Short Communication

# Lepidoptera Pest Species Response to Mid-Summer Fire

**T.R. Evans[1, 2, *], C.J.M. Musters[1], E.D. Cashatt[2], and G.R. de Snoo[1]**

[1] Institute of Environmental Sciences, Leiden University,
van Steenisgebouw, Einsteinweg 2, 2333 CC Leiden, The Netherlands

[2] Illinois State Museum Research and Collection Center,
1011 E. Ash Street, Springfield, Illinois 62703, USA

*Corresponding author: Tel.: 001-217-498-0345; e-mail: tracy.evans62545@gmail.com

## ABSTRACT

In the American Midwest, summer fires are infrequent, and there is little information on their impact on ecosystems. After an accidental wildfire in a 20 ha grassland restoration, new growth provided effective substrate for the noctuid species corn earworm, *Helicoverpa zea* (Boddie), and tobacco budworm, *Heliothis virescens* (Fabricius). These agricultural pests feed on a number of important crop species and have been implicated in crop losses of up to 50 %. Invertebrate collections were made at 16 days, 45 days, 70 days, and 101 days post fire. A comparison of burned and unburned areas at 70 days post fire show 18 times the number of Lepidoptera larvae collected in pitfall traps in the burned area compared to the adjacent unburned area of the grasslands. These findings demonstrate that a mid-summer fire can affect the abundance of economically important insects.

## RESUMEN

En el medio oeste estadounidense los incendios de verano son infrecuentes y existe poca información sobre su impacto en los ecosistemas. Después de un incendio accidental de 20 ha en un pastizal en restauración, la regeneración formó un sustrato adecuado para las especies de noctuidos *Helicoverpa zea* (Boddie), gusano elotero, y *Heliothis virescens* (Fabricius), gusano cogollero del tabaco. Estas plagas agrícolas se alimentan de un número importante de cultivos, llegando a causar pérdidas de más del 50 % en cosechas en pie. Las colectas de invertebrados se hicieron 16 días, 45 días, 70 días y 101 días después del incendio. Al comparar las áreas quemadas y las zonas adyacentes sin quemar 70 días después del incendio, se encontró que en las áreas quemadas se colectaron 18 veces más larvas de Lepidoptera en las trampas. Estos resultados demuestran que los incendios de mediados de verano pueden afectar la abundancia de insectos con importancia económica.

*Keywords*: agricultural pests, corn earworm, Lepidoptera larvae abundance, Midwest, prairie management, tobacco budworm, wildfire

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## INTRODUCTION

In prairie management in the United States, prescribed burning is a preferred technique used to achieve a variety of objectives: fuel load reduction (Fernandes and Botelho 2003), mineral soil exposure (Choromanska and DeLuca 2002), nutrient release (Boerner 1982), seedbed preparation (Chapman 1936), invertebrate pest control (Vermeire *et al.* 2004), disease reduction (Hardison 1976), and invasive species control (Pendergrass *et al*. 1999). Most research has been conducted on the impacts of spring prescribed fire in specialized habitats (Panzer 2002, Vogel *et al*. 2007); information on the consequences of summer fires is limited. Interestingly, summer fires may more accurately represent natural and historical processes (Gleason 1913, Howe 1995).

The ecology of important agricultural pest species and proximate factors influencing their abundance are incompletely understood. These factors may include management practices un-related to pest control. In Illinois, Conservation Reserve Program (CRP) management takes place within an agricultural landscape and requires consideration of unintended consequences in an agricultural context. After an accidental wildfire, we set pitfall traps in the burned and unburned areas within a 20 ha field to observe the invertebrate repopulation of the area. Here we show that a mid-summer burn may provide additional opportunities for breeding of important pest species.

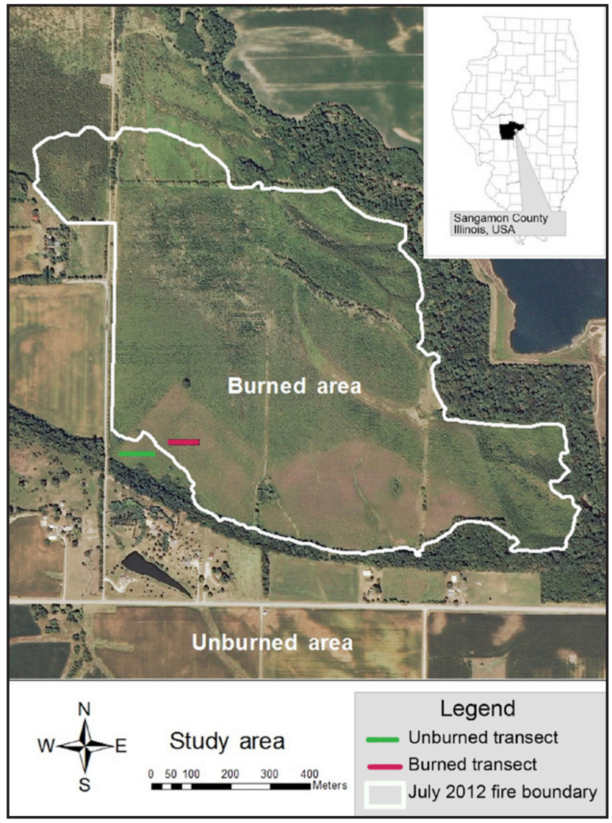


**Figure 1.** Site of wildfire (27 July 2012) showing the extent of the burned and unburned areas and the location of the transects. Inset shows the location of Sangamon County in Illinois, USA.

## METHODS

### *Study Area*

The study area was located in central Illinois (Figure 1, inset) in Sangamon County, USA (39°45'09.18"N, 89°28'16.98"W), within the Grand Prairie Natural Division (Schwegman 1973), a vast plain formerly of mostly tall-grass prairie. The research area was a 20 ha field enrolled in the Conservation Reserve Program (CRP) for 12 years and seeded in native warm season grasses and mixed forbs. This field was part of a larger area of CRP that included tree plantings. Management of the field included hand removal of brush and trees with cut stump herbicide treatment.

Due to reduced precipitation and high ambient temperatures during the preceding 15 months, this region was considered to be in an extreme drought (National Oceanic and Atmospheric Administration 2012). An unplanned wildfire (27 July 2012) burned more than 100 ha, including the 20 ha field that was later selected for study (Figure 1). The fire was reported to be intensely hot, in part due to the high fuel load resulting from the drought, and was allowed to burn uncontrolled while available fire crews were protecting neighboring homes. It consumed all of the above-surface vegetation. This was followed by a flush of growth, closely resembling new growth in the spring. We used this unique opportunity to study post-fire invertebrates.

### *Sampling*

We sampled invertebrates using 18 pitfall traps placed on two 80 m transects in unburned and burned prairie restoration. There were nine pitfall samples 10 m apart on each transect. The end points of the transects were 50 m apart, 25 m from the burn boundary (Figure 1). Pitfall traps were 150 ml plastic cups with a water and vinegar solution and detergent added to break the surface tension of the water (Eymann *et al*. 2010). In a pilot study, ethylene glycol was found to be a problem by attracting mammals to the traps. It was found to be a problem in similar studies and this disturbance could result in significant loss of data (Fassbender 2002). For this reason, vinegar was used rather than ethylene glycol. The pitfall contents were retrieved 7 days after placement and stored in isopropyl alcohol. We collected samples 11 August, 9 September, 5 October, and 4 November 2012 (16 days, 45 days, 70 days, and 101 days post-fire, respectively). The small area (2 ha) of unburned prairie limited the number of replicates (Figure 1). All specimens were counted and identified to family. Nomenclature follows Lafontaine and Schmidt (2010). The presence of large numbers of Lepidoptera larvae prompted a more thorough identification than study protocols indicated. Lepidoptera larvae were identified using keys and morphological characters from Crumb (1956), Neunzig (1964, 1969), and Stehr (1987).

### *Data Analysis*

We performed statistical analysis using R software 2.14.1 applying a General Linear Model (GLM) assuming a quasipoisson distribution because of the non-normal data distribution. The model we used for the GLM analysis included all interactions between factors: Number ~ Burned * Month * Species. "Number" was the number of Lepidoptera larvae per pitfall, the response variable. "Burned" was a binomial variable indicating whether the pitfall was in the burned or unburned area, and "Month" was the month of the observation. "Species" was either corn earworm, *Helicoverpa zea* (Boddie), or tobacco budworm, *Heliothis virescens* (Fabricius). The effect of separate factors was studied by applying an $F$-test.

## RESULTS

In October (70 days post fire), the average number of Lepidoptera larvae in the burned area ($n$ = 60) was over 18 times the number found in the unburned ($n$ = 3) area. Noctuids, corn earworm and tobacco budworm (Neunzig 1964, 1969), comprised 83 % (50 of 60) of the Lepidoptera larvae collected (Figure 2). Corn earworm was the most abundant (53 %), followed by tobacco budworm (30 %). The remaining larvae (17 %) were classified as Arctiidae and Noctuidae. They were categorized as "other" as they were clearly different from *H. zea* and *H. virescens* and were different from each other. Because of the low numbers of the other larvae, they were not identified to species nor included in further analyses.

Interaction effects were not significant (Table 1). Numbers of Lepidoptera larvae differed in the burned and unburned areas of the field ($F = 91.776$, $P \leq 0.001$). The month in which the sample was taken also differed, with October having the most larvae ($F = 66.224$, $P \leq 0.001$). Numbers of corn earworm and tobacco budworm larvae differed from each other ($F = 6.127$, $P < 0.015$).

The observed increase in number of Lepidoptera larvae (Figure 2) corresponded to the time needed for vegetation to re-grow, adult moths to lay their eggs on new vegetation, and larvae to go through several instars. The

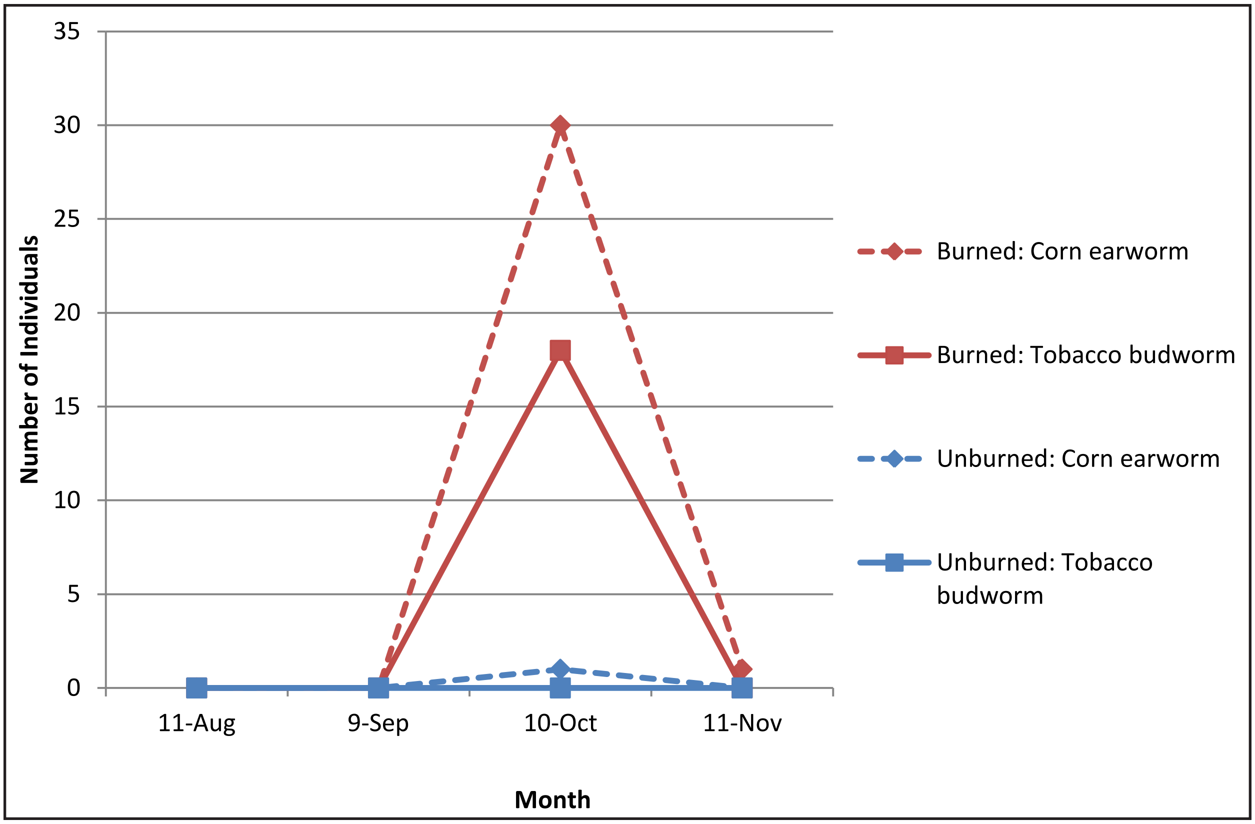


**Figure 2.** Numbers of corn earworm and tobacco budworm larvae in burned and unburned CRP field (Sangamon County, Illinois, USA) during sampling at 16 days, 45 days, 70 days, and 101 days post fire (27 July 2012).

**Table 1.** Analysis of the separate factors of the complete model. Factors significantly affecting larvae numbers are the portion of the field that was burned or unburned (Burned), month of sampling post-fire (Month), and larval species of corn earworm or tobacco budworm (Species).

| | Df | Deviance | Resid.df | Resid.dev | *F* | Pr (>*F*) |
|---|---|---|---|---|---|---|
| Complete model | 143 | 264.992 | | | | |
| Burned | 1 | 59.511 | 142 | 205.481 | 91.776 | <2e-16 *** |
| Month | 3 | 128.826 | 139 | 76.655 | 66.224 | <2e-16 *** |
| Species | 1 | 3.973 | 138 | 72.683 | 6.127 | 0.015 * |
| Burned:Month | 3 | 0.041 | 135 | 72.642 | 0.021 | 0.996 |
| Month:Species | 3 | 0.904 | 132 | 71.738 | 0.465 | 0.707 |
| Burned:Species | 1 | 0.928 | 131 | 70.810 | 1.431 | 0.234 |
| Burned:Month:Species | 3 | 0.000 | 128 | 70.810 | 0.000 | 1.000 |

*** = <0.001
* = 0.05

abrupt decline in numbers for November reflects a killing freeze (–3 °C) on 4 November 2012, and autumn pupation.

## DISCUSSION

The key novel finding in this study is that a mid-summer burn can produce immediate major shifts in distribution of agriculturally important insects, in the sense that it attracts adult moths to lay their eggs on tender regrowth after the fire. It is unlikely that the differences we found in the number of larvae were due to the change in vegetation density or movement of the larvae. In other studies (T.R. Evans, Illinois State Museum and Leiden University, unpublished data), vegetation height and density had no significant impact on trapping probability.

In this study, the predominant species collected were the noctuids corn earworm and tobacco budworm. Both species are polyphagous (Tietz 1972) and significant agricultural pests because of their abundance and wide host range of many agricultural crops (Neunzig 1969). Host crops include corn (*Zea* spp.), tomato (*Solenum* spp.), cotton (*Gossypium* spp.), green beans (*Phaseolus* spp.), clover (*Trifolium* spp.), vetch (*Vicia* spp.), lettuce (*Lactuca* spp.), peppers (*Capsicum* spp.), soybeans (*Glycine* spp.), and sorghum (*Sorghum* spp.). Estimated losses in field corn in the southern United States range from 1.5 % to 16.7 %. In Illinois, major economic impact is limited to damage to sweet corn and seed corn, with as much as 50 % loss (Cook and Weinzierl 2004). The North Central Integrated Pest Management Pest Information provides at least biweekly monitoring information in several Illinois counties for abundance of corn earworm adults.

Although the encountered noctuids usually die out during winter in most of the state, pupae survive winter in soil in far southern Illinois in most years. Populations can also overwinter in other parts of the state during mild winters. Despite some local overwintering, populations of these insects in Illinois emigrate from southern states in late spring and early summer (Cook and Weinzierl 2004), with moths arriving on weather fronts and laying their eggs in susceptible crops. In Illinois, adults are usually found in June and can produce two full generations per season. At an average temperature of 25 °C, it takes 49.3 days to complete development and burrow into the soil to pupate (Neunzig 1969). Adults lay eggs on host vegetation; when larvae hatch, they move away from light to moist shady areas. Population densities usually peak in late summer.

Dominant plants in the burn area and within 10 m of the trapping area were ground cherry (*Physalis* spp.), sunflower (*Helianthus* spp.), and goldenrod (*Solidago* spp.)—all known hosts of both larvae (Tietz 1972). These plant species are common in CRP restorations and provide host plants outside the agricultural crops.

Prescribed burning guidelines provide limits of fuel load, ambient temperature, wind speed and direction, and time of day (Bunting *et al.* 1987). The accidental fire described in this study would not fall within limits found in prescribed burn guidelines. However, the flush of new growth occurs as part of the burning process, either planned or accidental. The newly emergent growth provides benefits for desired species (Baum and Sharber 2012) as well as undesirable species.

The marked increase in number of Lepidoptera larvae we found in the newly established vegetation could indicate either that this type of young vegetation is a limiting factor for oviposition of the species concerned, or that the females of the species have strong preference for this type of vegetation for oviposition (Verdasca *et al*. 2011, Baum and Sharber 2012). In the first case, mid-summer fire would strongly increase the number of eggs laid by the species in a certain area. In the latter case, assuming that the preference of the females is related to the survival of eggs and larvae, the mid-summer fire would increase the survival of the egg and larvae population in an area. In both cases, the mid-summer fire will increase the number of pupae in the soil during winter and in turn increase the probability of recruitment in the event of a mild winter. Only in the improbable case of no or a negative relationship between preference of females and egg and larvae survival, would mid-summer fire not increase the number of pupae in the soil. The abundance of available host plants allows early establishment of this pest species in those years in which there are mild winters.

Grasslands evolved for millennia under conditions of natural summer and early fall fire started by lightning (Keeley and Rundel 2005, Anderson 2006, Pausas and Keeley 2009). Historical frequency of fires is uncertain, but available evidence indicates that fire occurrence varied from every 5 yr to 10 yr, to every 20 yr to 30 yr (Wright and Bailey 1982). The assumption that an individual ecosystem is adapted to fire is different than the assumption that a specific ecosystem is adapted to a specific fire regime (Pausas and Keeley 2009). Application of a fire regime different from that to which species have evolved could produce negative results in (semi-) natural habitats (Howe 1995). On the other hand, a regime that closely resembles natural fire events could be a risk for agricultural systems, as our results would seem to suggest. How large the actual impact of a mid-summer fire on agriculture could be, both in terms of crops and area that would be affected, needs to be studied.

Both timing and frequency of fire as a management tool are important facets of the planning process. Management goals should be clear, with possible unintended consequences to the neighboring agricultural landscape taken into consideration. Fire has consequences and being aware of potential impacts lets us more wisely choose how to get the desired results.

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