Grasshopper Biology and Management

Desert Locust Outbreak in Kenya 2020

Dave Branson

US Department of Agriculture
Agricultural Research Service
Pest Management Research Unit
Sidney, Montana
Dave.Branson@usda.gov

Nicole Davidson

Lead technician and grasshopper identification expert

USDA ARS Grasshopper Website:
ars.usda.gov/grasshopper/

SCIENCE

Grasshoppers Are Descending on the West in Swarms

BY GRACE WOODRUFF

JULY 12, 2021 • 5:16 PM

7/20/2021 Grasshoppers and cattle compete for food in US drought - CNN

US

LIVE TV

- Jeff Bezos and crew speak after their historic flight to the edge of space
- Dr. Fauci and CDC chief Dr. Walensky discuss the Covid-19 pandemic at a Senate hearing

Cattle are competing against grasshoppers for food in the West's historic drought. The bugs are winning.

By Rachel Ramirez, CNN

Updated 10:43 AM ET, Fri July 2, 2021

Grasshoppers Swarm Wheat Fields, A Phenomenon One Grower Hasn't Seen Since the 1980s

AgDay 07/16/21 - Montana Drought

LATEST VID

theguardian.com/environment/2021/jul/04/grasshopper-swarms-us-west-drought

Environment ▶ Climate change **Wildlife** Energy Pollution

Insects

'A scourge of the Earth': grasshopper swarms overwhelm US west

The drought has created ideal conditions for grasshopper eggs to hatch and for the insatiable eaters to survive into adulthood

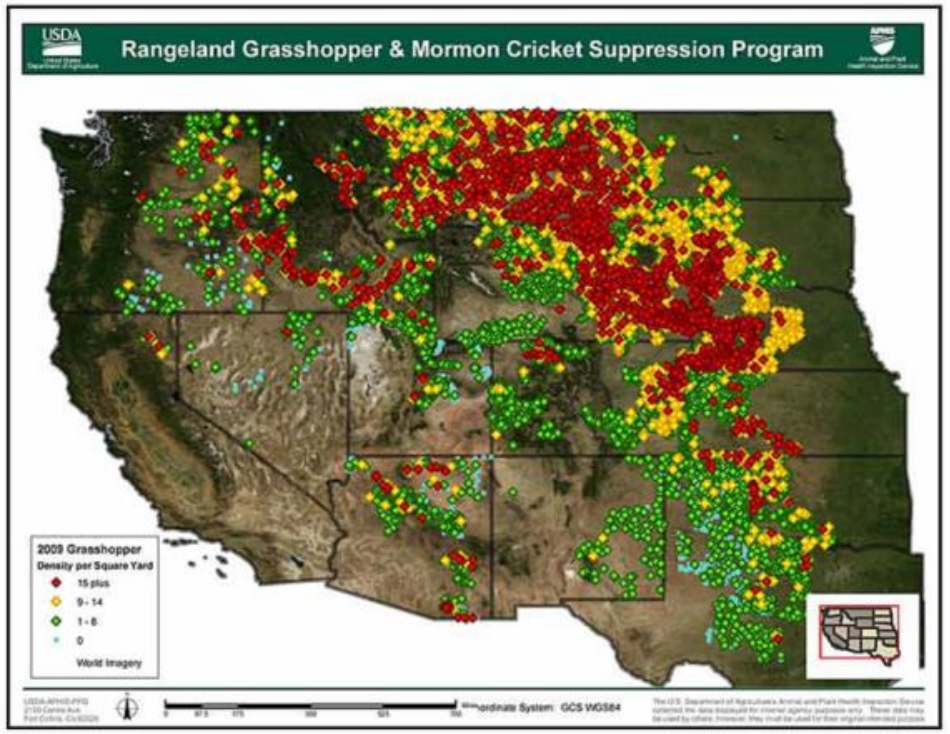
Lee van der Voo *in Portland*

Wed 7 Jul 2021 22.44 EDT

Grasshopper outbreaks and impact

- Regional cyclical outbreaks: 4-15 years.
- Outbreaks: ~2 to 6 of ~80 rangeland species
- Economic problems for ranchers ↑ during drought like 2021 when grass production is low, compete with livestock
- Rangeland forage losses in U.S. ~$1.7 billion/year
- Outbreaks lead to large scale chemical control programs

Summer 2021



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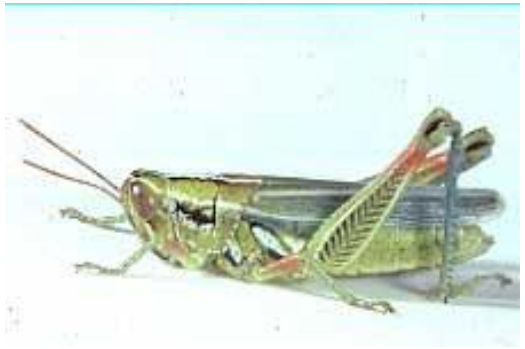
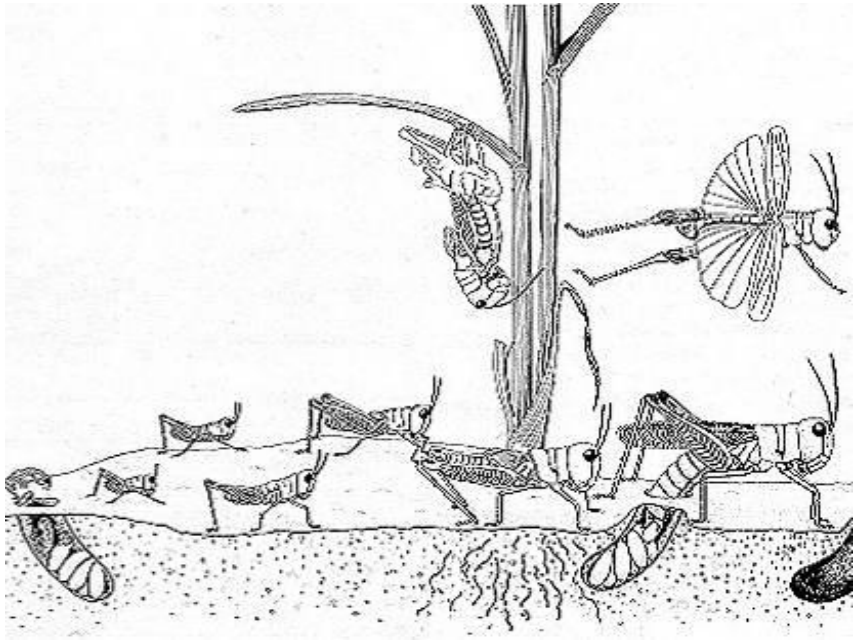
Grasshopper feeding impacts on rangeland function

- Grasshoppers can eat more than cows when abundant and weigh more per acre
- Beneficial roles at low to moderate densities
  - Important food source for grassland birds and game birds
  - Can increase productivity through nutrient cycling modifications. Unknown: how often + vs -
- Grasshoppers can modify native grass composition

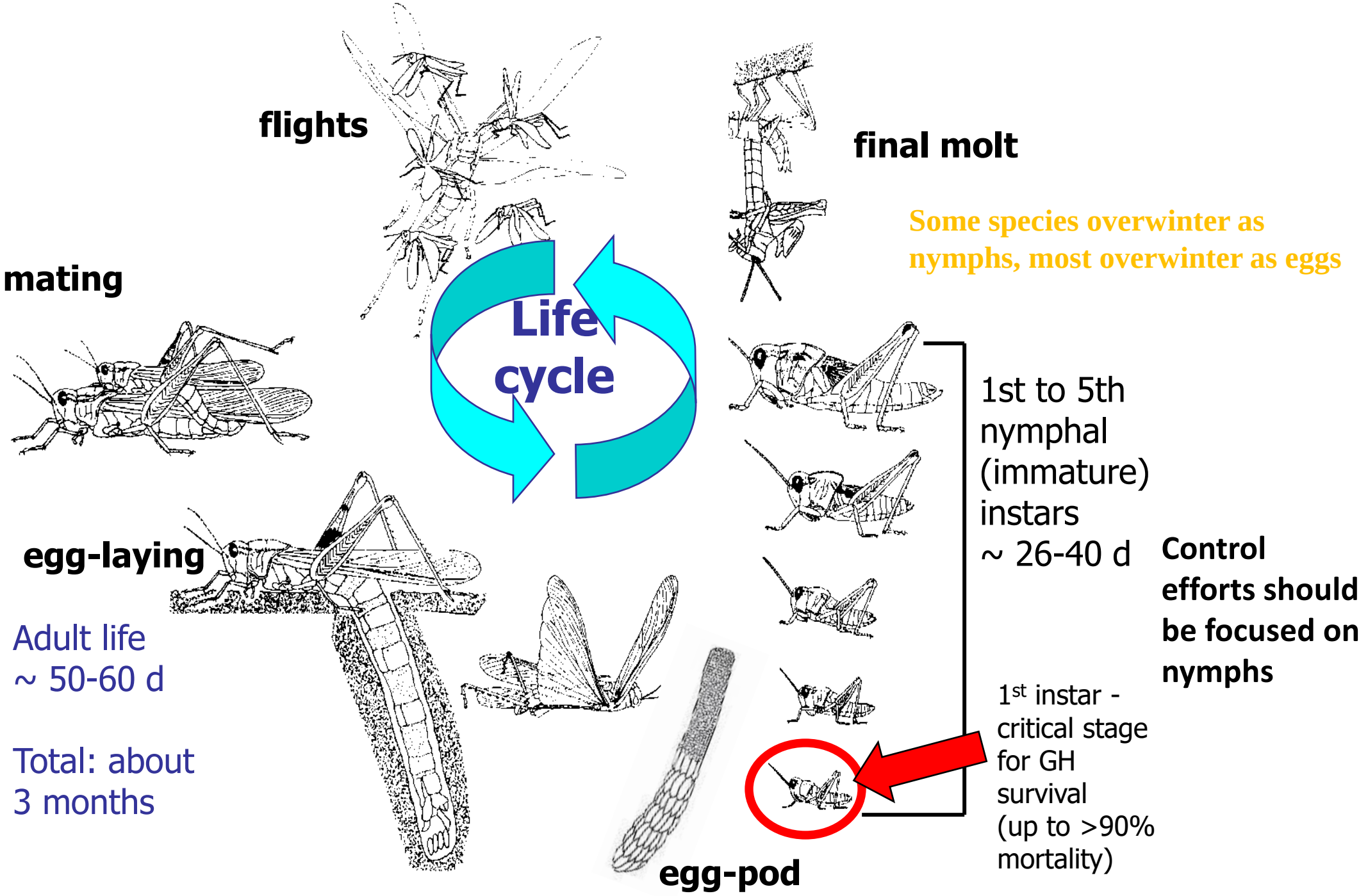
Grasshopper Biology and Ecology

- Typically 5-20 species at a location, 1-4 typically dominant
- Plant community determines species present
- One generation per year
- Lay eggs in soil, hatch in spring and early summer





"It's going to be a bad year, I just saw grasshoppers in March"
~5 species hatch in late summer. Spend winter in litter or in cracks in the soil. Adults by April or May.
<u>Not</u> an economic concern.


flights
final molt
Some species overwinter as nymphs, most overwinter as eggs
mating
Life cycle
egg-laying
1st to 5th nymphal (immature) instars ~ 26-40 d
Control efforts should be focused on nymphs
Adult life ~ 50-60 d
Total: about 3 months
1st instar - critical stage for GH survival (up to >90% mortality)
egg-pod

Spur throated grasshoppers

- Most prominent grasshoppers by their numbers, activities and diversity
- Several economically damaging species to both rangeland and crops, including migratory grasshopper in the current MT outbreak
- Often ~nondescript looking

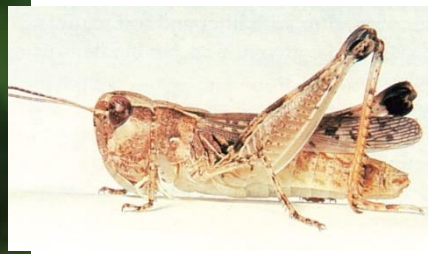
Banded-winged grasshoppers

- Colored wings a sign that they are not pest species.
- Many species snap hindwings as they fly (crepitation) and can be heard across a field
- Clear-winged grasshopper is a pest species, but isn't common in our area

Slant faced grasshoppers

Some economically damaging species, largely eat only grass

Males call attention to themselves by "singing" in the vegetation (stridulating their legs) to attract females.



Grasshopper species can be hard to identify

Species differ in what they eat – influences risk to crops

fifth-instar two-striped grasshopper

fifth-instar two-striped grasshopper

fifth-instar two-striped grasshopper

Multiple identification keys, Android and iPhone ID apps, naturalist's guides and species information at:

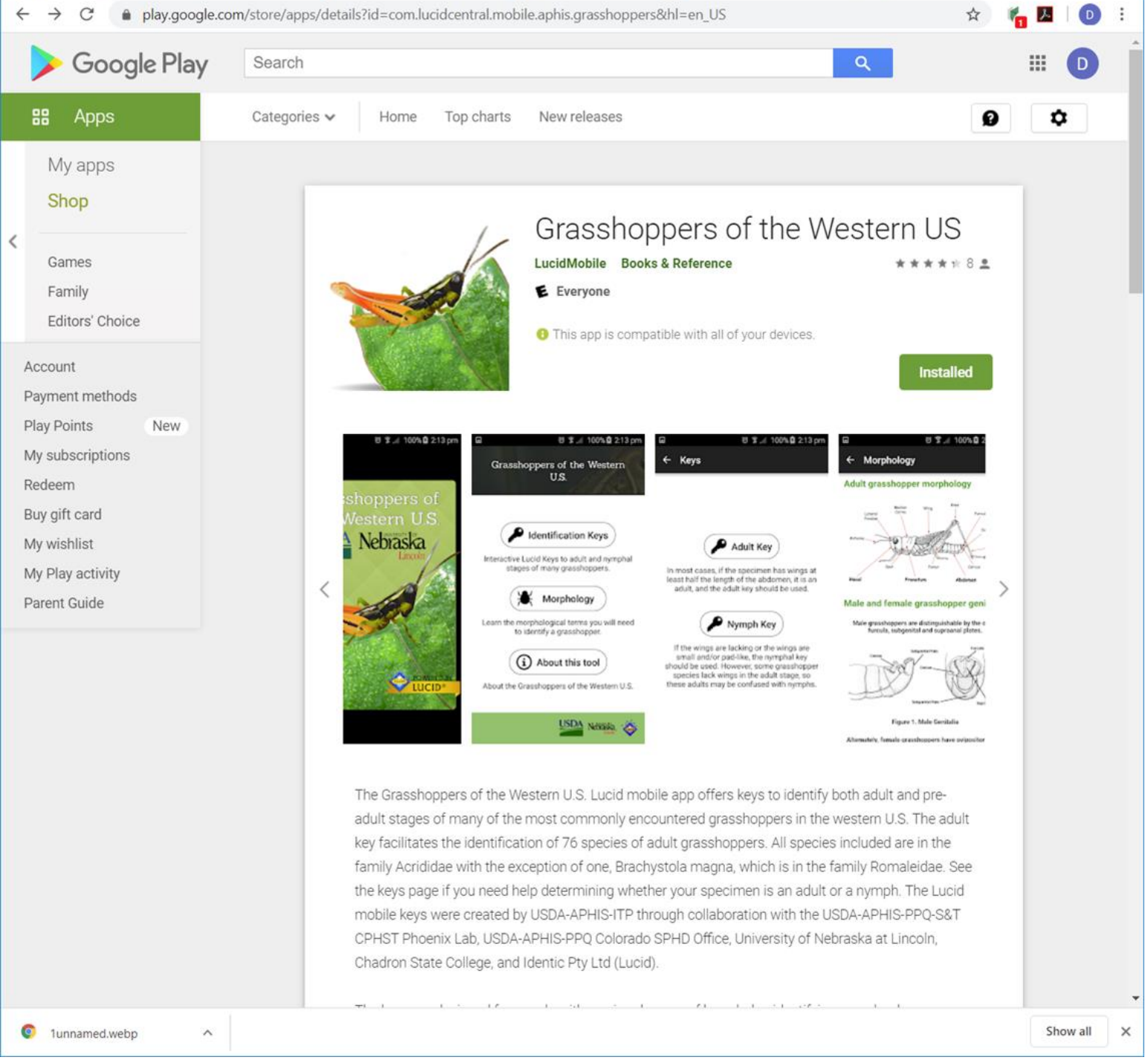
ars.usda.gov/grasshopper/

Grasshopper Plant Associations

Strong diet and habitat restrictions for some species

Russian thistle grasshopper

- Eats Chenopods: kochia, Russian thistle, four winged saltbush, greasewood, winter fat, lambsquarters
- Starves to death when confined with grass
- Not common enough to serve as a weed control agent



Free USDA nymph and adult grasshopper identification app available in iPhone, Android app stores

Feel free to call us at the lab: 406-433-2020

www.idtools.org/id/grasshoppers/

Grasshoppers: Adult Key

Not secure | idtools.org/id/grasshoppers/adult_key.php

Grasshoppers of the Western U.S.

About | Morphology | Fact sheets | Keys | Glossary | Gallery

Adult grasshopper key

search fact sheets... GO

full screen key

Features Available: 29

- Pronotal spine
- Inner hind femur pattern
- Forewing (tegmen) pattern
- Hindwing disk color
  - red/orange
  - yellow
  - black/brown

Entities Remaining: 8

- Arphia conspersa Scudder
- Arphia pseudonietana (Thomas)
- Derotmema haydeni (Thomas)
- Hippiscus ocelote (Saussure)
- Metator pardalinus (Saussure)
- Pardalophora apiculata (Harris)

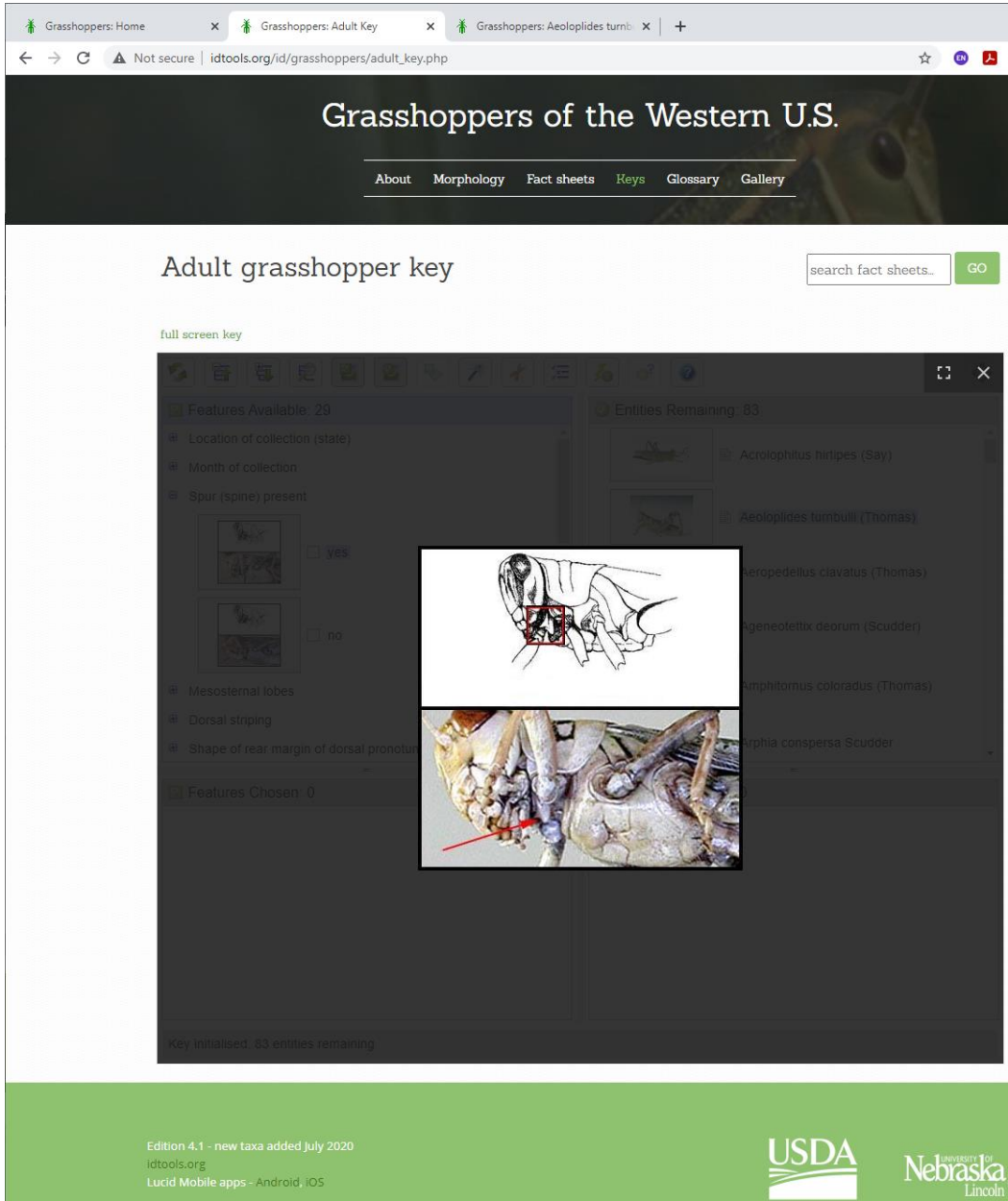
Features Chosen: 2

- Spur (spine) present
- Hindwing disk color

Entities Discarded: 75

- Acrolophitus hirtipes (Say)
- Aeoloplides turnbulli (Thomas)
- Aeropedellus clavatus (Thomas)
- Ageneotettix deorum (Scudder)

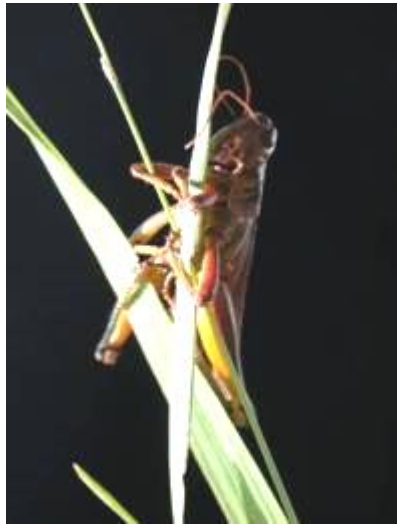
40 entities discarded, 8 remaining



Predators and pathogens

- Grasshoppers are a primary food source for many grassland birds. Birds and spiders can regulate grasshopper populations when densities are lower.

- Many diseases, predators, and parasites



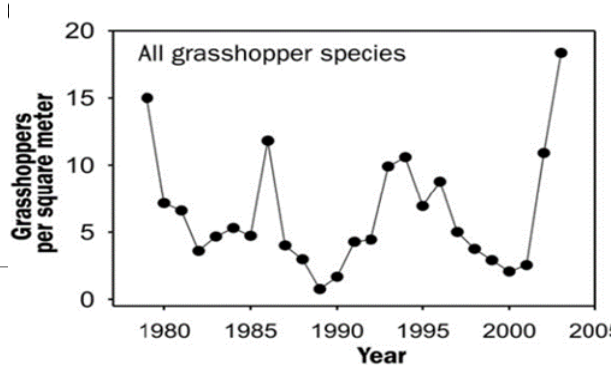
Fungal “Summit disease”

Birds and Grasshoppers

Sharp-tail grouse crop, Richland County, fall 2020 (Josh Campbell)

Grasshoppers are an important component in the early diet of sage grouse chicks and in general for many grassland songbirds, pheasants and grouse

A Refresher: Grasshoppers and Weather

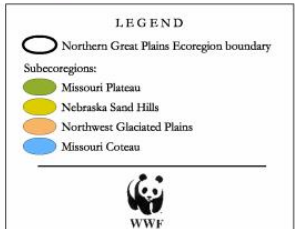


Ability to proactively manage grasshopper problems constrained by an inability to predict responses to weather variation and forage quality.

- Highly variable dynamics, patterns differ between ecosystems in the US.

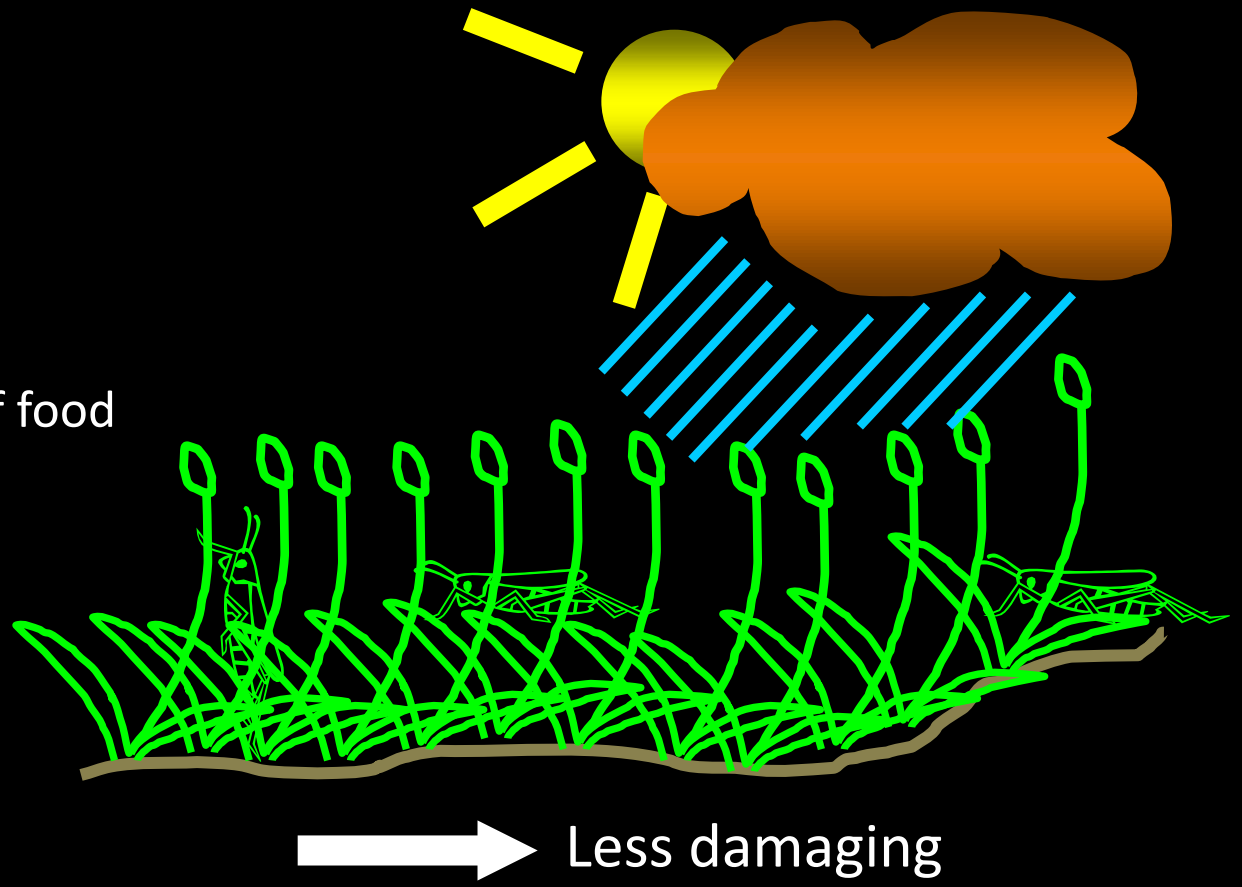
Short term to decadal scale weather patterns impact grasshoppers

- Northern Great Plains (US): assumed population increase with warm/dry conditions.



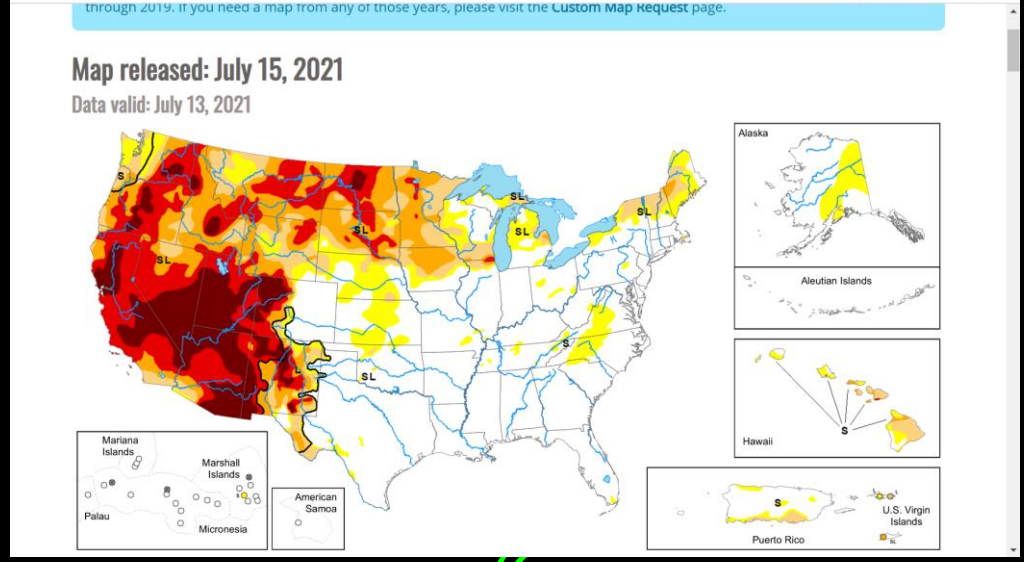
Weather Impacts: Rule of Thumb

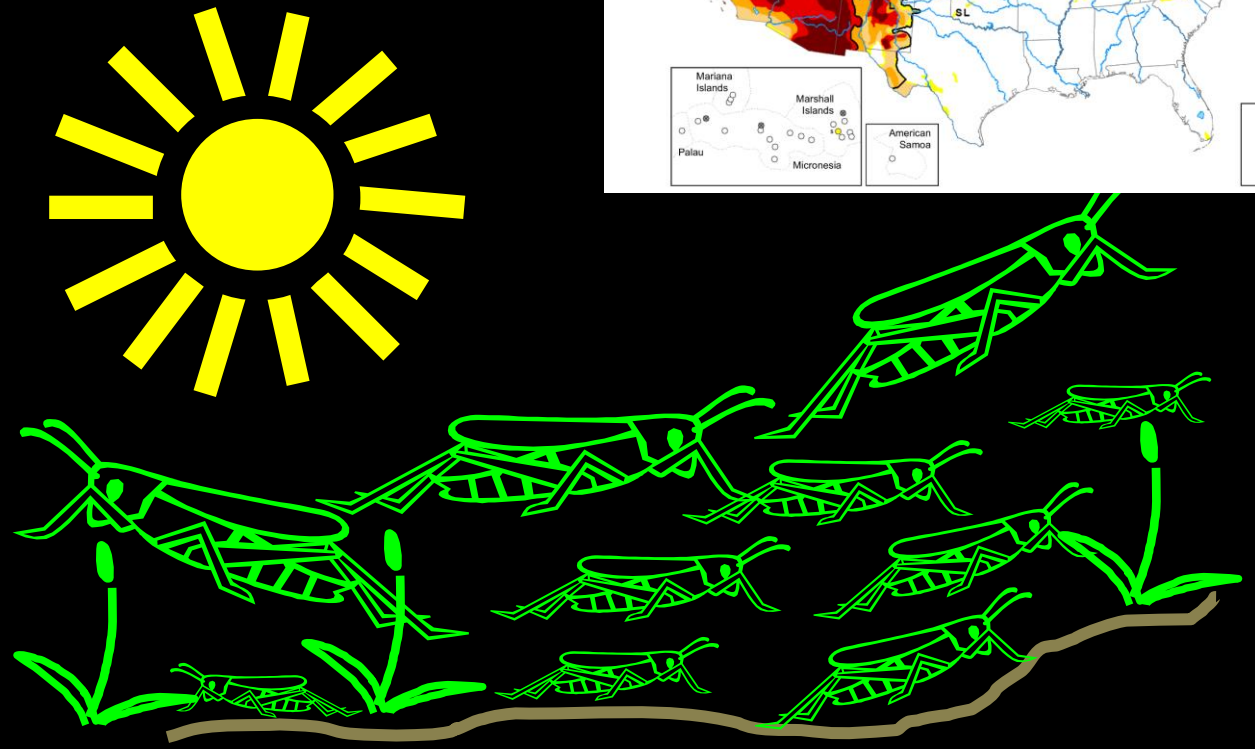
- Direct and Indirect Effects
- Slower development
- ?? More susceptible to diseases and natural enemies
- Higher mortality, fewer eggs laid
- Higher forage production, so plenty of food to go around for cows and hoppers



Weather: Direct and Indirect Effects

- Faster development
- Less susceptible to diseases
- Lower mortality
- More eggs produced IF quality forage
- Much we don't know, ARS hired John Humphreys a mathematical modeler/ insect pest forecaster to improve our ability to predict outbreaks

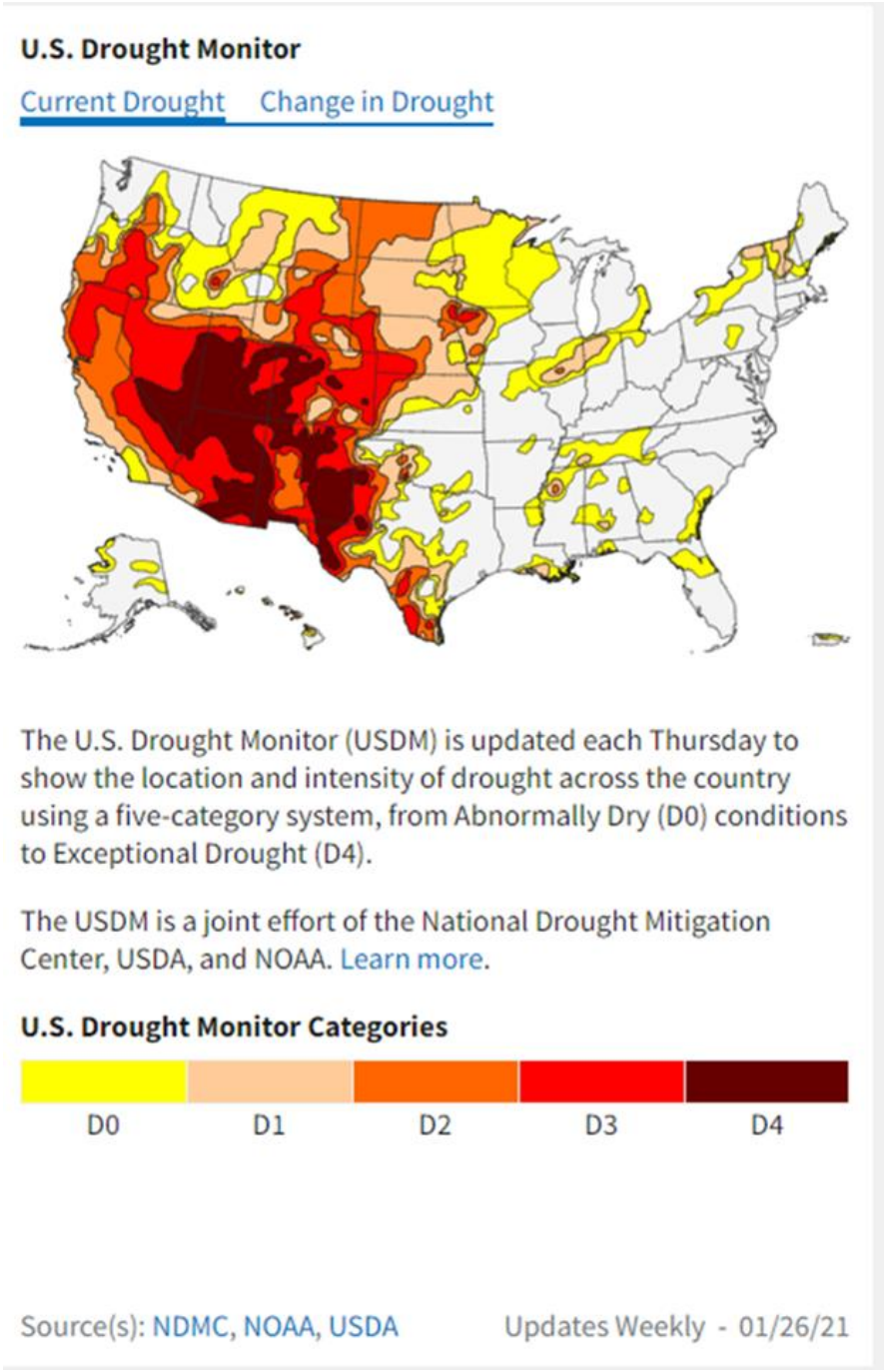




More damaging

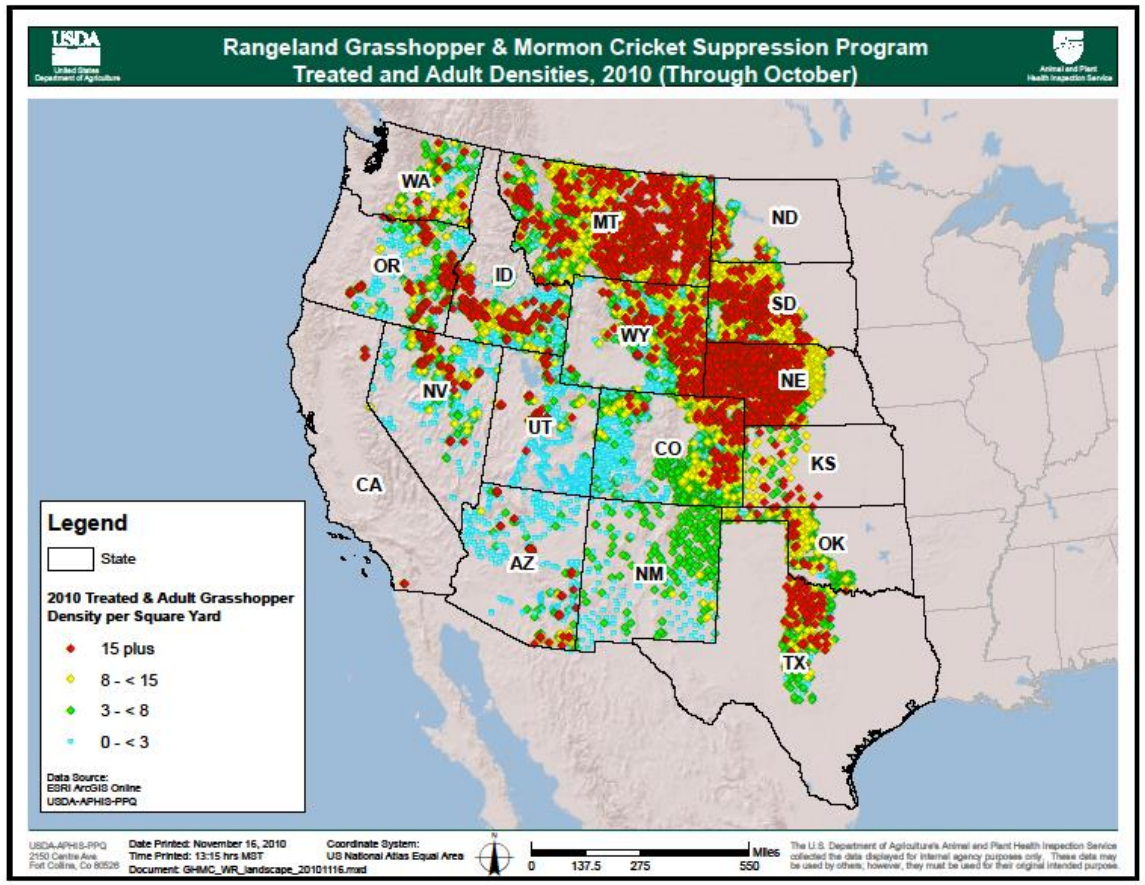
Egg survival in winter?

- Eggs can handle cold temps, infrequent mortality with cold temps and no snow cover
- Low soil moisture content/extreme drought can infrequently affect egg survival, poorly understood
- Lots of predators and parasites underground

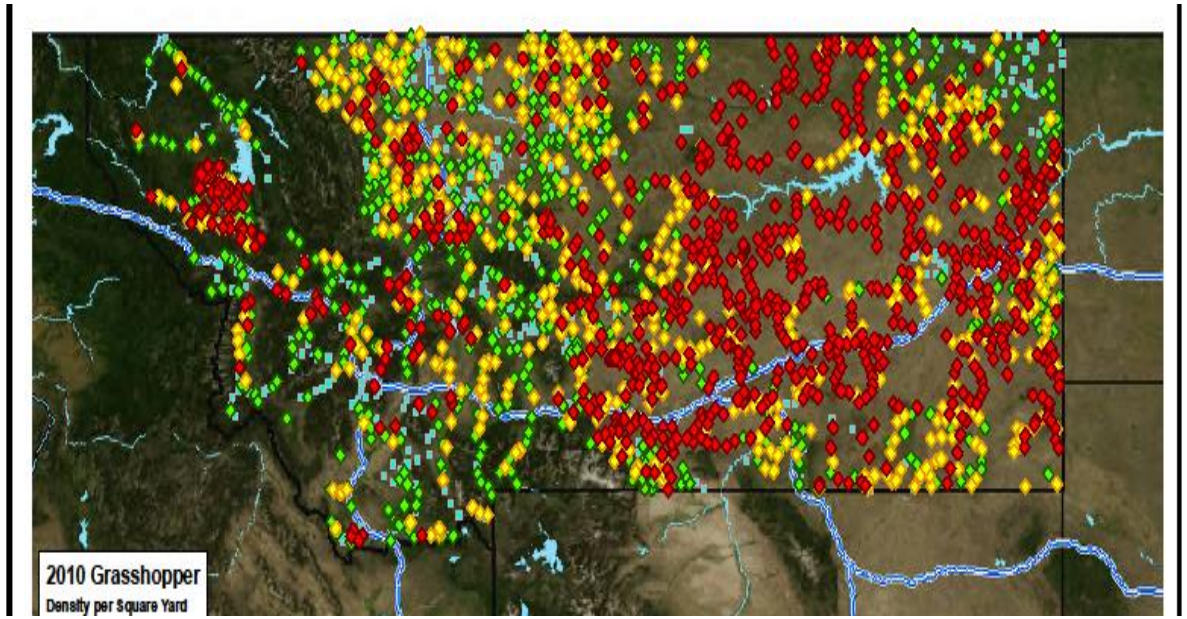


Past examples: Large scale observations of grasshopper fluctuations, the potential roles of weather and food

Widespread economically damaging grasshopper outbreaks in 2010

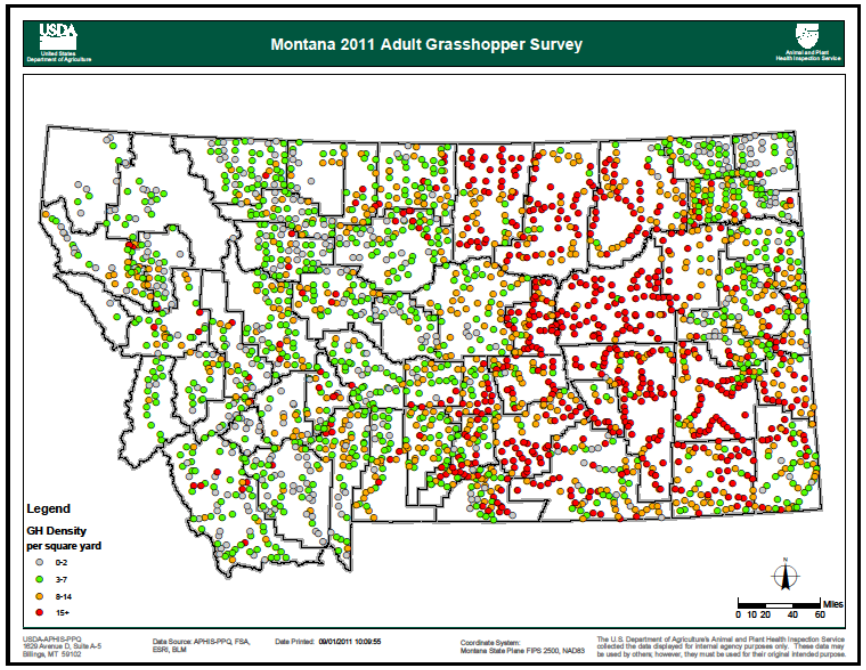


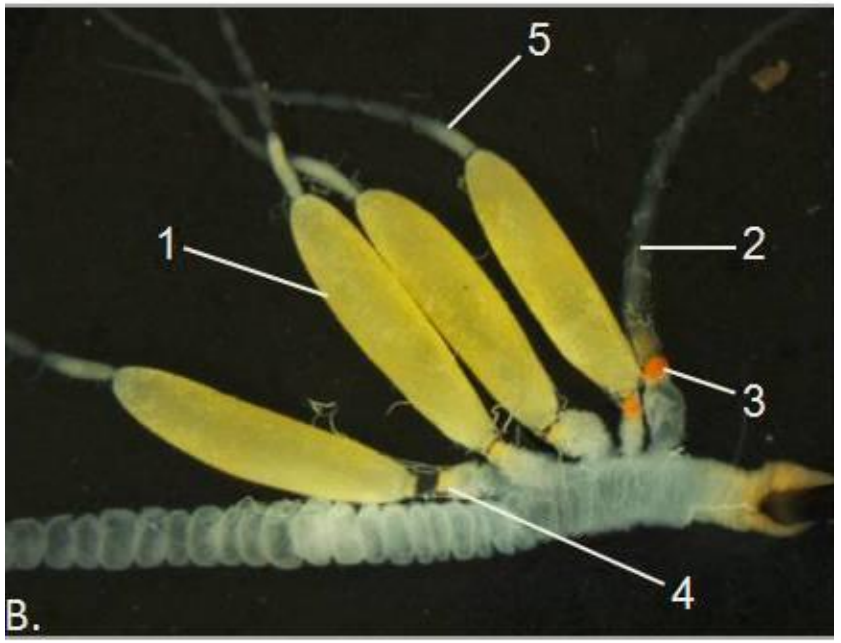
- Millions of acres sprayed in 2010
- Outbreak densities in much of Montana



2011 Weather and grasshoppers

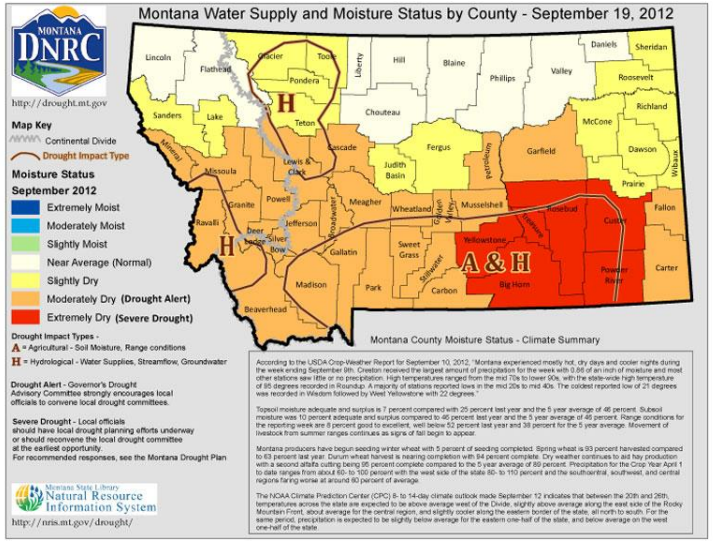
- Cold and wet early summer didn't wipe out hoppers
  - Takes severe conditions to directly kill young hopers
  - Many pest grasshoppers didn't hatch until late June or early July - after the cold wet weather

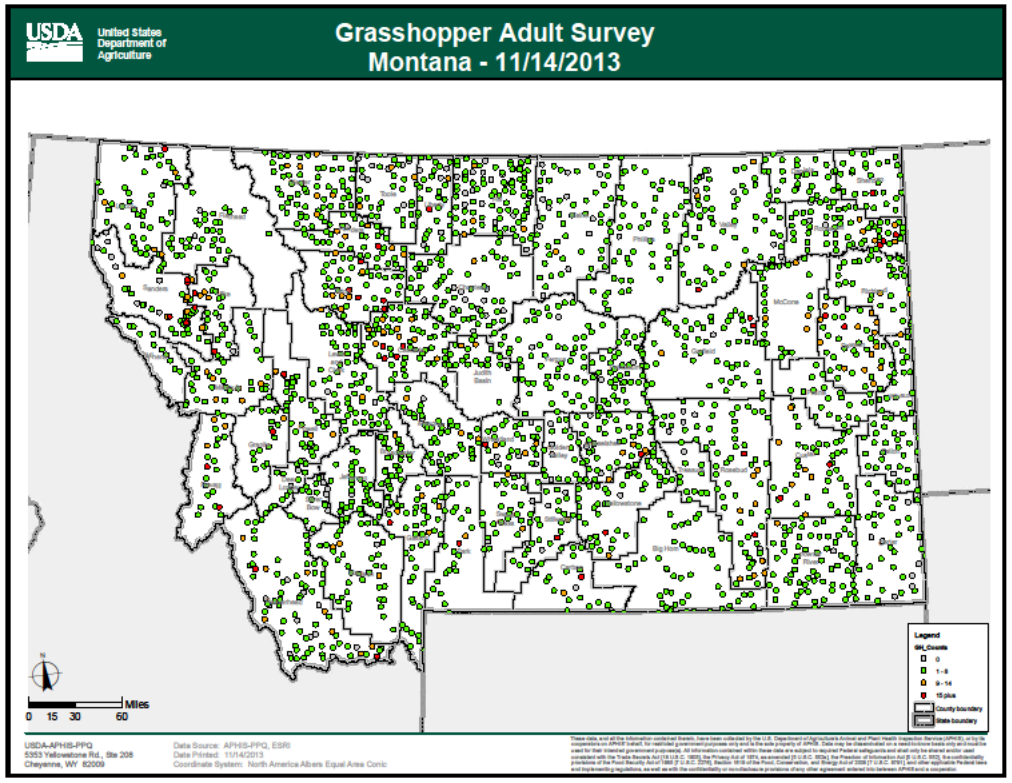


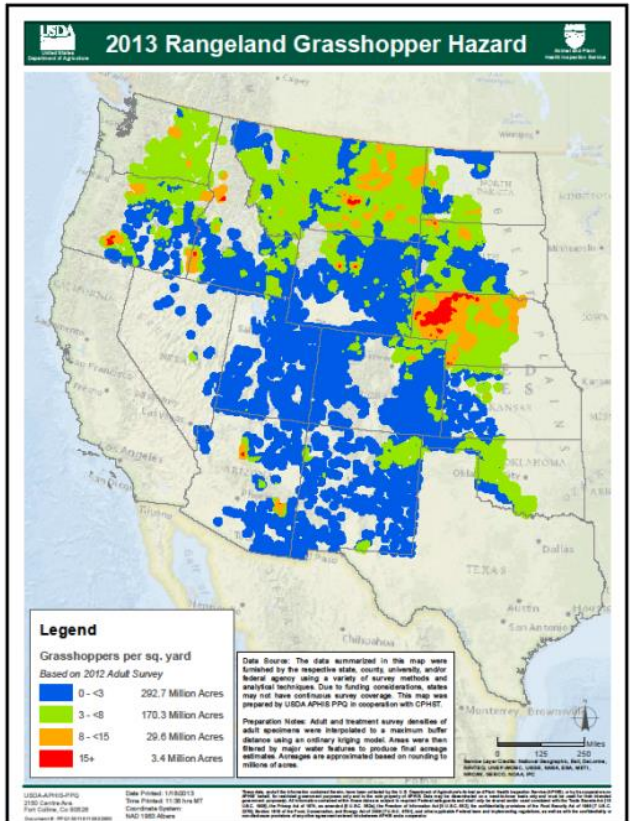


2012: Food and grasshoppers

- Severe drought in much of the western U.S.
- Southern Montana, low plant biomass and quality in early summer.
  - High # of hatchlings, but few survived to adults.
  - Strong decline in 2013, food limited mortality and reduced egg laying.







Food and weather as drivers of outbreak dynamics in Montana (USA)

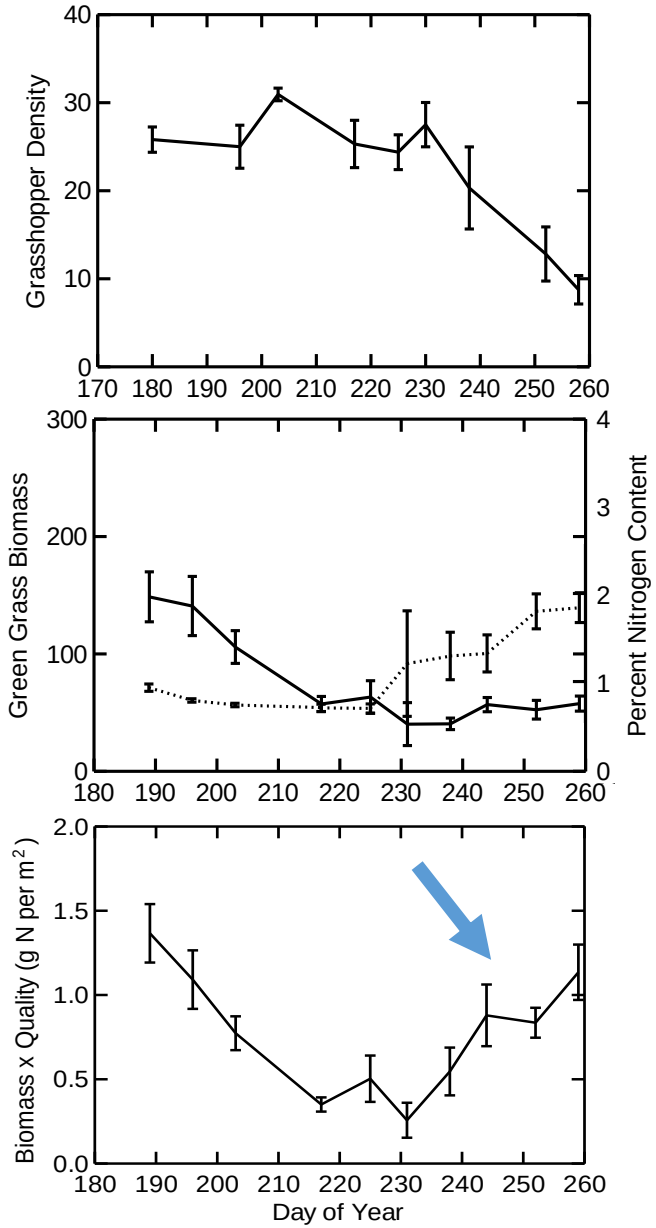
Branson. 2008. Influence of a large late summer precipitation event on food limitation and grasshopper population dynamics in a northern Great Plains grassland. *Environmental Entomology* 37:686-695.

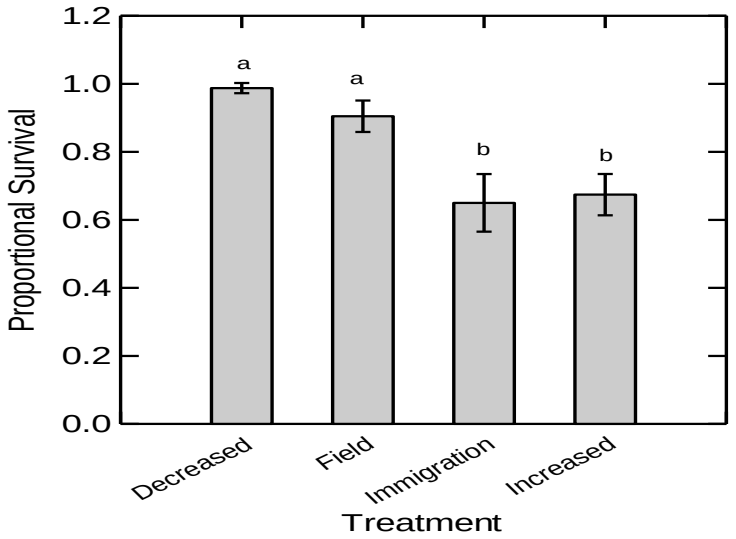
Figure 1.

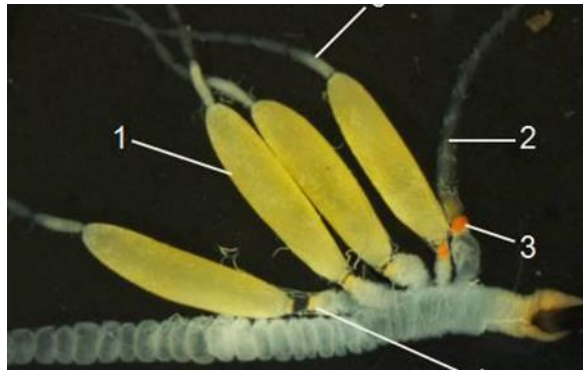
A.

B.

C.

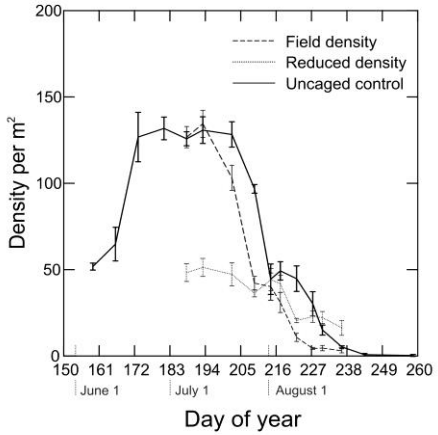


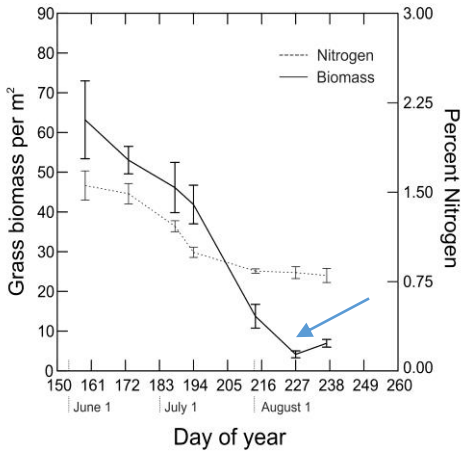


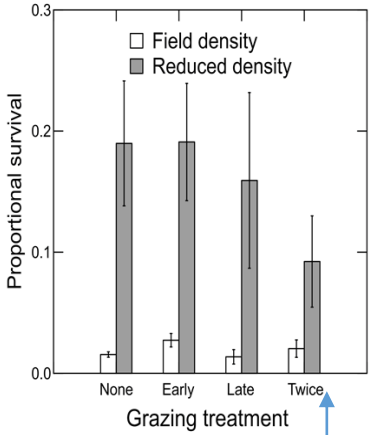


- **Increased late summer food, from a large, rare, late summer rainfall event**
- High survival and reproduction in all treatments

2000

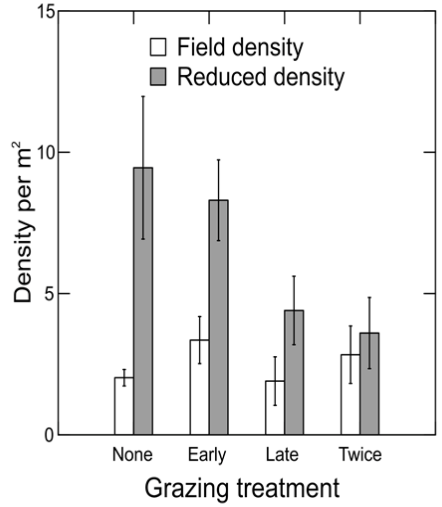


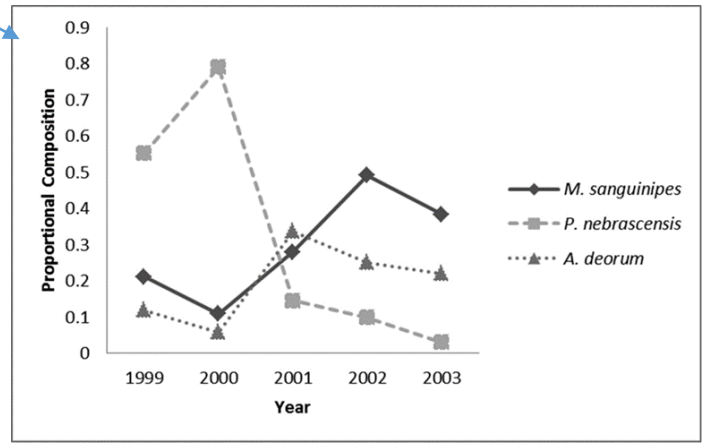




- **Late summer rainfall event in 1999 → severe outbreak of 130 per m² in 2000, due to forage quality/availability.**
- Food limitation during 2000 led to low survival, reproduction and 2001 hatching - particularly for late season species.
  - Overall **densities at the site dropped by 85% in 2001**
  - Densities of the dominant late summer species **dropped by 97%** from 100 to 3 per m2!
- **Implications: Severe outbreaks can rapidly end due to food limitation -** may not get multi-year benefit from chemical control.
- **Forage and weather impacts aren't included in existing hazard maps, but <u>ranchers are already watching these factors</u>**

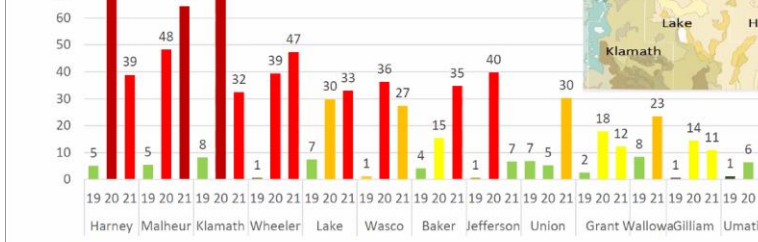
2001 Hatch



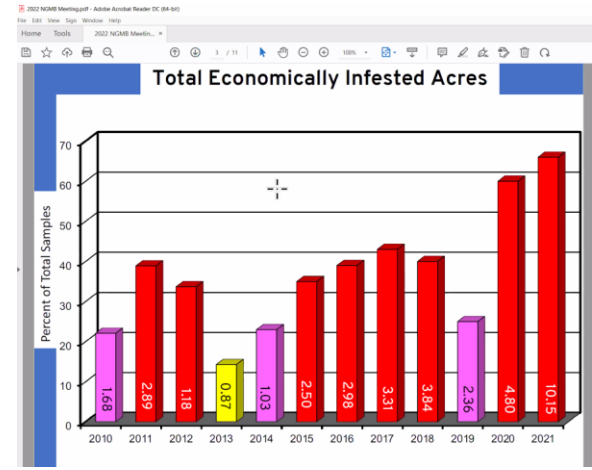


Economic infestation

- Sample economic thresholds: WY ranch ~ 17/yd^2, NM 23/yd^2 , Alberta <50 gh/m^2. Lockwood ~20/yd^2 . RAATs improves EIL
- Economic infestation variable: productivity, drought, species comp
- Case studies: With/without GH: Due to plant regrowth, little indication of reduced rangeland biomass <12-15/m^2 in less arid ecosystems – at times ~ 40+/m^2.
- <u>15 per square yard is a reasonable warning density</u>



2019: From down trends, boom starts w/ few hotspots (especially S. H
2020: Nymphal counts shot up widely (similar trends in adult surveys,
2021: Most widespread problem yet, with above counties > 8 / yd^2



USDA United States Department of Agriculture

Objective 2

Objective 2: Develop a grasshopper outbreak predictive mo

- Compiled historic rangeland grasshopper outbreak survey data **(density ≥ 15/sq. yd.)** from the 17 contiguous western states of the U.S.A.
- Mapped 18 years of GH outbreak data to 5x5 km grids for the western US
- Grasshopper outbreaks data visualizations and spatial modeling

Grasshopper impacts on rangeland production

Received: 27 October 2017 | Accepted: 5 August 2018
DOI: 10.1111/1365-2656.12897

RESEARCH ARTICLE

Journal of Animal Ecology | BRITISH ECOLOGICAL SOCIETY

Effects of grasshoppers on prairies: Herbivore composition matters more than richness in three grassland ecosystems

Angela N. Laws[1,2] | Chelse M. Prather[2] | David H. Branson[3] | Steven C. Pennings[2]

Species matter in terms of their feeding impact on plant biomass – grasshopper is not a grasshopper.

Much stronger effects of grass feeding species on production than mixed grass and forb feeders.

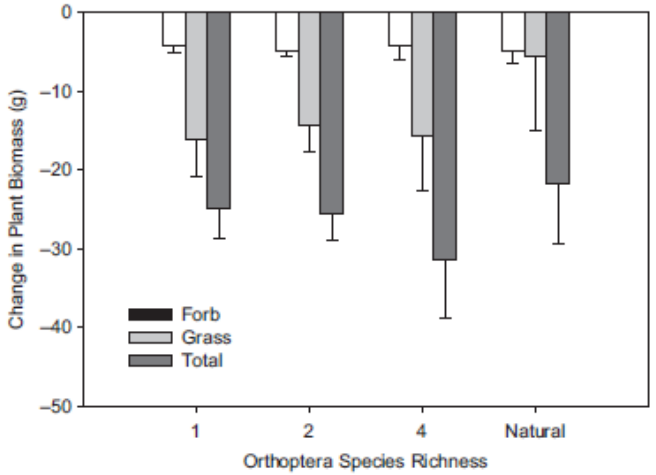


FIGURE 2 The average change in total plant biomass (g) relative to controls for each orthopteran species richness treatment. All sites were pooled. No effect of herbivore species richness was observed in any of the sites. Bars are standard errors

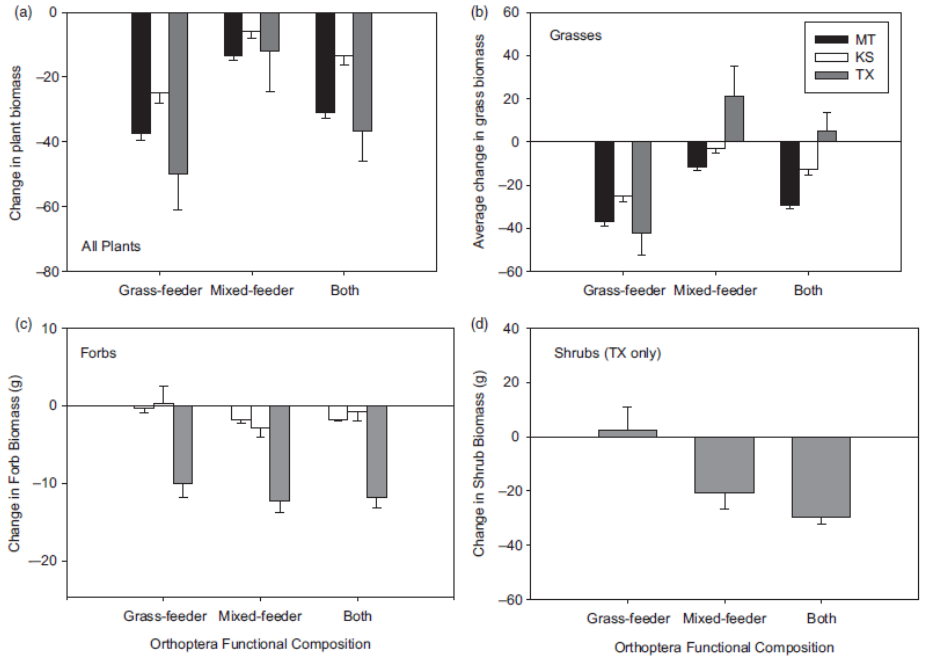
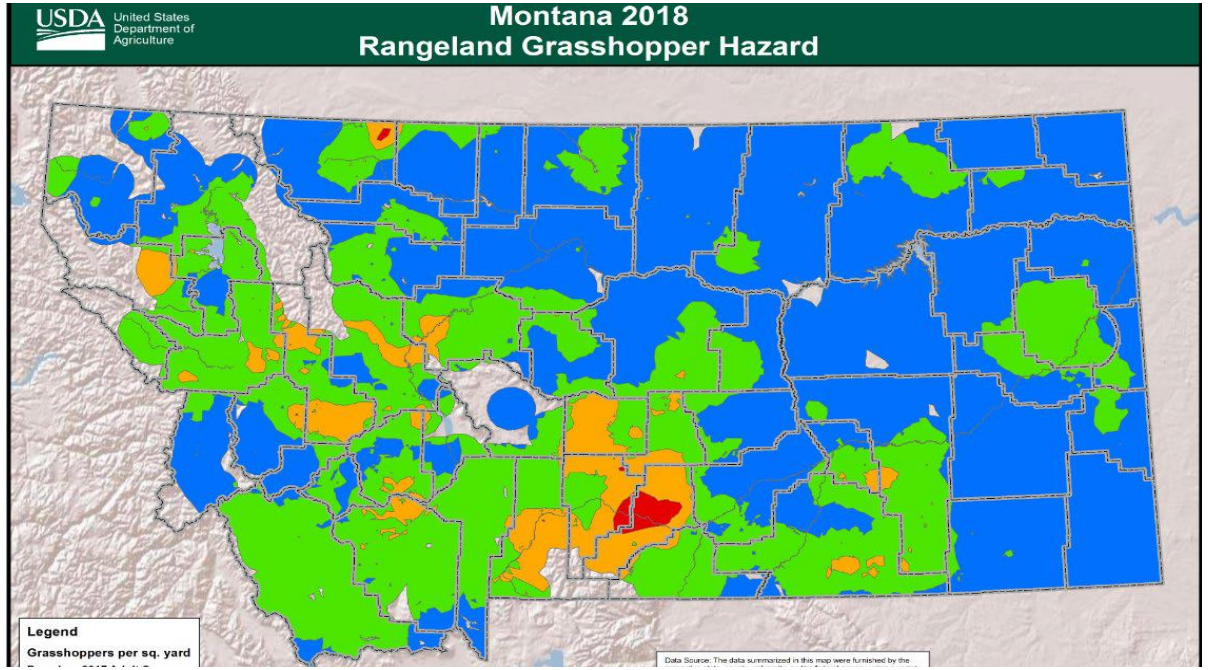
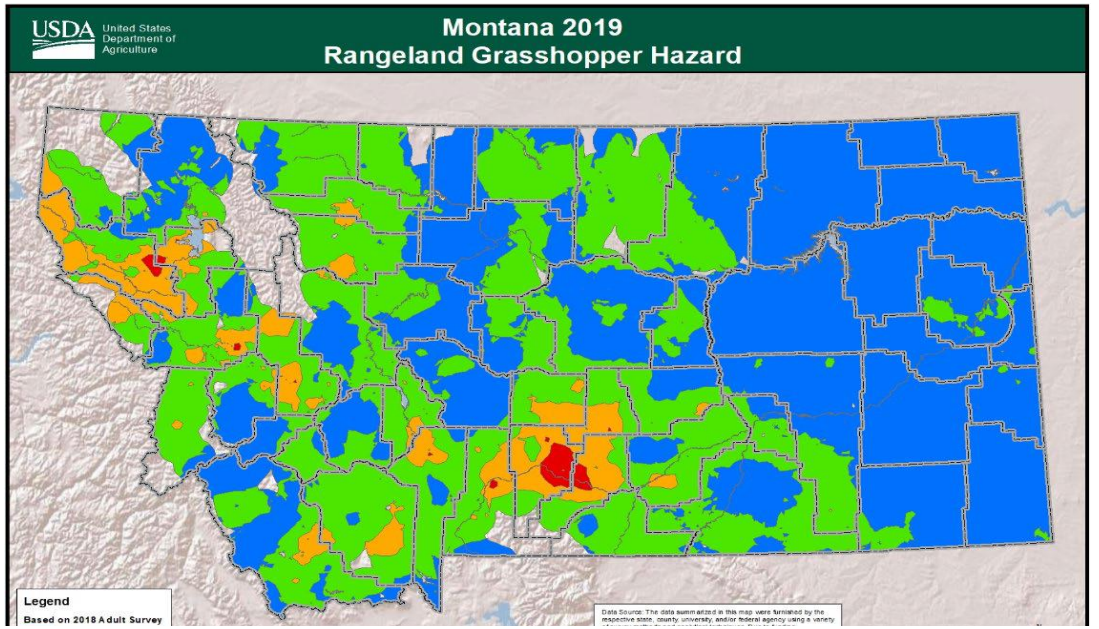


FIGURE 3 The change in plant biomass relative to controls for (a) total plant biomass, (b) grasses, (c) forbs and (d) shrubs for each herbivore functional composition treatment. Bars are standard errors

Determine the role of rangeland insects on rangeland ecosystem function and production

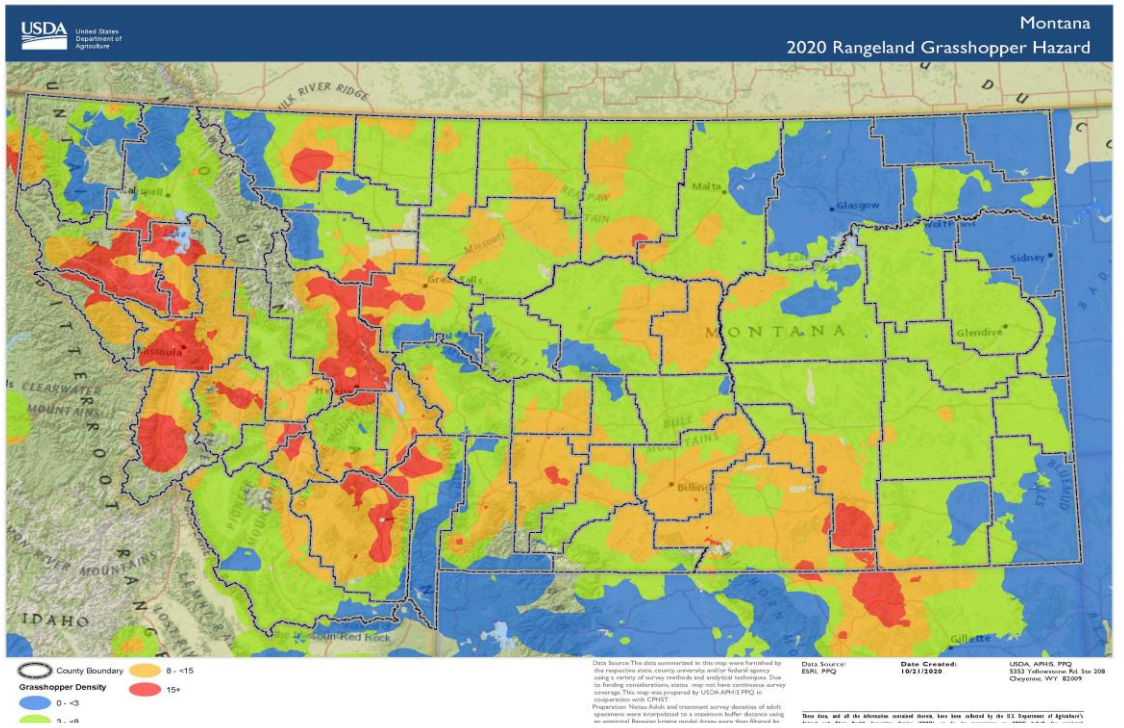
- Limited understanding of how plant regrowth following grasshopper feeding and weather variation affects economic thresholds for control
  - Initial 3 site study in the Northern Great Plains
  - Longer term: Expand collaboratively, in multiple ecosystems. Shift to dynamic predictions
  - Treatment programs need info on damage thresholds





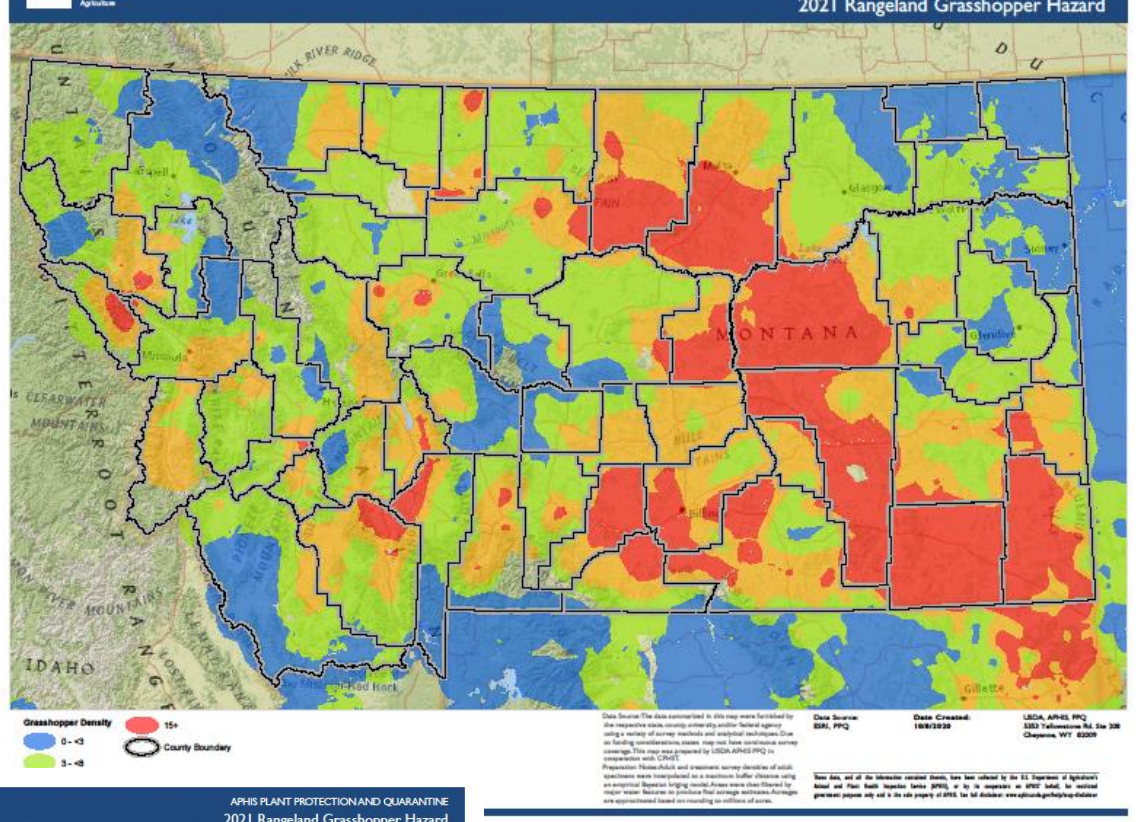
Where are things headed?

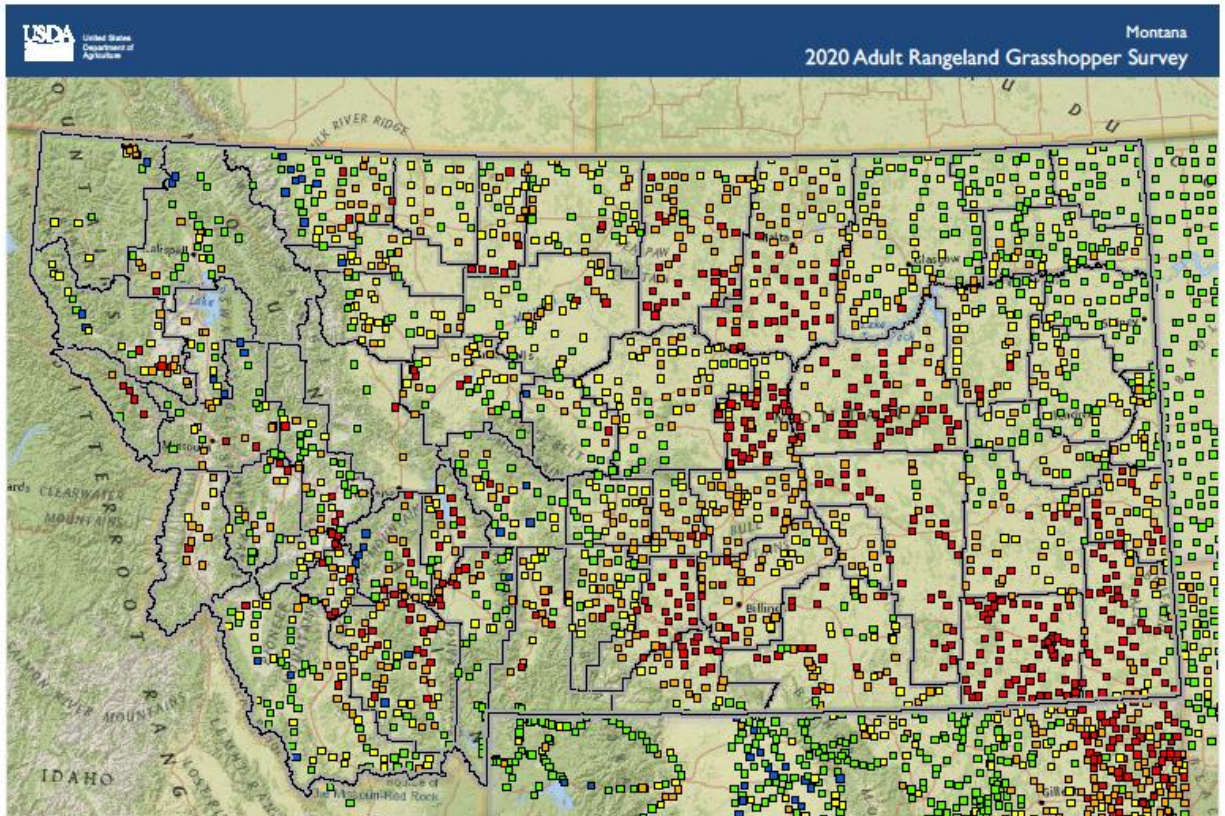
- Hazard maps are based solely on the previous years densities (i.e. 2018 Hazard ~= 2017 densities)
- Red indicates high grasshopper densities
- Note: To create the maps, adult survey densities are interpolated using a kriging model that underestimates smaller hot spots

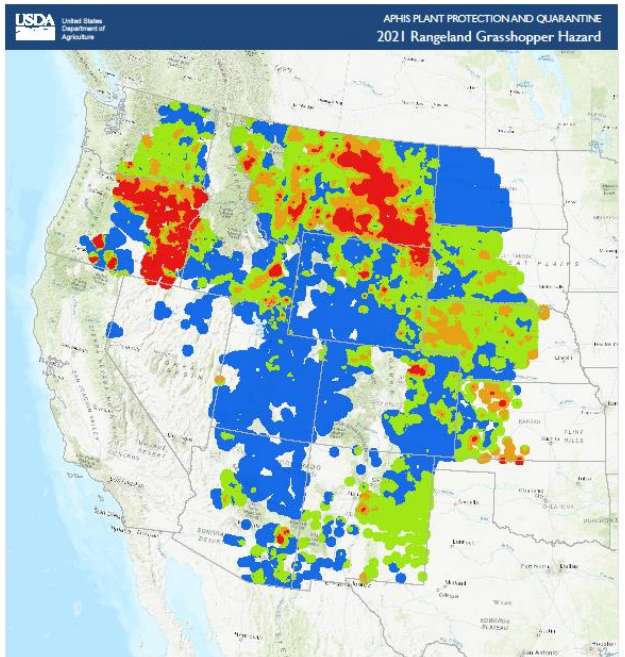


2020 USDA APHIS adult grasshopper survey

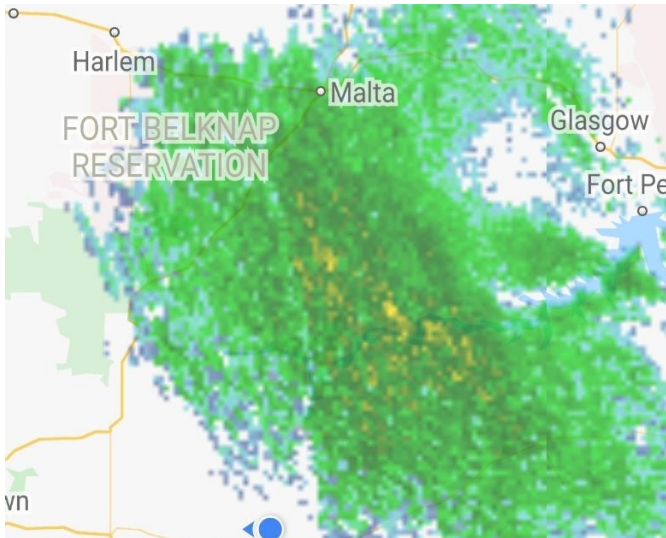
- **Predicted a high risk in much of MT**
- Relying on previous year density to predict risk isn't accurate, much of NE MT and McKenzie County predicted low risk
- John Humphries with ARS is working to develop more complex models that include satellite vegetation data and weather data





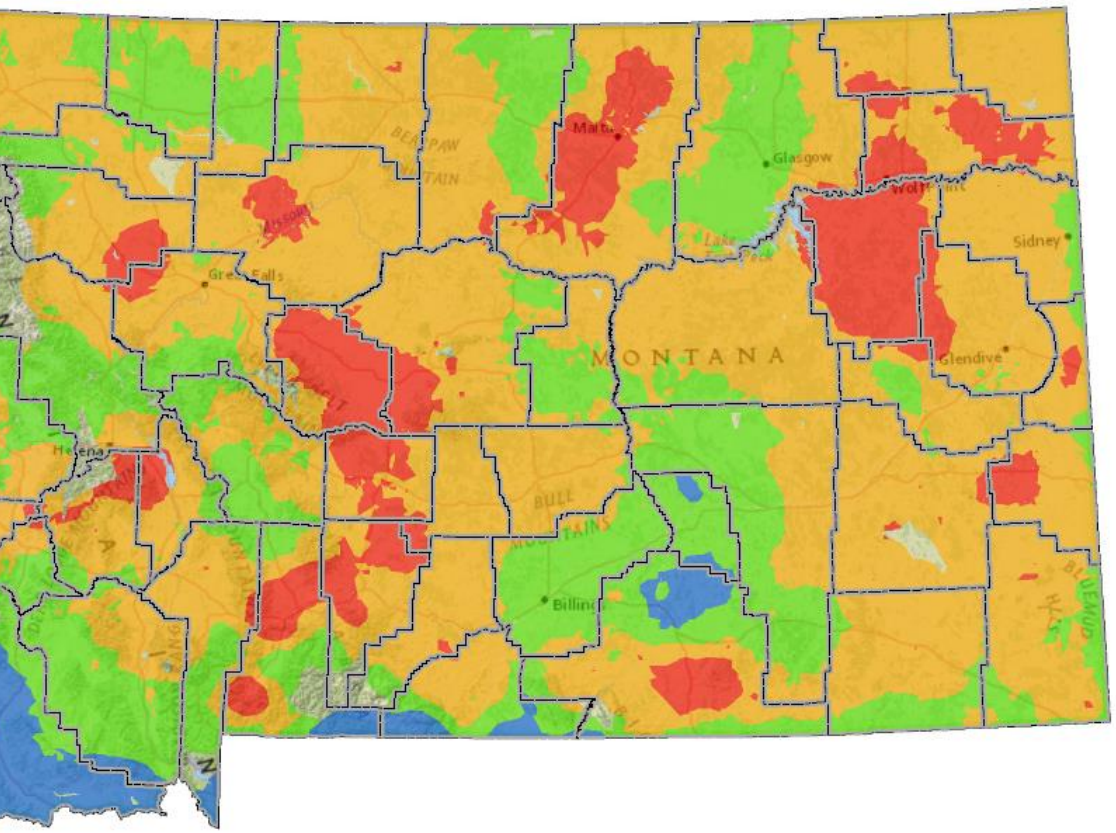


Grasshoppers on radar?



MONTANA

2022 Rangeland Grasshopper Hazard



acres

cres

0 30 60 Miles

Data Source: ESRI, PPQ

Date Created: 11/17/2021

USDA, APHIS, PPQ
5353 Yellowstone Rd. Ste 208
Cheyenne, WY 82009

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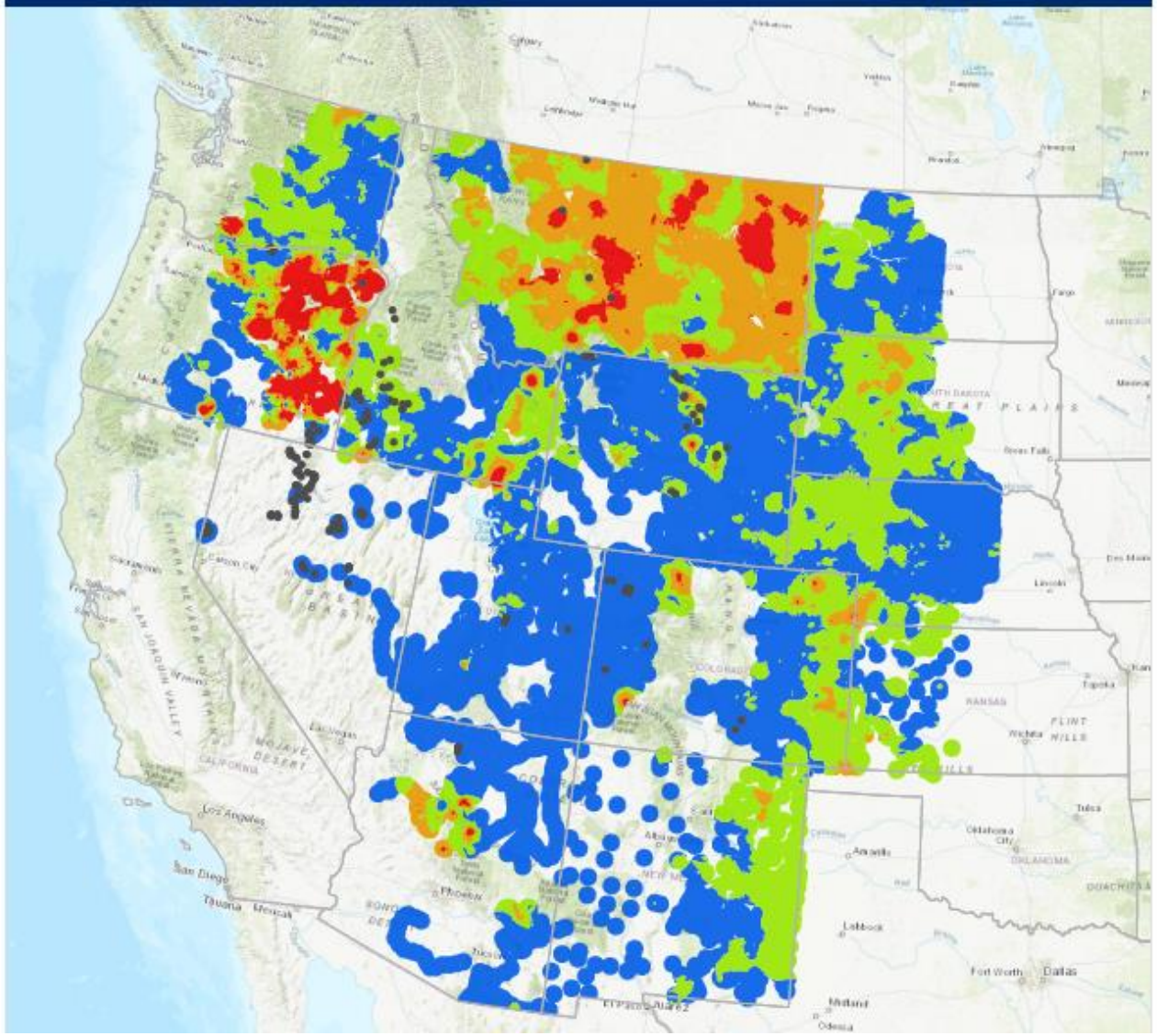
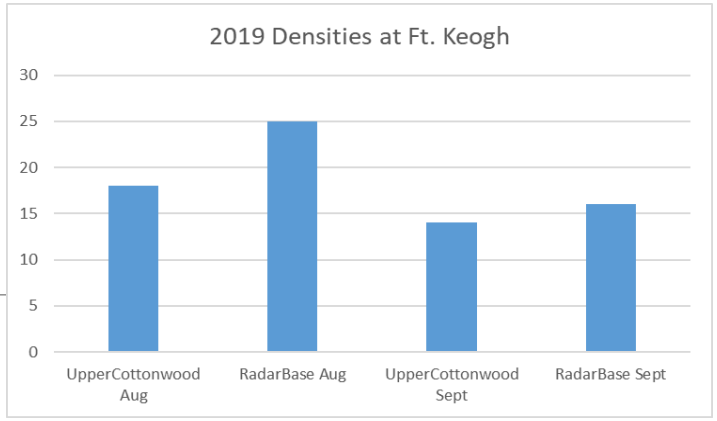
USDA Animal and Plant Health Inspection Service
UNITED STATES DEPARTMENT OF AGRICULTURE

2022 RANGELAND GRASSHOPPER HAZARD WITH MORMON CRICKET PRESENCE

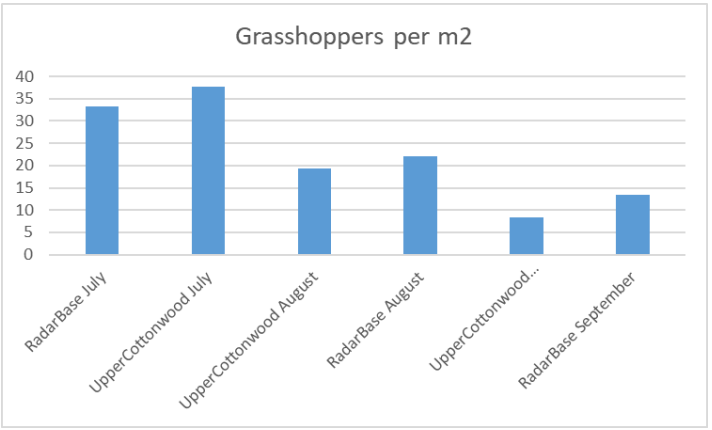


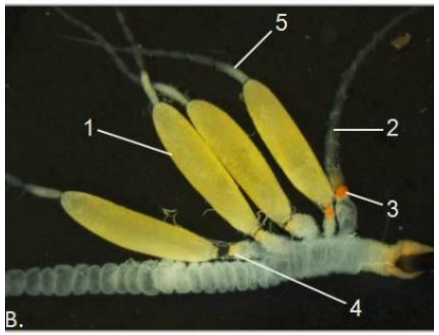
AGRICULTURAL RESEARCH SERVICE

Recent example from Miles City



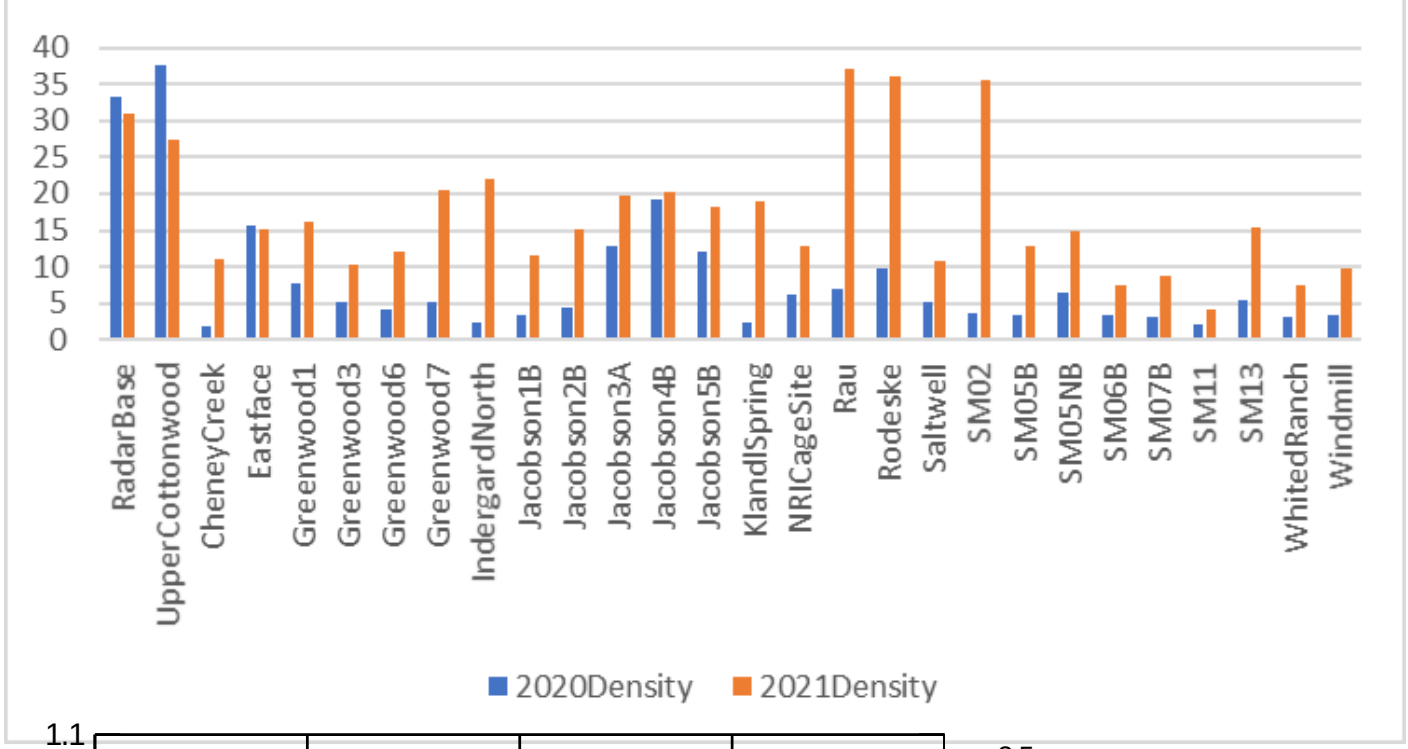
- Abundant grasshoppers in 2019
- Fall 2019 rain maintained forage quality in 2020. ~16%↑in insect degree days
- **Reproduction:** densities x forage conditions x temperature in late summer strongly affect future risk
- Densities remained high in late summer 2020.
- High reproduction, predicted high probability of ↑ severe outbreaks in 2021
  - 90% of females laid ≥ 1 egg pod by mid-Sept
  - 76% of ovarioles (picture) producing eggs in mid-Sept, good forage for reproduction
- 2021 – Densities remained roughly the same. Some areas in Montana increased dramatically, other areas did not. Why…

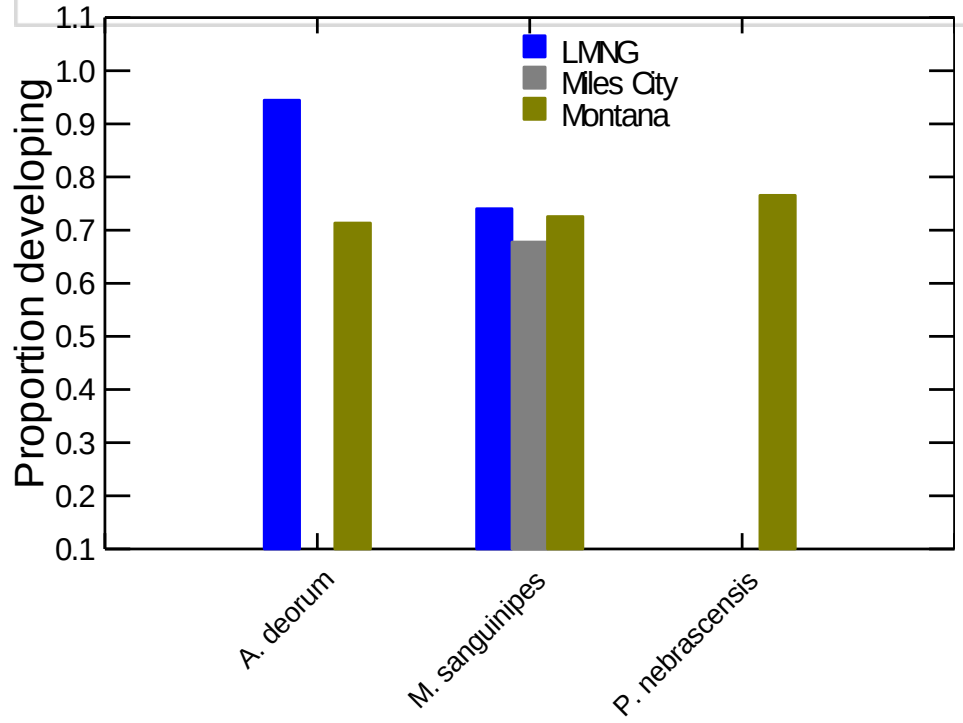




ARS Long Term Monitoring Sites

- Miles City MT: Largely stable 20/21
- Western ND: 2021 densities ~**much higher**, often >15/m^2
- *APHIS map shows much lower density/risk in ND than our extensively sampled long term monitoring sites
- Reproduction?





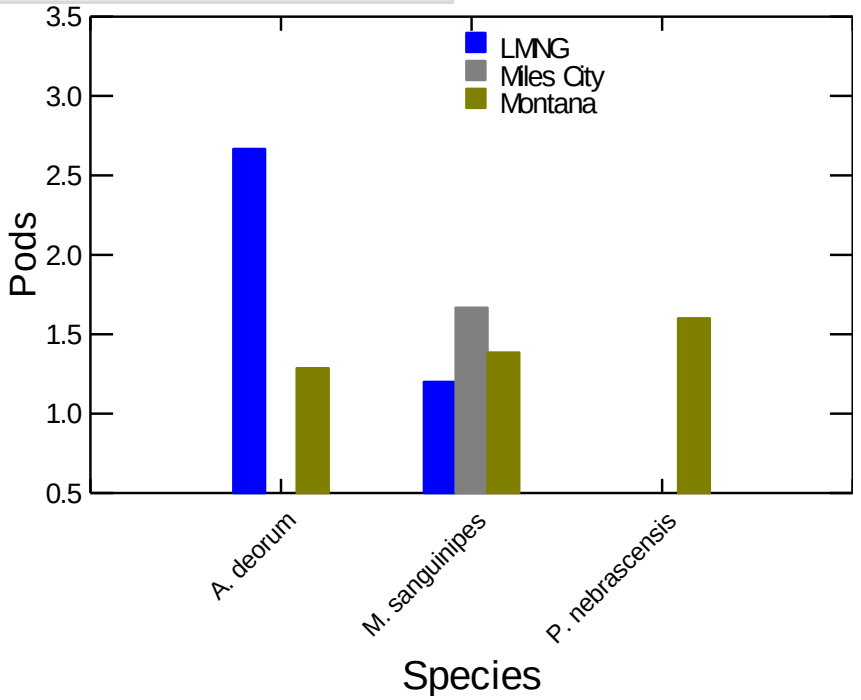


Photo taken in McKenzie County

Where are we headed?

Degree days higher in 2021 – grasshoppers are ectotherms and develop faster and eat more when it is warmer. More time for reproduction.

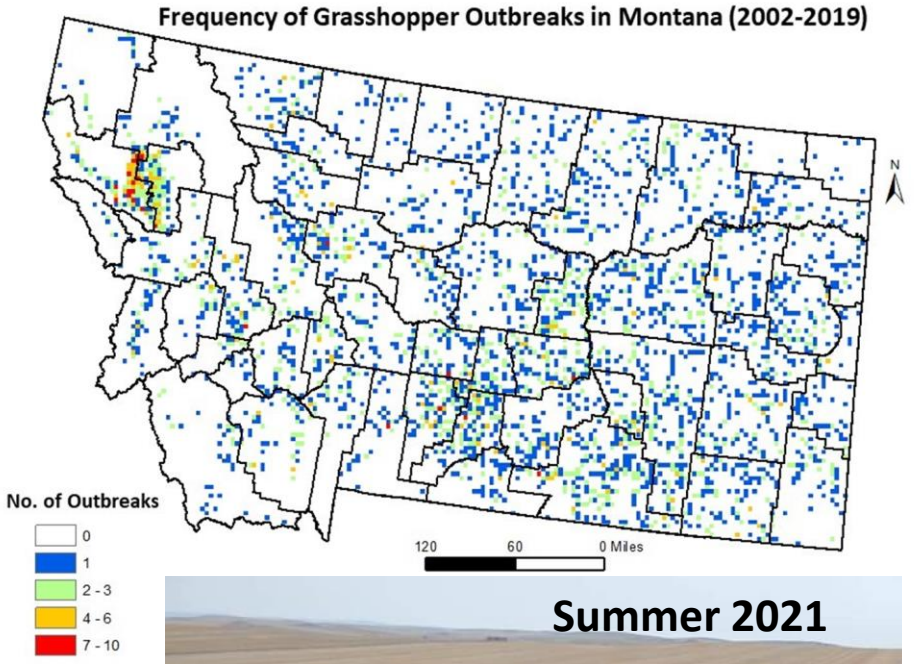
Low forage production from drought – grasshoppers need protein content with some veg moisture

Densities: Increased from 2020 to 2021 in much of NE MT and western ND. Some rangeland sites >30m2

Late summer rangeland forage quality highly variable due to spotty rain, grasshopper problems in ‘22 likely variable

Grasshoppers will move off rangeland into crops if crops are ~greener

Risk assessment for ranchers: What to look out for?



Late summer forage condition?

- Grasshoppers need protein and at least some green vegetation

Did hopper numbers remain high into late summer?

- Egg laying occurs in late summer and early fall

Late summer and fall weather conditions - warm vs. cool?

- Grasshoppers need heat to lay many eggs, if cool may stay alive but less egg laying

Areas with high late summer densities are where high hatching could occur –> **frequently look for small hatchlings** (1/8-1/4”) or you may lose most of your forage before spraying

Can we better examine drought impacts on outbreaks using cage experiments?

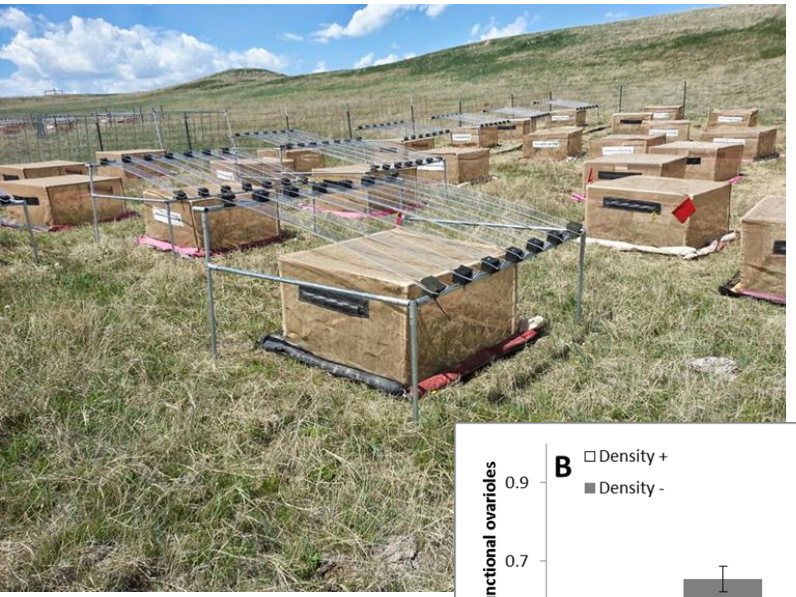
- Passive drought frames frequently used in grasslands

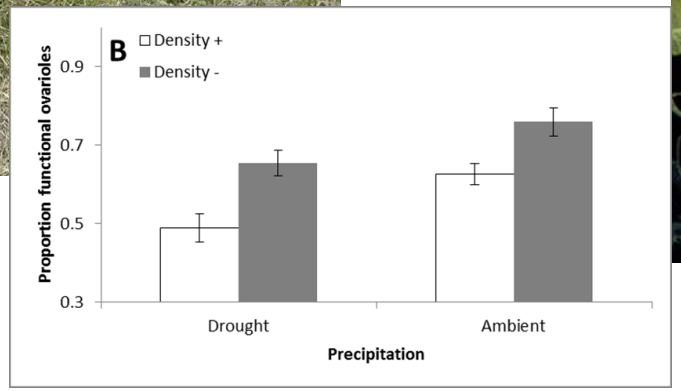
Drought vs. no-drought treatments

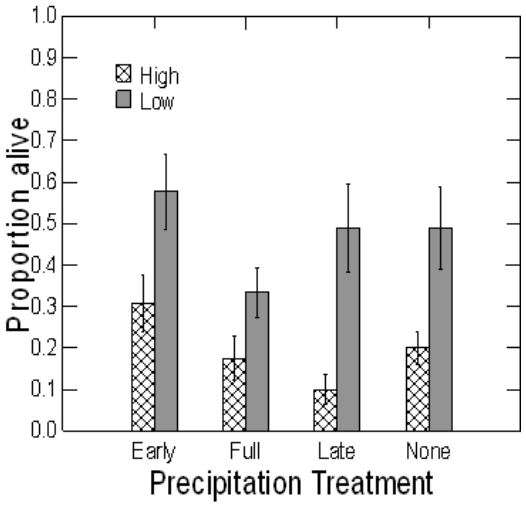
- Weak survival impacts
- Similar impacts of high density and drought on grass and grasshoppers
- Moderate drought reduced reproduction in a year with low early and high late summer rains

Follow up: How does season of drought affect hoppers?

- Precipitation: (-50% season long, -70% early drought, -70% late drought, ambient precipitation)
- Drought timing matters: Early summer drought reduced grass biomass but **positively** affected nitrogen content and grasshopper survival
- **Extreme early summer drought** and high grasshopper densities may be required to strongly affect dynamics

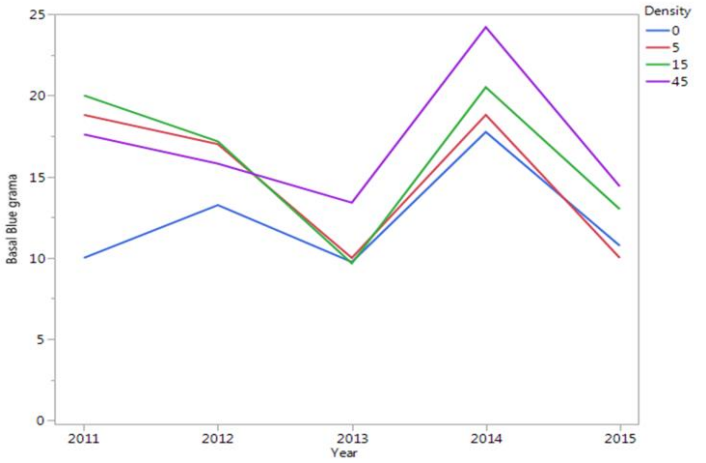


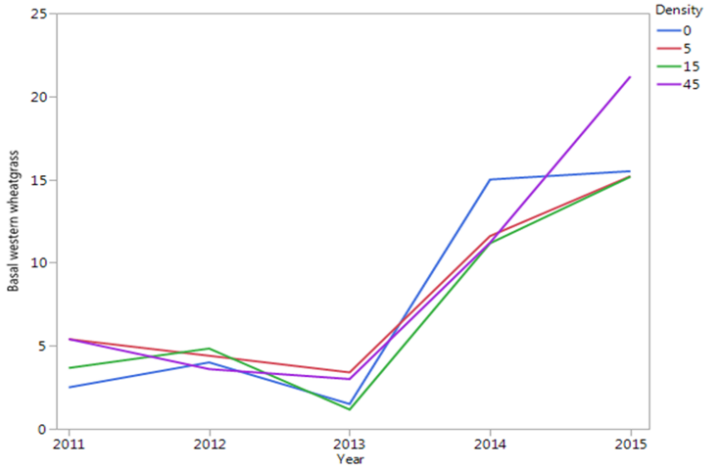




Do sustained high densities of grasshoppers harm longer-term production of rangeland grasses?

- 5 years at a grass dominated site
- Migratory grasshopper, mixed forb and grass feeder, dominant pest.
- 0 to 45 grasshoppers per cage.
- Monitored plant composition

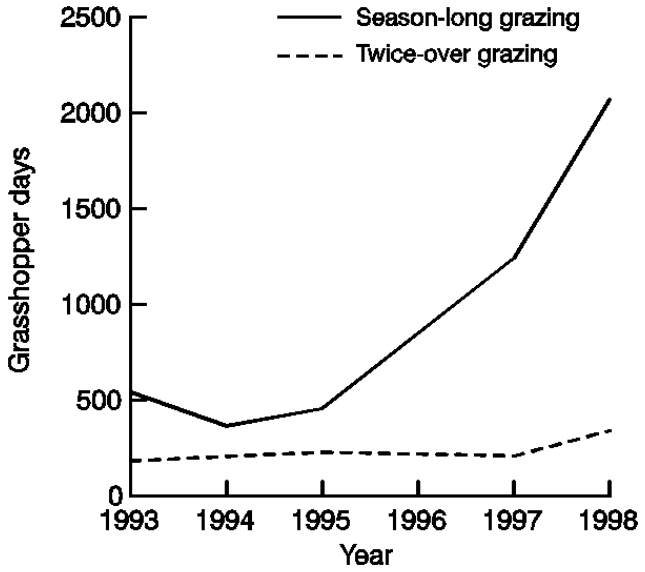




- Even with a sustained density of 45 per m^2, considered a severe outbreak, few impacts of a mixed feeding grasshopper on primary production or species composition.
- <u>Caveat:</u> Species composition matters – grass feeding species have stronger detrimental impacts on rangeland

Preventative management of grasshoppers through rangeland management

- Focus of grasshopper management: Managing rangeland through grazing and fire
  - Manipulate habitats to slow growth, reduce survival and reproduction

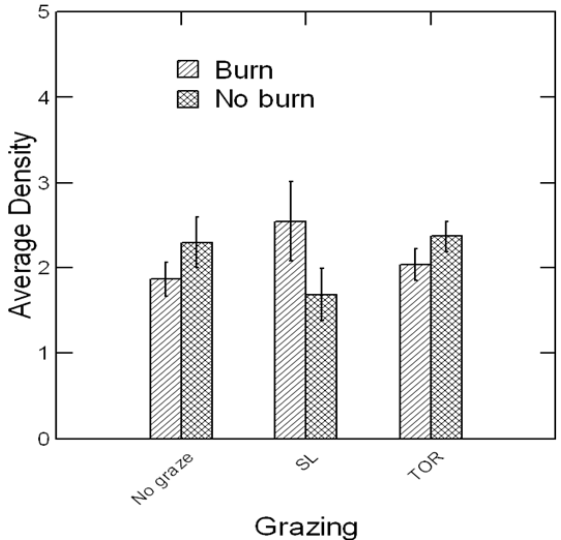


Mechanisms - twice over grazing:

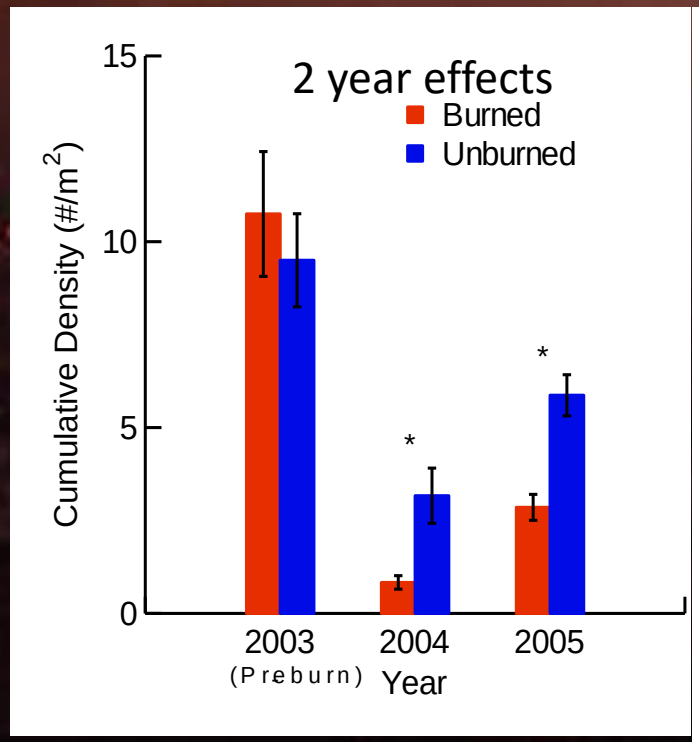
- Slower development rates than season long livestock grazing
- Lower late season species densities

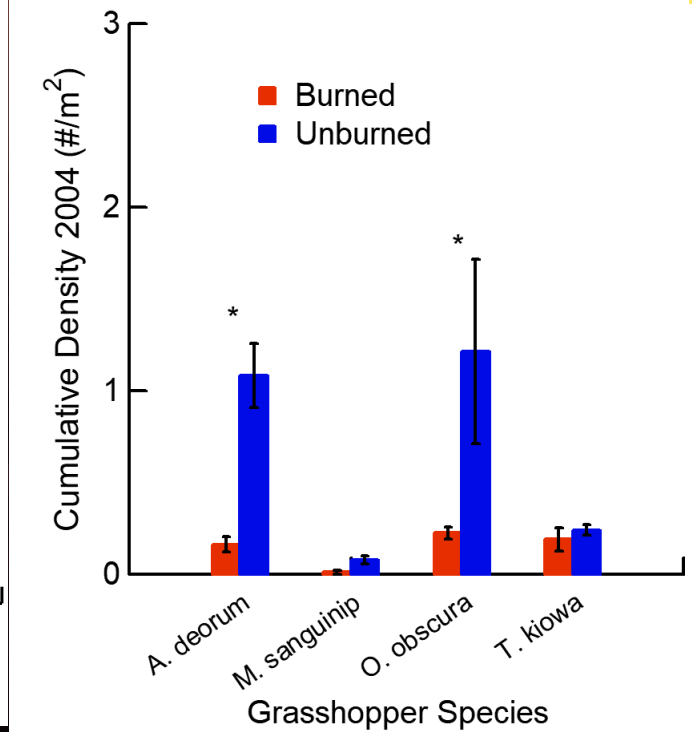
Season-long grazing (SL): Consistent grazing pattern, uneven canopy
Twice over rotational grazing (TOR): Inconsistent pattern/timing between years

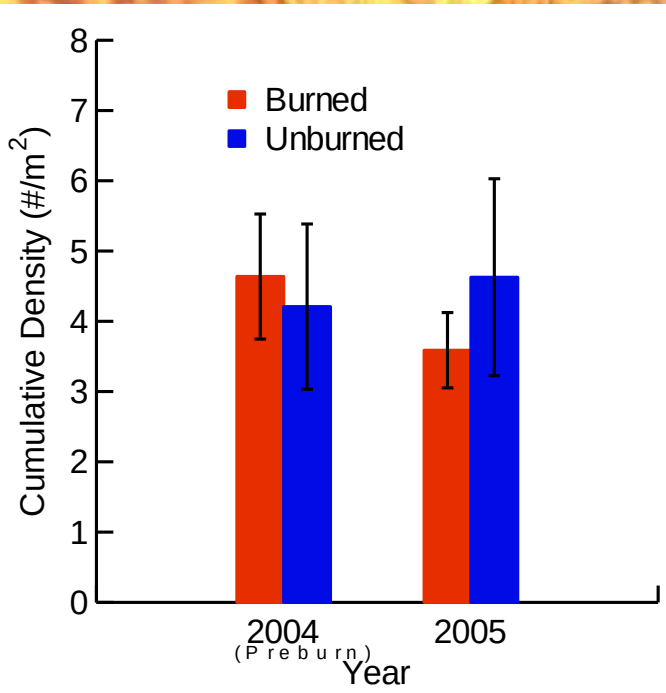
Grazing impacts aren't always clear, due to variation in weather and grasshopper densities



Fire can reduce densities of some grasshopper species by >80%, but effects depend on grasshopper species, fire timing, and standing plant biomass

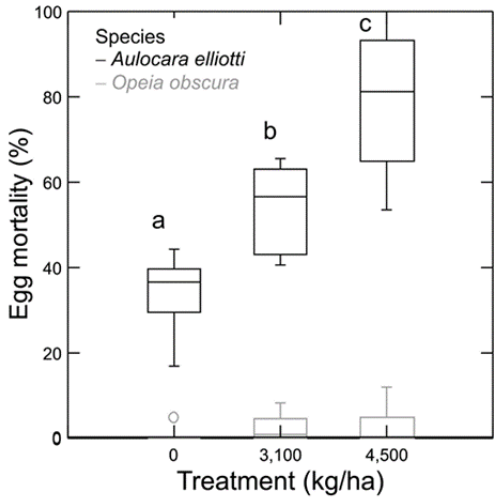






Egg mortality mediated both by how deep a given grasshopper species lays eggs belowground and fire intensity

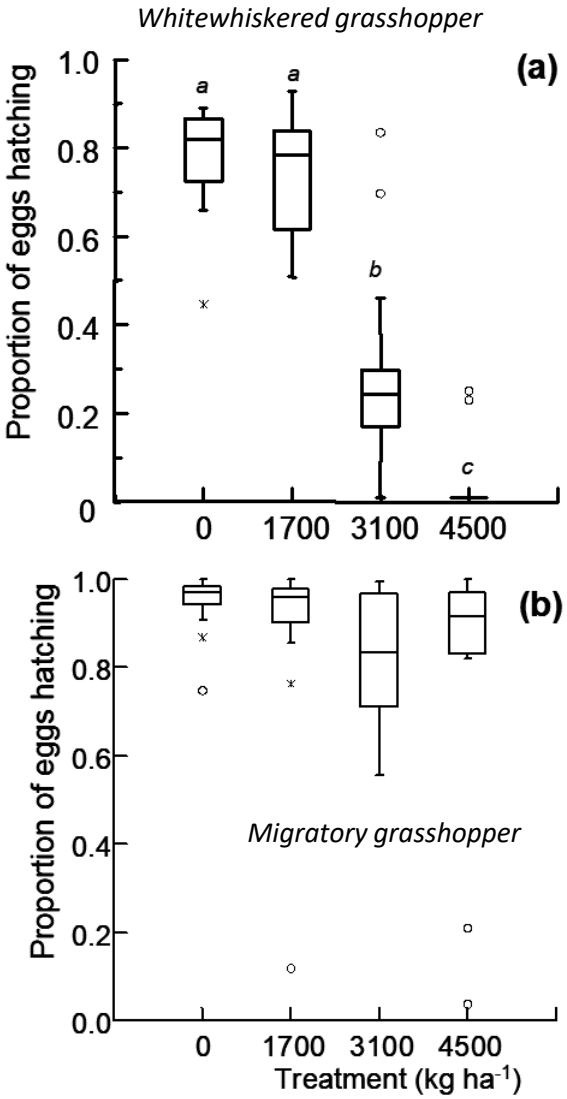
- Burning elevates soil temperatures
- *Whitewhiskered grasshopper* strongly reduced following fire
- Small egg pods of 3 to 5 eggs just below the soil surface.



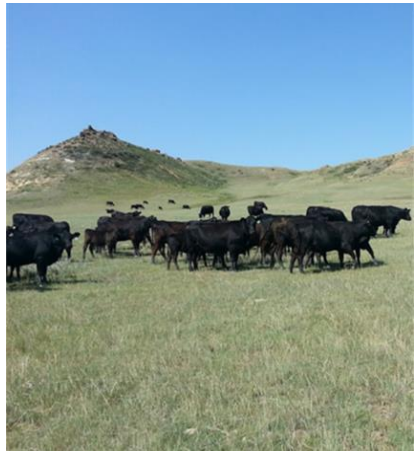
Deep laying species not affected. Many pest species lay ~vertical and deeper egg pods

Of species strongly reduced by fire:
Whitewhiskered: egg mortality
Obscure: terminated reproduction, not egg mortality

Precipitation drives fire intensity through plant production

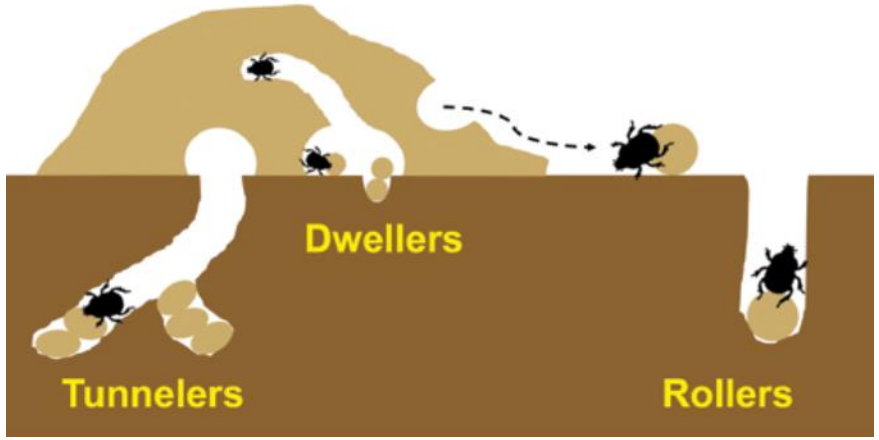


Examine impact of alternative grazing management practices and fire on invasive grasses and grasshoppers



Testing if multiple grazing management strategies and fire can be used to reduce dominance of the invasive grass Kentucky Bluegrass (ARS Mandan)?

- Examine grasshopper responses
- Examine dung beetles and dung decomposition/nutrient cycling



Conclusion

- Management approaches are best integrated before outbreaks, if they are to reduce outbreaks
  - Variability in climate conditions, vegetation, grasshopper population dynamics
  - Sustainable rangeland management strategies that minimize outbreaks and promote biodiversity while satisfying needs of the grazing industry

2022 Research – Post control monitoring

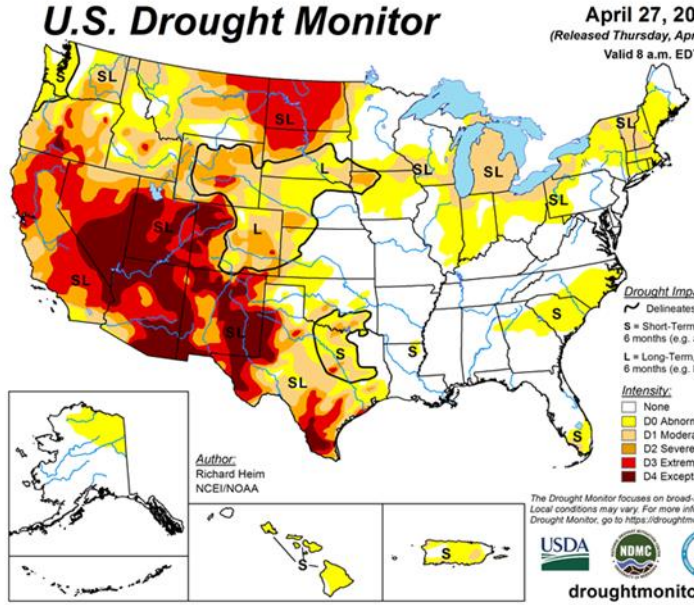
Follow up on spray programs – Stakeholder questions addressed:

- Impact of no-action. Would outbreak end without control (ie short duration)?
- Multiyear returns on spray?
- Do population dynamics differ post spray program, vary between pest and non pest species, etc?

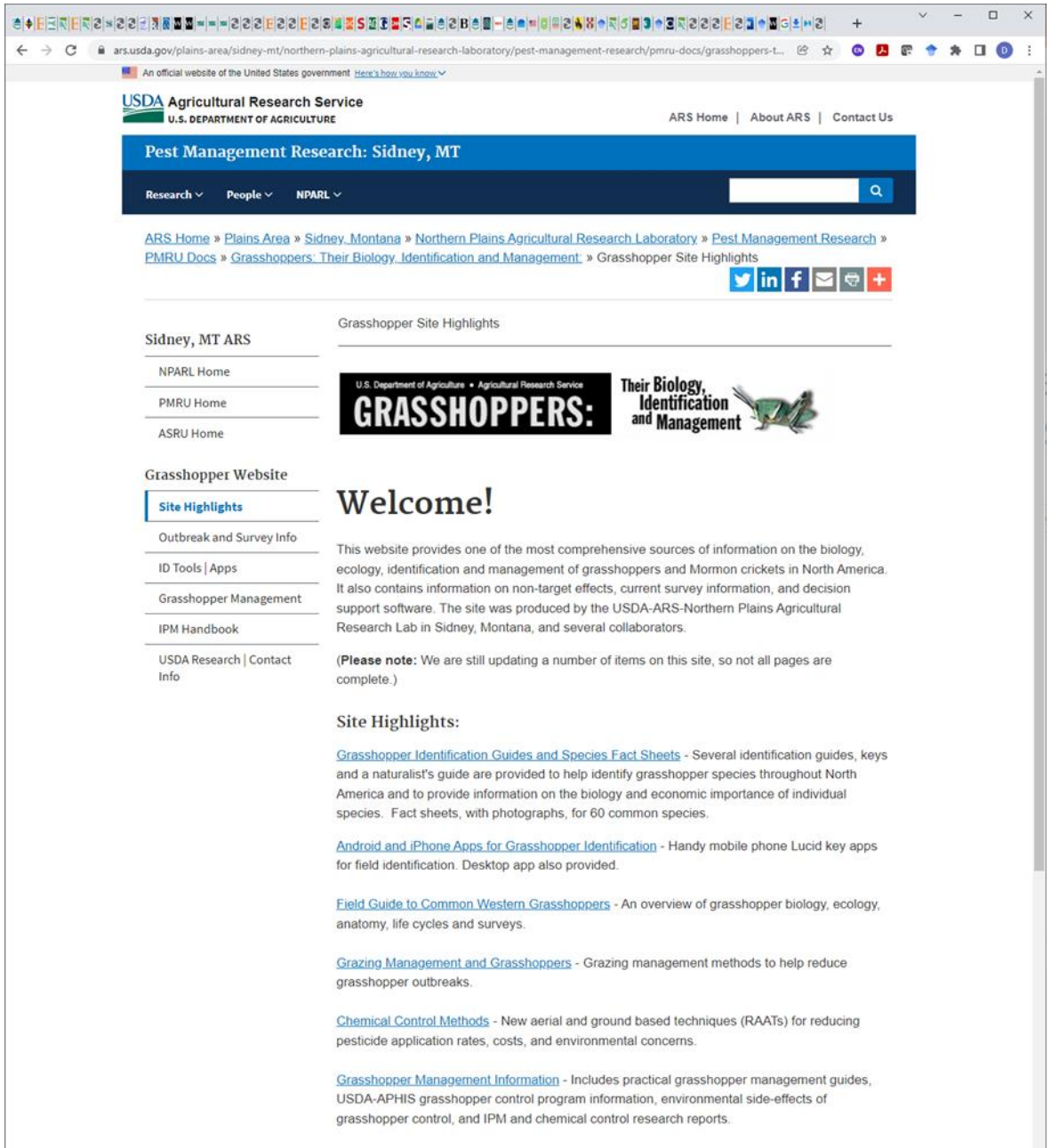
ARS may at times be able to do longer term monitoring that APHIS can't due to time and personnel constraints.

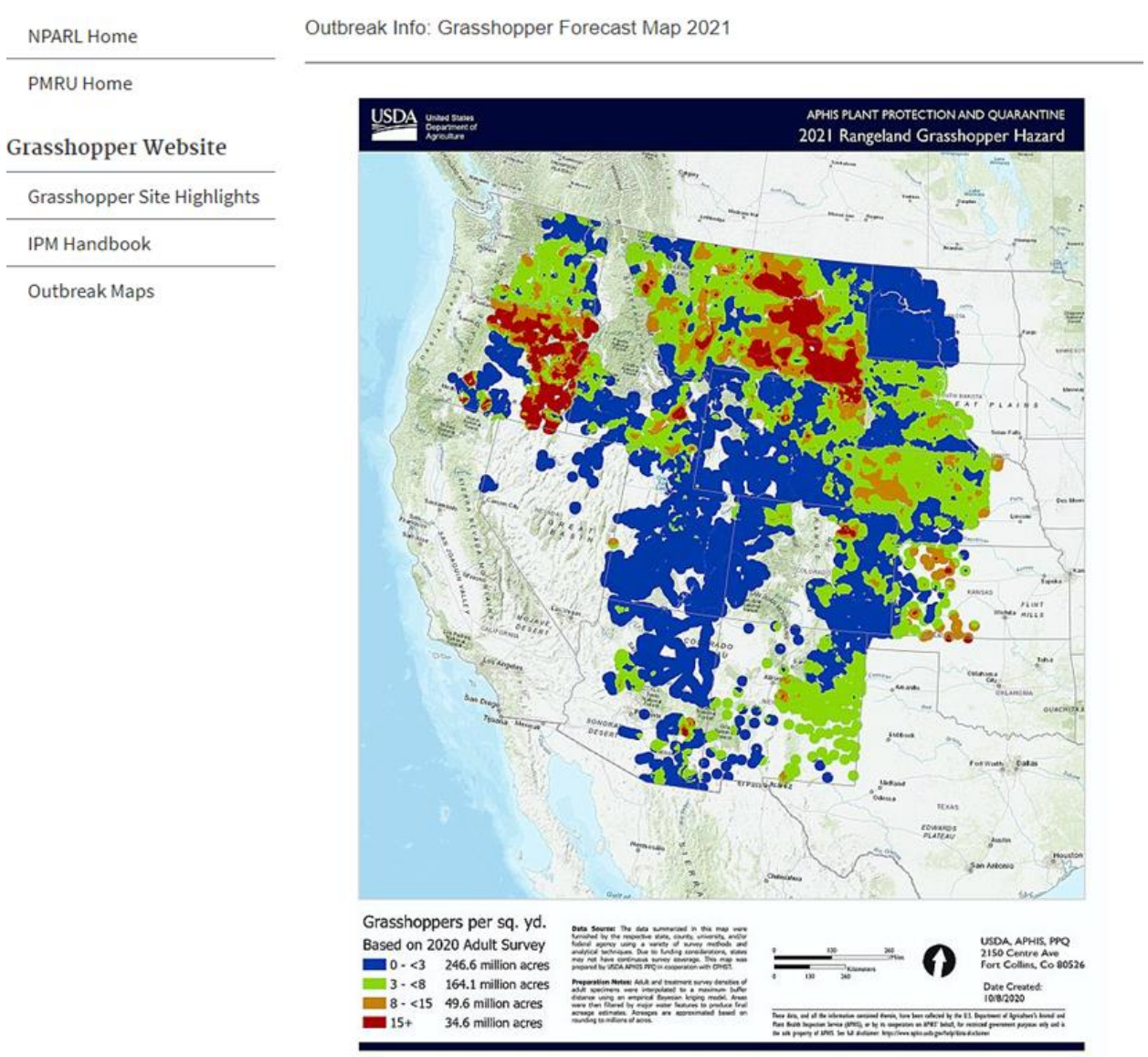
Some ongoing projects

- Long term grasshopper population dynamics sites in MT and ND
- Fire and grazing rangeland management in southern ND
- Impact of invasive grasses on grasshopper communities
- Impact of fire in juniper encroached landscapes in ND on grasshoppers and pollinators



USDA ARS Grasshopper Website: ars.usda.gov/grasshopper/





Questions:

1. What do you see as your biggest impediment to effectively managing grasshoppers?

2. If you could have us research one area that would improve grasshopper management or generate needed knowledge what would that be?

Questions or suggestions?

dave.branson@usda.gov ; 406-478-3860

- Much ongoing ARS research came about from input from land managers, APHIS, ranchers and farmers