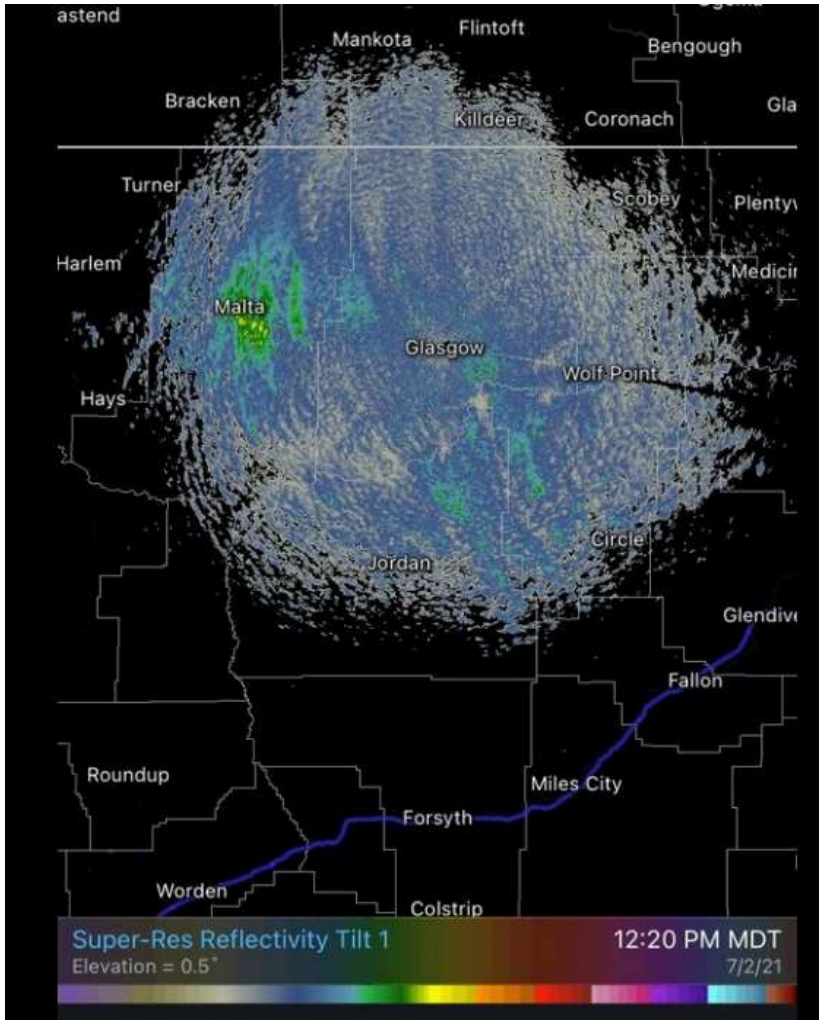
all locusts are grasshoppers…

that **phase shift** to migrate

- Larger wings
- Brighter coloration
- Collective migration behavior

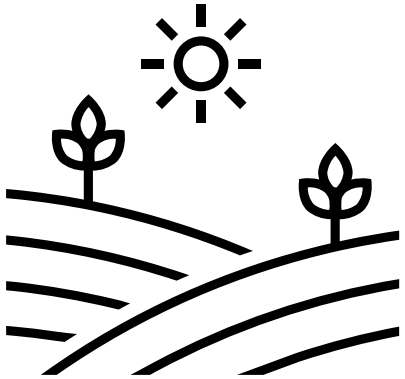
(moving in bands/swarms)

Migratory GH *Melanoplus sanguinipes* – a locust species



…in swarms massive enough to see on weather radar.

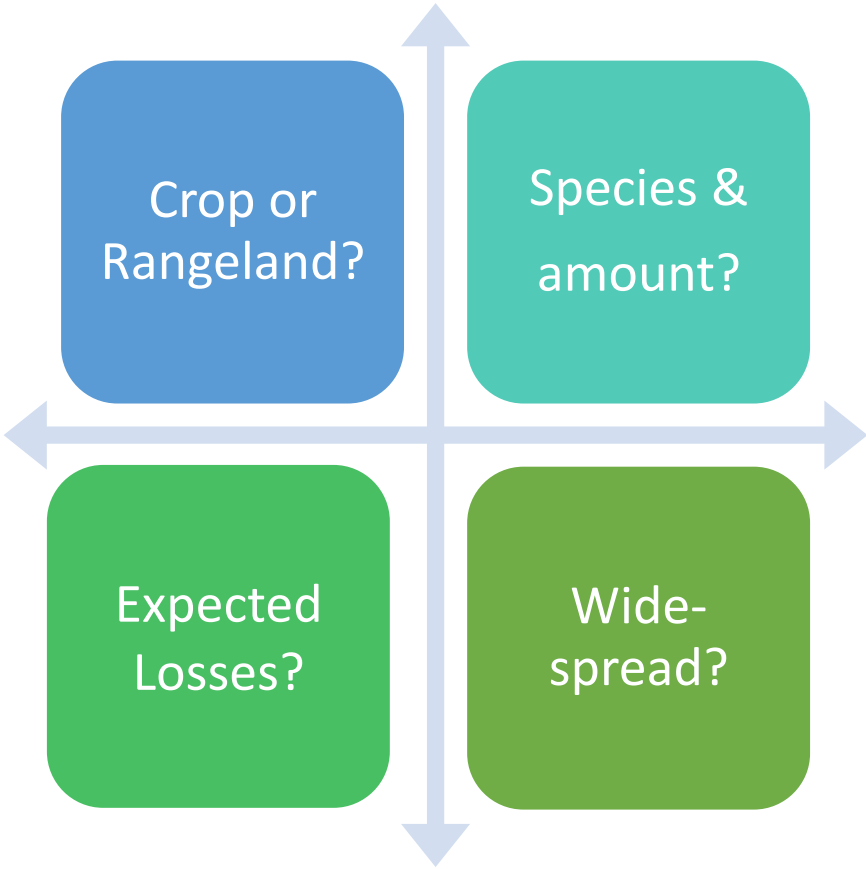
Is it *Economical* to treat?



Does it cost more to treat *or* **not** to treat?

Answer depends on:

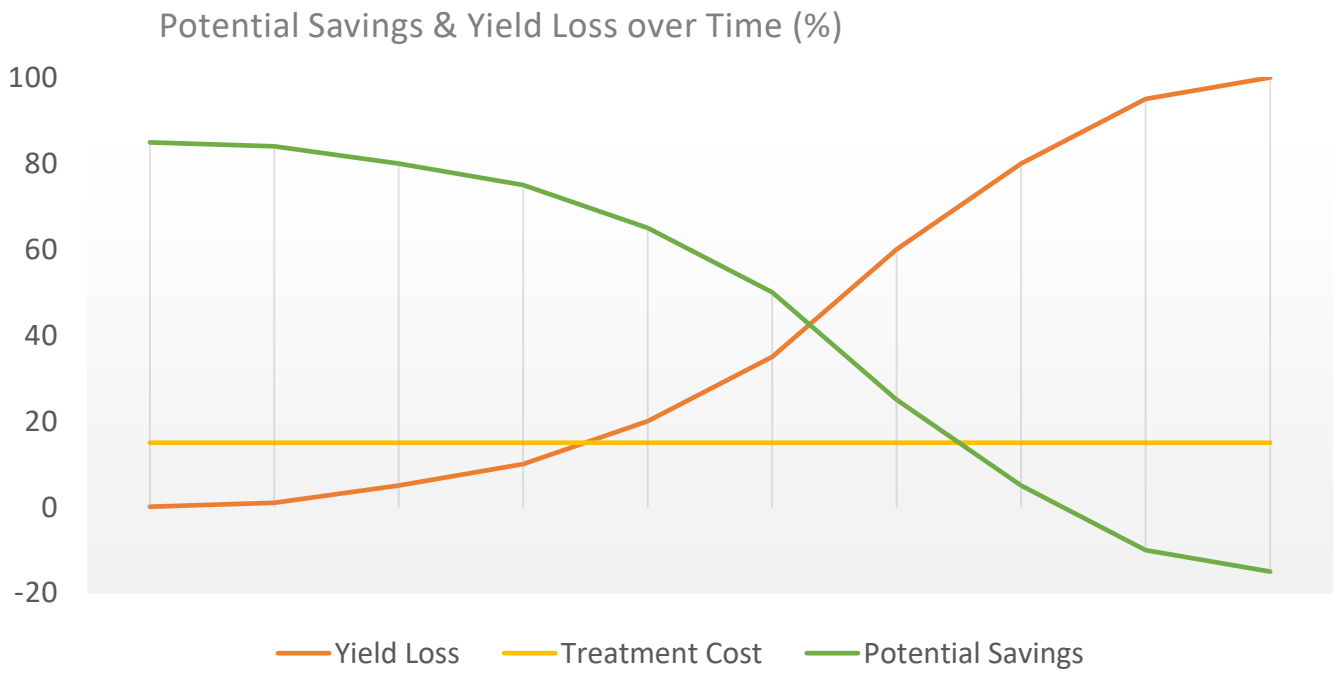
- Grower
- Species & abundance
- Expected losses
- Distribution



For Crops:

Compare expected yield loss to cost of treatment

Treating earlier results in greatest potential benefit

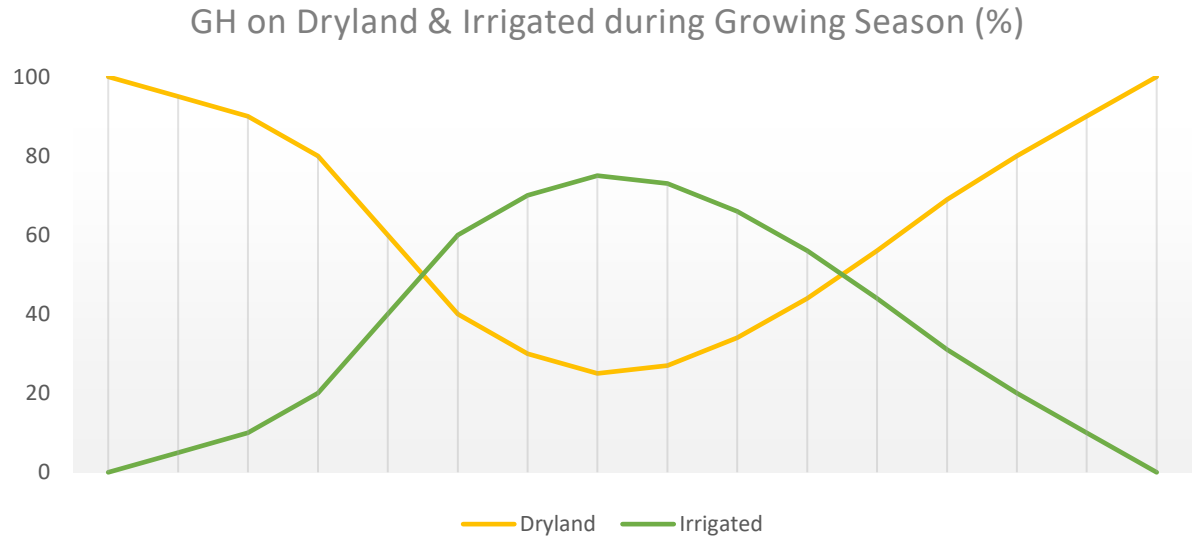


For Crops:

Do surrounding areas need to be surveyed & treated?

Consider how fast (knock-down) & long-lasting (residual) treatment will be

GH/yd^2 in area can determine potential future loss in crop… observation of injury level & documentation also useful



For Rangeland:

Each GH eats about body weight/day

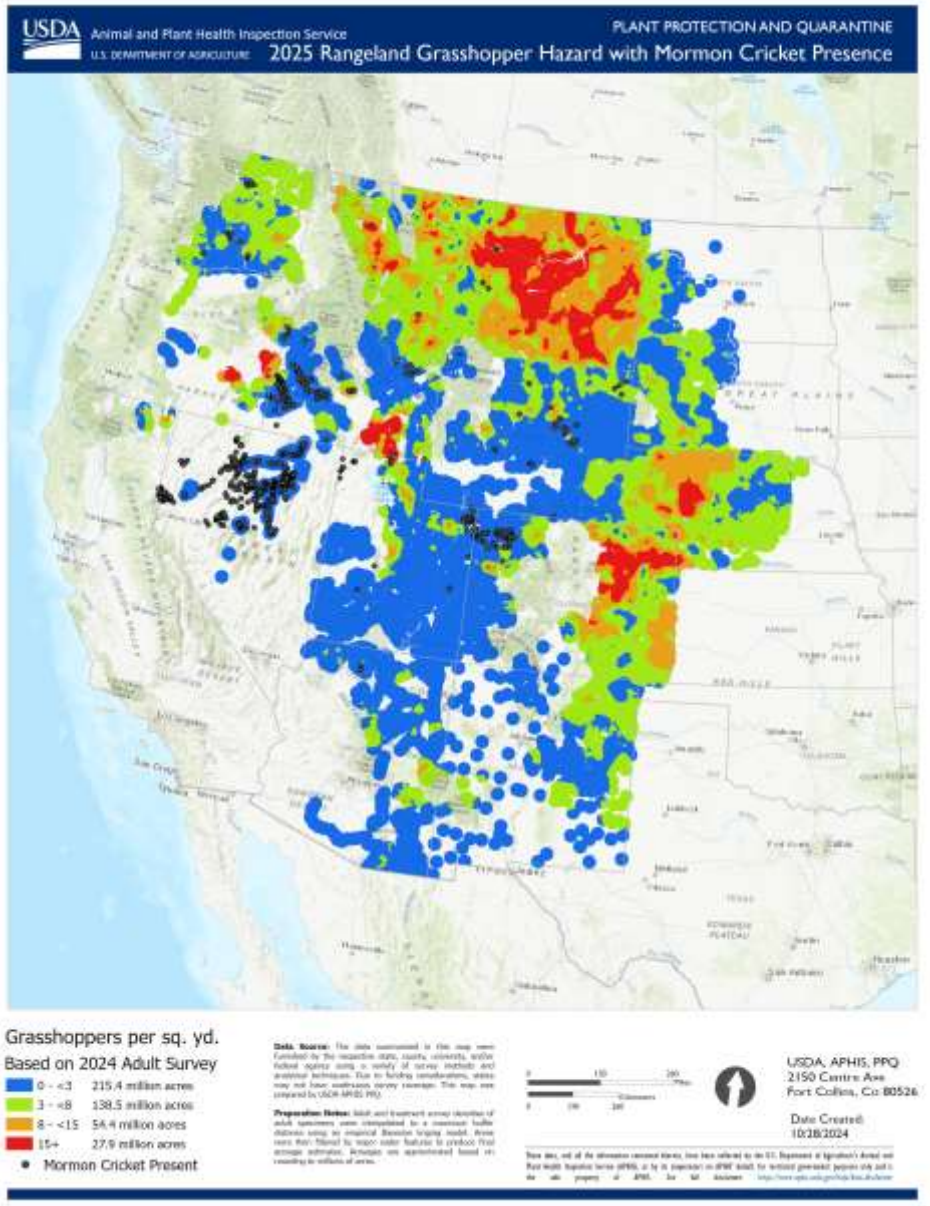
>20% of forage on average is used by GH on rangeland in Western US

GH/yd^2 used to estimate potential yield loss but context dependent

Drought favors both increase in GH populations and decrease in plant regrowth

Predicting outbreaks in advance is difficult

Outbreaks usually last a few years (as do potential benefits of successful treatments)



Economic Action Threshold?

Factors for Ranchers:

How much forage is there to save?

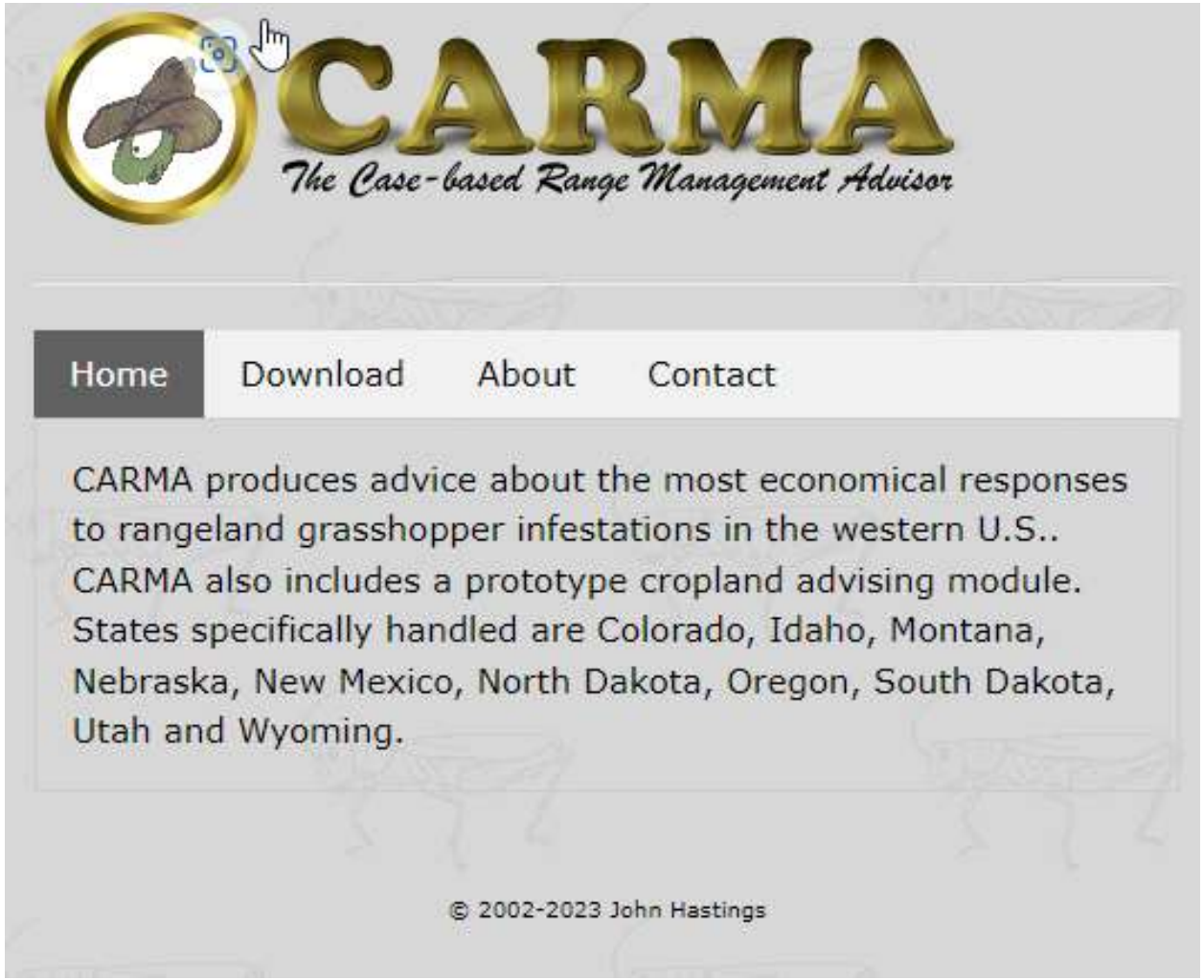
Is regrowth likely?

Cost of hay or more land to lease?

Will the GH populations crash naturally?

Is a treatment area too small to not get reinfested?

Do the neighbors want to treat too?



johnhastings.herokuapp.com/carma/index.html

Promoting Biological Controls

Many predators, parasites and diseases use GH for food

Helps control populations and prevent outbreaks but…

If GH populations scale up rapidly, they can ‘escape’ control:

- Predators become ‘saturated’
- Populations take time to build

Cultural practices and treatment programs that support biocontrol controls help to prevent future outbreaks!

Ground mantis *Litaneutria minor* hunting grasshoppers near Mann Lake

Area was treated with softer pesticide and using RAATs to preserve predatory insect populations and other non-target species.

Handbook of forage and rangeland insects:

(free at Internet Archive)

Arthropod Predators & Parasites of Grasshopper Pests in Western US	
Arachnida	**Mites and Spiders**
Mites	3 families of mites are known to parasitize grasshoppers but aside from reducing egg viability, population regulation is considered minimal.
Spiders	Web-building spiders and hunting spiders, both ground dwelling (e.g. 'wolf spiders') and foliage dwelling (e.g. 'jumping spiders'), are often abundant.
Coleoptera	**Beetles**
Carabidae	Ground beetle adults and larvae are generalist predators, including of grasshopper eggs, that can have signicant impacts.
Meloidae	Blister beetles larvae attack grasshopper eggs significantly, however adults are herbivorous and can be crop pests, also can cause blisters on human skin.
Cleridae, Tenebrionidae & Trogidae	Generalist predators that may feed on grasshopper eggs.
Diptera	**Flies**
Parasitoids	Internal parasites that kill their host, many species of flies target grasshoppers (in families Anthomyiidae, Nemestrinidae, Sarcophagidae, & Tachinidae).
Asilidae	'Robber flies' are the raptors of the insect world and many prefer grasshoppers; in one 6 year WY study, they reduced grasshopper populations by 11-15%.
Bombyliidae	'Bee fly' species can resemble bumble bees and many species are considered important predators, with larvae that hunt grasshopper eggs in the soil.
Calliphoridae & Chloropidae	Generalist predators that may feed on grasshopper eggs.
Hymenoptera	**Ants and Wasps**
Formicidae	Ants are localized, general predators, especially of eggs and newly hatched grasshoppers, with little impact on larger instars or distances from colonies.
Scelionidae	Large family of wasp that parasitize insect and spider eggs, including about 20 species that specialize on grasshoppers; very small (1-3 mm, 1/16-1/8").
Sphecidae & Crabronidae	Large families of solitary wasp with about 30 species that capture grasshoppers to provision their nests (e.g. 'digger wasps'); distribution & control varies.
Odonata	**Dragonflies and Damselflies**
	Generalist predators that breed in aquatic habitats but can fly into crop fields or rangelands.
Orthoptera - Mantidae	**Mantids**
Litaneutria minor	The 'agile ground mantis' or 'minor ground mantid' is a generalist ground hunting predator in dry habitats of the arid mountain west, 30 mm, 1.2" long.

Entomopathogens of Grasshopper Pests in Western US	
Fungi	Infect on contact--useful for conservation biocontrol or biopesticide
Beauveria bassiana	-a mold causing white "powered sugar" coating - can be purchased
Metarhizium anisopliae	-a mold causing green "powered sugar" coating
Aspergillus flavus	-a mold causing green "powered sugar" coating - more saprophytic
Entomophaga grylli	-causes "summit disease" since insects grip top of stems in death
Microsporidia	"Protozoa" are unicellular parasites, studied for biopesticide use
Antonospora locustae	-a biopesticide formulation of this species is marketed as Nolo bait
Nosema, Vairimorpha	Genera of protozoa parasites with species that attack GH & MC
Bacteria	Bacteria have been studied for biopesticide use, but with no success.
Bacillus thuringiensis	-limited impacts so far, unlike Bt kurstaki in moths
Viruses	Viruses have potential as biopesticides, but difficult to mass-produce.
entomopox	-infects fat body tissue - sluggishness/slow growth/death
crystalline array	-too similar to mammalian viruses to study as biopesticide

Increase canopy cover & organic matter to promote GH diseases. See chapter V of www.ars.usda.gov/pa/nparl/pmru/IPMHandbook

Adding soil building amendments or biopesticides that promote entompathic fungi can help prevent outbreaks

Figure VII.5–1—An immature rangeland grasshopper, *Melanoplus sanguinipes*, exhibits the fungus *Beauveria bassiana*, which caused its death. (Photo by K. Christian Reuter.)

Treatments for outbreaks with beneficial fungi researched by the USDA for decades, some have excellent potential…

Cultural Practices to Prevent Outbreaks

- Reduce erosion and control weeds
- Twice-over-rotational grazing

Disturbance to Eggbeds:

- Tilling
- Drenching with water
- Locate during mating/egglaying
- Early spring ‘hotspot’ treatment during hatch

Effects of Weather

- GH active when temps remain below 90 °F, and will shelter if temps go above 95 °F (Feeding stops)
- Will began to feed again as temps drop (ectothermic)
- Less active during windy and or cloudy days
- Will stop feeding when rain is imminent and throughout wet weather
- As the ground warms back up, feeding will resume
- Cool, moist weather increases the chances of disease to spread within a GH population

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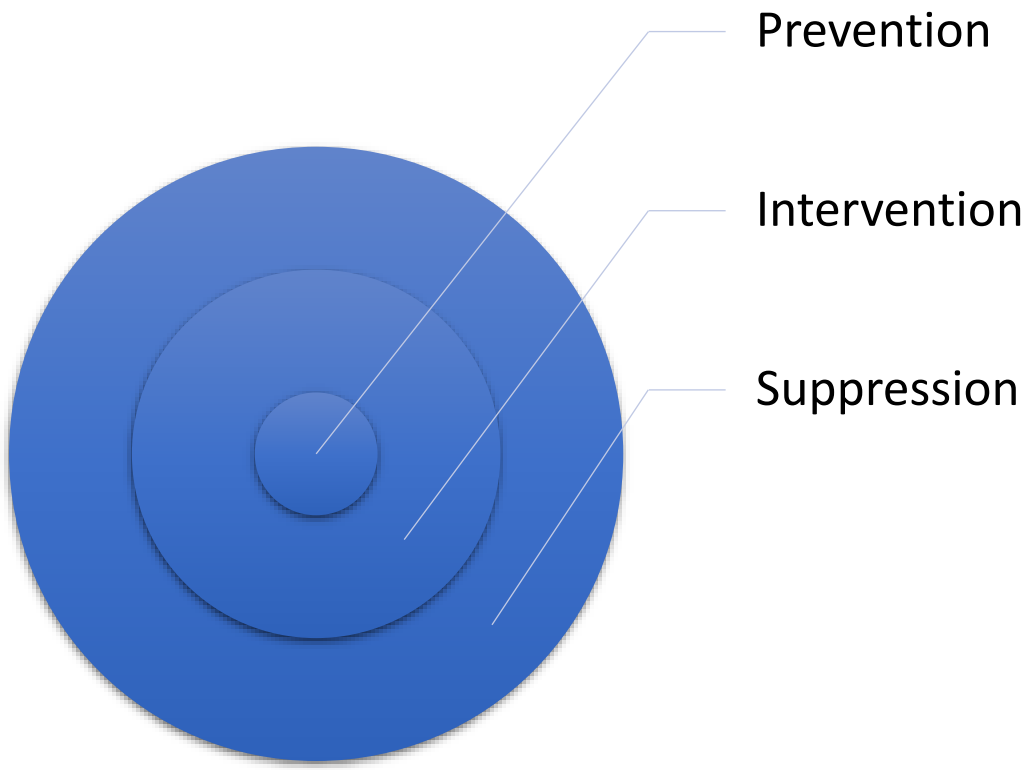
Integrated Pest Management

Systematic approach to realistic pest management

informed practices + *phased responses*



IPM theory adapted from Alex Latchininsky, U. of Wyoming Ext. 2008. Slide credit: Colin Park, USDA

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Integrated Pest Management

Integrated Pest Management is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices:

Essential Components:
Monitoring
Decision-making
Methods & Materials

3-Phased Approach, *All rely on Survey & Sampling* (species type/stage)

Prevention
cultural control (e.g. 'twice over' livestock grazing)

Intervention
decision support (forecasting) + hot-spot chemical control

Suppression
last resort, 10k minimum, decision support (economic model), while supporting general diversity (conservation biocontrol)

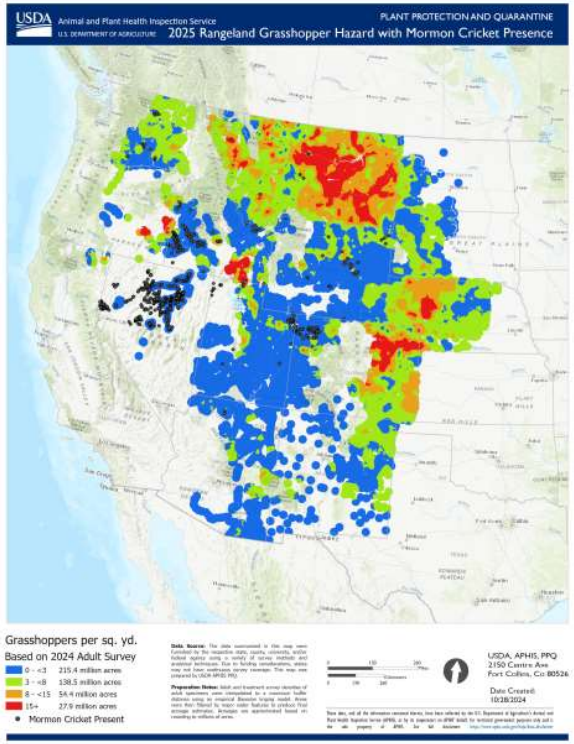
Artwork by Michel Launois, CIRAD-Prifas Montpellier, France

Integrated Pest Management

Survey is Key

Spring / Nymphal survey: Detect hatch to start treatment window, delimit hot spots, map densities to support treatment decisions.

Summer / Adult survey: helps with following year Predictions.



1

2

3

4

Clearwinged grasshopper

Nymphal development: 26-40 days (~1 wk/instar)

5

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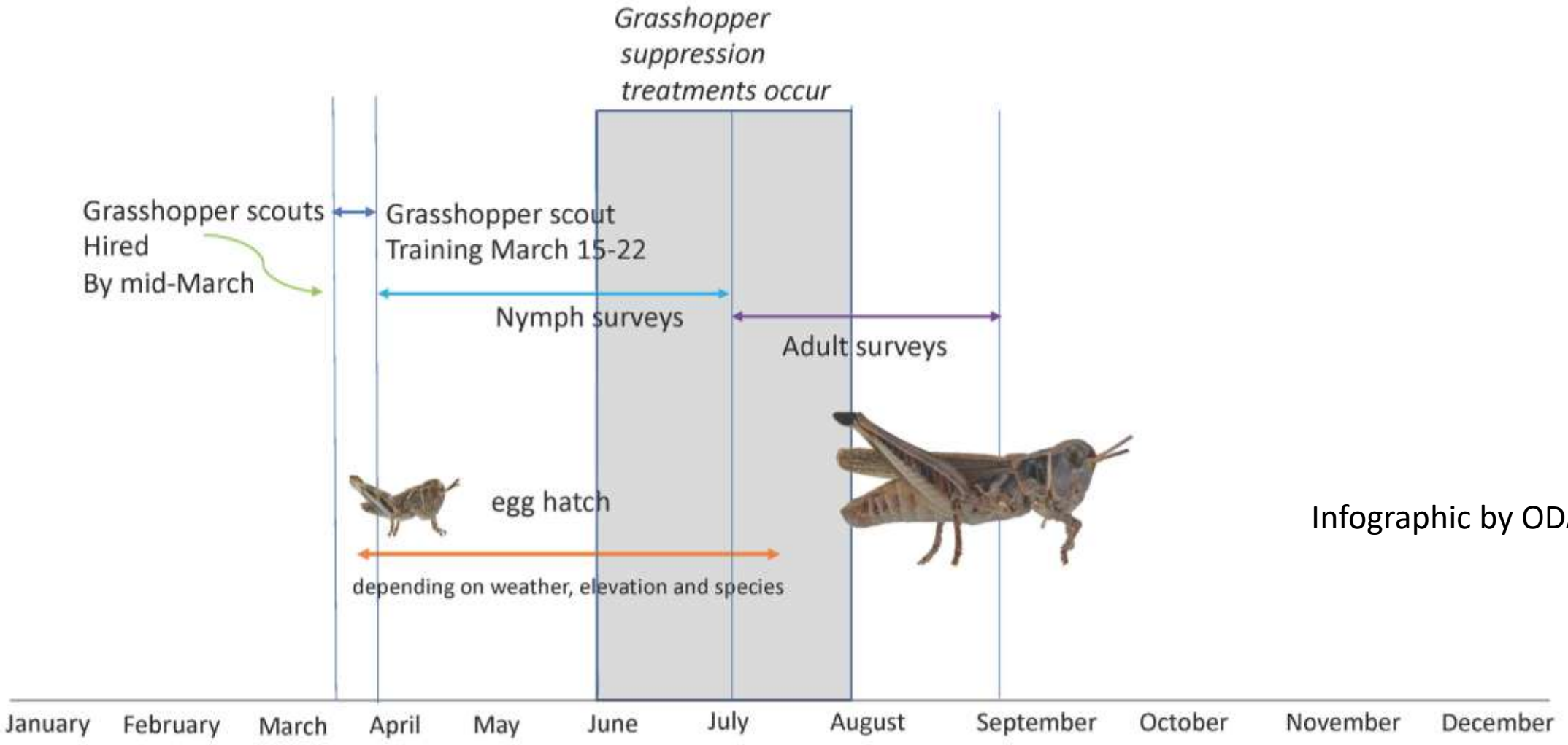
Integrated Pest Management



Timeline of Grasshopper Activity

Infographic by ODA

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Integrated Pest Management

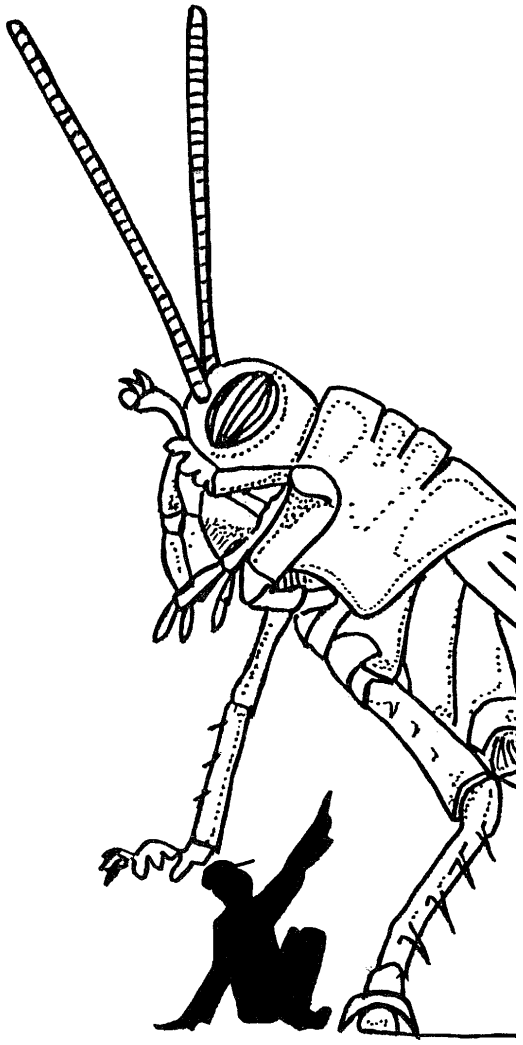
If Suppression Treatment is Required:

Talk to neighbors and treat ~10k acre or more of to prevent reinfestation

Use skip swathing aka Reduced Area Agent Treatments (RAATs) to increase efficiency & limit non-target impact

<u>Preventive Method</u>: e.g. Targeted egg bed treatments (works especially well for Clear-wing grasshopper), or border treatments of a protected resources

More IPM methods are available to land managers, see ARS Handbook, such as "Twice Grazing", also not killing beneficial insects, though natural controls will become 'saturated' during outbreaks.



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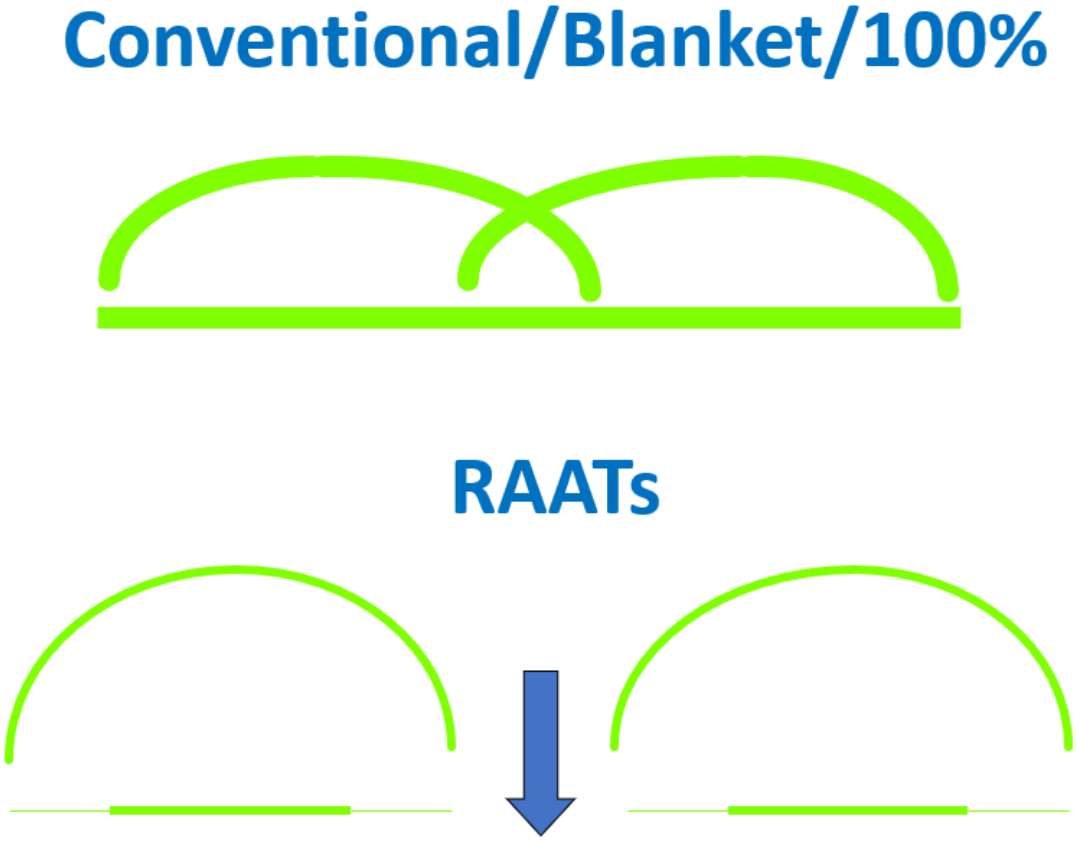
Grasshopper IPM: Skip-swath/RAATs

Reduced Area Agent Treatments (RAATs):

Leaves untreated swaths as refuge for non-target insects within the block

Works very well with residual pesticides like Dimilin:
Immature insects not usually very mobile, while grasshoppers are extremely mobile!

Also works with bait applications



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Contact email: jordan.juzdowski@usda.gov

further Resources:

Special Thanks to:
University of WY, Entomology
https://www.uwyo.edu/entomology/grasshoppers/
Provided much of the Grasshopper Biology, Ecology, & IPM information in this presentation

USDA ARS IPM Handbook
Grasshopper IPM User Handbook (1996-2000).pdf

ODA Grasshopper Field Guide
final_update_grasshopper_pests_species_oregon_id_guide_book_2024.pdf (odaguides.us)

USDA APHIS Grasshopper & Mormon Cricket Program:
www.aphis.usda.gov/vanityurl/plant-health/grasshopper

Grasshopper ID Tools:
idtools.org/id/grasshoppers/

USDA ARS Grasshopper,
Biology, Identification & Management:
www.sidney.ars.usda.gov/grasshopper/

USDA ARS Field guide:
www.ars.usda.gov/ARSUserFiles/30320505/grasshopper/Extras/PDFs/FieldGde.pdf