Effects of summer fire and post-fire grazing on grasshopper abundance and species composition

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Introduction

Grasshoppers often reach outbreak densities that cause significant economic impact to the grazing industry, especially during drought periods when forage is already scarce. Collectively, grasshoppers can rival large mammalian grazers in terms of ecosystem impact when densities are high. Rangeland management practices such as burning or livestock grazing have the potential to be important tools in grasshopper management, by manipulating the quality of habitat available for grasshoppers and/or their predators. Grasshoppers are highly responsive to altered habitat structure, providing opportunities for managing populations through habitat manipulation (Branson et al. submitted).

Fire Effects on Grasshoppers

Burning has been shown to influence grasshopper population density and community composition in multiple ecosystems, including the northern Great Plains. Changes in grasshopper populations following fire have been attributed to direct mortality of eggs, nymphs or adults; as well as indirect effects from changes in host plant quality and plant community composition. Fire has been shown to help control certain pest grasshopper species over the short term in the Great Plains (Vermeire et al. 2004, Branson 2005), suggesting that fire may be useful as a management tool for grasshoppers.

Grazing Effects on Grasshoppers

Studies in a number of ecosystems have shown that livestock grazing can either positively or negatively affect grasshopper population densities. There are several mechanisms by which livestock grazing could affect ecological processes that limit and regulate grasshopper populations. Foraging by livestock could directly reduce food availability for grasshoppers through competition or indirectly via changes in plant community composition. In addition, both grazing and trampling can affect the structure and microclimate of the grasshopper habitat. No studies have examined the effects of post-fire grazing intensity on grasshopper populations in the northern Great Plains.

Study Objectives

The responses of grasshoppers to late summer fire and post-fire grazing intensity were examined in a field experiment at the Ft. Keogh Livestock and Range Research Lab in eastern Montana to aid in post-fire management decisions. The study was designed to examine two separate questions.

1. Does late-summer fire affect grasshopper densities and species composition?
2. Does post-fire grazing intensity influence the effect of burning on grasshopper densities and species composition?

Materials and Methods

Study was conducted at the USDA-ARS- Ft. Keogh Livestock and Range Research Lab in Miles City, Montana (Fig. 1)

- Dominant grasses were western wheatgrass, needle-and-thread and blue grama

Fig. 1. Fire break between burned and unburned plots.

Fig. 2. Vegetation and soil sampling in 2004, illustrates low biomass production in 2004.

Experimental Design

- Four replicated 0.75 hectare plots (1.85 acre) for each treatment
  - No fire and 0% utilization
  - Fire and 0% utilization (Ungrazed)
  - Fire and 17% utilization (Light)
  - Fire and 34% utilization (Not sampled for grasshoppers)
  - Fire with 50% utilization (Moderate)
- Experiment replicated at adjacent sites burned in consecutive years (August 2003, 2004) to encompass a wider range of climate conditions
- Vegetation and soil sampling (**See related poster #2 in this session**)

Grasshopper Sampling

- Grasshopper density estimated every 2 to 4 weeks by counting the number of grasshoppers within 30 or 40 0.1m^2 aluminum wire rings (Fig. 3a). Grasshopper community composition was determined through sweep net samples taken 2 or 3 times each summer (Fig. 3b)
- Densities of individual species were determined by combining ring counts and sweep net samples
- Low grasshopper population densities were present in all plots during 2004 and 2005

2003 Fire Plots:

- Fire applied August 29, 2003
- 50% utilization plots received 81 sheep-days of grazing from 6/30 through 7/8 in 2004, while 17% utilization plots received 27 sheep-days
- Pre-fire and 2 years post-fire grasshopper sampling

Fig. .3a. 0.1m^2 density sampling ring

Fig. 3b. Collecting a sweep net sample in 2005

2004 Fire Plots:

- Fire applied August 24/25, 2004
- 50% utilization plots received 388 sheep-days of grazing from 6/6 through 7/8 in 2005, while 17% utilization plots received 129 sheep-days (Fig. 5)
- Pre-fire and 1 year post-fire grasshopper sampling to date

Fire and grazing effects analyzed separately:

- Fire Effects: No fire and 0% utilization, Fire and 0% utilization
- Grazing Effects: Fire and 0%, 17% and 50% utilization treatments

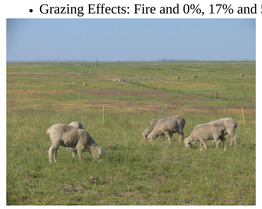

Fig. 5. Sheep grazing in June 2005

Fig. 6. Adult grasshopper killed by the 2003 fire

Results and Discussion

Fire: Variable effects of late summer burning on grasshopper population densities and species composition

2003 Fire

- Burning strongly reduced grasshopper population densities in the 1st and 2nd years post-fire
  - 74% lower cumulative density in burned plots in the 1st year post-fire (2004) (Fig. 7)
  - 51% lower cumulative density in burned plots in the 2nd year post-fire (2005) (Fig. 7)
  - Grasshopper population densities and species composition did not differ in pre-burn sampling (Fig. 7)
- No significant effects of burning on either species richness or Shannon diversity.

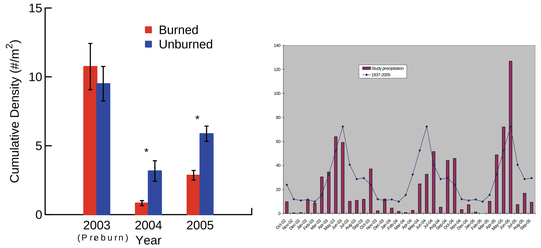

Fig. 7. Cumulative population densities for pre-burn sampling (2003) and post-fire sampling (2004-2005) (2003 Fire)

Fig. 8. Precipitation over the experiment compared with average precipitation from 1937-2005.

Species specific effects of burning

- Densities of the two most abundant grasshopper species were reduced over 80% with burning (Figs. 9, 10).
- *Ageneotettix deorum* (Whitewhiskered grasshopper):
  - 85% reduction with burning in the 1st year post-fire (2004) (Fig. 9)
  - 76% reduction in the 2nd year post-fire (2005) (Fig. 10)
  - The strong detrimental effects with burning fits with Vermeire et al. (2004), who found a two-thirds reduction of *A. deorum* following prescribed fires in Oklahoma.
  - *A. deorum* lays small egg pods just below the soil surface (Box 1), exposing eggs to high temperatures during fires and leading to egg mortality (Branson and Vermeire, submitted). *A. deorum* is an early hatching species and a relatively small proportion of total egg production would typically take place after the end of August.

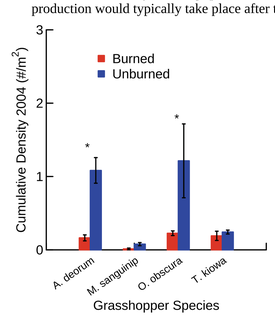

Fig. 9. Cumulative densities of common grasshopper species in 2004, the 1st year post-fire (2003 Fire)

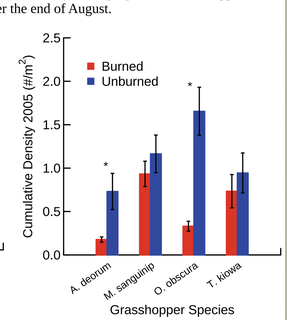

Fig. 10. Cumulative densities of common grasshopper species in 2005, the 2nd year post-fire (2003 Fire).

Species specific effects of burning (continued)

- *Opeia obscura* (Obscure grasshopper):
  - 81% reduction in densities with burning in the 1st year post-fire (2004) (Fig. 9).
  - 79% reduction in 2005 with burning in the 2nd year post-fire (2005) (Fig. 10).
  - *O. obscura* is a late hatching species (Box 1). The reduced densities likely resulted from both reduced reproduction due to adults being killed by the fire (Fig. 6) and fire induced egg mortality, as *O. obscura* also lays relatively small egg pods (Box 1).
- *Melanoplus sanguinipes* and *Trachyrhachys kiowa* both lay deep vertical egg pods (Box 1) and were present in low numbers. Branson and Vermeire (submitted) found that *M. sanguinipes* egg survival was unaffected by fires simulating 4500 kg ha^{-1} standing crop biomass.
- The 2003 fire did not have large detrimental effects on dominant grasses in 2004 (see related poster #2), and all common grasshopper species feed on grasses and sedges.

2004 Fire

- Burning in 2004 did not significantly reduce grasshopper population densities or affect species composition in the 1st year post-fire (2005) (Figs. 11, 12).
  - Drought in the first half of 2004 reduced available fuel (Fig. 8), leading to much less intense fires in 2004 than in 2003.
  - Branson and Vermeire (submitted) found that fires simulating 3100 kg ha^{-1} standing crop biomass significantly reduced populations of *A. deorum* through egg mortality, while populations were unaffected by fires simulating 1700 kg ha^{-1} standing crop biomass.

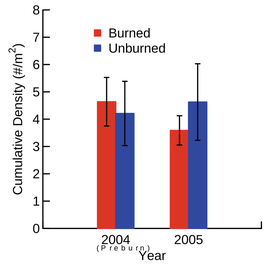

Fig. 11. Cumulative population densities from pre-burn sampling (2004) and 1st year post-fire sampling (2004 Fire)

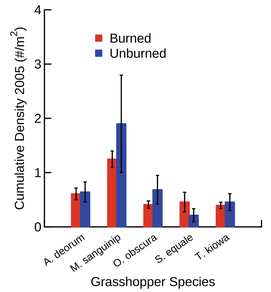

Fig. 12. Cumulative densities of common grasshopper species in 2005, the 1st year post-fire (2004 Fire)

Conclusions: Fire

- The effects of burning on grasshopper populations were likely influenced by drought effects on fuel load at the time of burning.
  - Grasshopper densities were reduced over 70% in a year with higher fuel biomass.
  - When fuel biomass was low due to drought conditions, burning did not significantly affect grasshopper population densities or species composition.
- Fuel load appears to be an important factor in determining whether a given fire will selectively control populations of *A. deorum*.
  - Fires conducted during periods of drought with limited vegetation production are less likely to control *A. deorum* populations, as elevations of soil temperatures will not be high enough to create egg mortality.
- The results from the 2003 fire indicate that large reductions in grasshopper populations can continue for at least 2 years post-fire, if the numerically dominant species are strongly reduced.
  - Previous studies in the northern Great Plains typically found only a one year post-fire effect on grasshopper densities.
  - Because populations of the two dominant species, *A. deorum* and *O. obscura*, were nearly eliminated by the 2003 fire, more than one year is required for populations to rebound.
  - Species composition is important in predicting the effectiveness of fire in controlling grasshopper populations, as *T. kiowa* was unaffected by the 2003 fire.
- Prescribed burning earlier in August would likely reduce egg production for a number of grasshopper species, thus reducing population sizes for species not vulnerable to egg mortality.
- Late summer burning appears an effective way to control some, but not all, grasshopper pest species in the northern Great Plains.

References

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Grazing: Does post-fire grazing intensity affect grasshopper populations when densities are low?

2003 Fire

- No effects of post-fire grazing intensity on grasshopper population densities, either during the year with grazing (2004) or in the year following grazing (2005) (Fig. 13).
- As burning reduced grasshopper populations by approximately 75%, densities were extremely low in all grazed plots in 2004.
- Little vegetation production occurred in 2004 (See Fig. 2), which led to relatively small differences between grazing treatments.

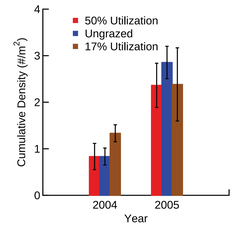

Fig. 13. Cumulative population densities in ungrazed, 17% utilization and 50% utilization pastures (2003 Fire)

2004 Fire

- After grazing was initiated, grasshopper population densities were significantly lower in 50% utilization plots compared to ungrazed plots (Fig. 14).
- Population densities of both *Melanoplus sanguinipes* and *Ageneotettix deorum* were significantly lower in the 50% utilization treatment than in ungrazed controls (Fig. 15).
- These reductions could have resulted from movement to adjacent plots where cover was greater or increased avian predation after grazing opened the vegetation canopy. Given the low grasshopper densities, grazing would not be expected to create food limitation.

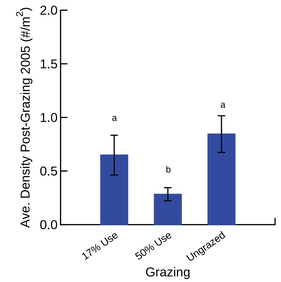

Fig. 14. Average densities during and after grazing in 2005 for ungrazed, 17% and 50% utilization (2004 Fire)

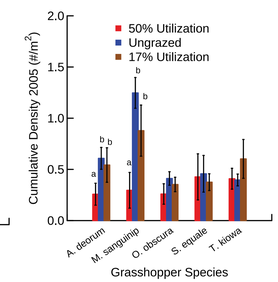

Fig. 15. Cumulative densities of common grasshopper species in 2005 for ungrazed, 17% and 50% utilization treatments (2004 Fire)

Conclusions: Grazing

- Post-fire grazing intensity is unlikely to have large effects on grasshopper population dynamics when densities are extremely low, as occurred in this study.
- Additional investigation is needed to examine if results differ when grasshopper densities are higher, and to determine if moderate grazing consistently leads to within year reductions in grasshopper densities.

Box 1. Common grasshopper species

Ageneotettix deorum (Whitewhiskered grasshopper, Slantfaced subfamily): small-bodied early hatching species, lays small egg pods of 3 to 5 eggs just below the soil surface, grass and sedge generalist, common economic species.

Opeia obscura (Obscure grasshopper, Slantfaced subfamily): small-bodied species that hatches as late as the end of June, lays small egg pods of ~8 eggs, prefers blue grama (*Bouteloua gracilis*).

Melanoplus sanguinipes (Migratory grasshopper, Spurthroated subfamily): begins hatching 1-2 weeks after *A. deorum*, lays large egg pods up to 4 cm deep with a froth plug, highly polyphagous feeder on both grasses and forbs, frequently a dominant economic pest species.

Trachyrhachys kiowa (Kiowa grasshopper, Bandwinged subfamily): intermediate hatching species, feeds on grasses and sedges – often preferring blue grama, lays vertical egg pods up to 3 cm deep with a froth plug, prefers areas with sparse vegetation.

All species have 1 generation per year

(Photos courtesy of S.P. Schell et al., B-1161, 2005, U. Wyoming)