The Effects of Fire on Arthropods in the Lake States Region

Jennifer L. Strangstalien[1], Jessica R. Miesel [1,2,3], P. Charles Goebel [2,3], and David J. Mladenoff[1]

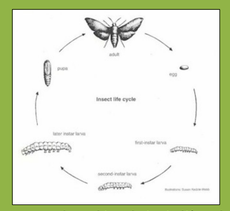
[1]Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, [2]Lake States Fire Science Consortium, and [3]Ohio Agricultural Research and Development Center, The Ohio State University

Background

- Both wildfires and prescribed fires occur in the Lake States Region
  - **Prescribed fire** is a fire ignited by management for a specific purpose and must have a written and approved plan (JFSP 2012).
  - **Wildfires** are an unplanned, unwanted fire, which can be caused by extreme weather or humans where the main objective is the put the fire out (JFSP 2012).
- Many arthropod groups significantly decline immediately after fire. The intensity of decline is related to the degree of exposure to the flames and the organism's mobility (DeSantis & Storer 2007, Panzer 2002, Swengel 2001)
- Intermediate-term effects are quite varied. Some arthropod populations will be lower, some similar to the initial and some will actually become higher. Examples of arthropods whose populations get higher are grasshoppers and ground beetles.
- Several dozen insect species in a variety of families worldwide have attractions to fire or smoke, or oviposit in freshly burned wood. Many of these species are highly adapted to fire conditions through sense organs sensitive to infrared wavelengths of fire and through wax glands protecting against dryness (Swengel 2001).

- Fire can affect arthropods in many ways, both positive and negative:
  - **Direct mortality-** Immediately after a fire, the population will usually decrease dramatically.
  - **Loss of shelter-** Many arthropods will lose their shelter in the event of a fire. This can cause many arthropods to leave the area to find new shelter.
  - **Loss of food-** Fire can destroy the areas vegetation, leaving the animals in the area with little to no food to eat. Arthropods can become the victims of animals that would usually eat something else, but that are no longer available.
  - **Increase in reproduction-** The effects of a fire can actually make an area more suitable for reproduction in some cases.
- Most federal funding for fire research has been directed towards ecosystems in the western United States that are characterized by catastrophic wildfires, rather than in the Lake States Region (JFSP 2012).
- The Lake States Fire Science Consortium's main goals are to:
  - Accelerate the awareness, understanding, and adoption of wildland fire science information
  - Provide the best available information on fire, fuels and fire-dependent ecosystems
  - Link managers, scientists, policymakers, and disciplines by providing information and tools to support management of fire-dependent ecosystems in the Lake States region

The objective of this study was to assess the current status of fire science information addressing fire effects on arthropods in the Lake States region.



The stage an arthropod is at during its life cycle can influence its response to fire.

The Lake States Fire Science Consortium is one of 14 regional fire science knowledge exchange consortia. For the purpose of this study, we included studies that were located within 150 km of the Consortium boundaries, including portions of Manitoba and Ontario.

Species of interest

There are many arthropods that are of special concern within the Lake States Region, including the Karner blue butterfly, the six-banded longhorn beetle, and the regal fritillary.

Karner blue butterfly
Lycaeides melissa samuelis
State Threatened
Federally Endangered

Six-banded longhorn beetle
Dryobius sexnotatus
State Threatened
Globally Not Ranked

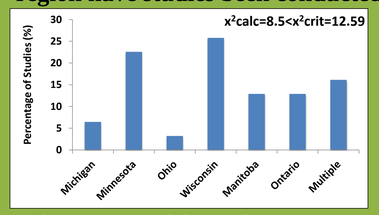
Regal fritillary
Speyeria idalia
State Endangered
Globally Vulnerable

Methods

- Several lists of keywords relating to fire, arthropods, study location, and habitat keywords were used in a literature search.
- A literature search was performed to identify all publications relating to the effects wildfire and prescribed fire have on arthropods in the Lake States Region.
- The results from the literature search were organized into categories based on **study location, ecosystem type, fire type, arthropod order, and variables studied.**
- These results were put into **pivot tables,** which allowed trends to be found easily by calculating percentages.
- That information was used to create figures showing the percentage of studies that addressed each category.
- We used **chi-squared analysis** to identify statistically significant differences in the frequency of studies occurring in each category.

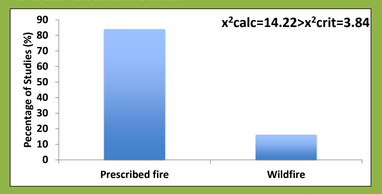
Results

In what areas of the Lake States region have studies been conducted?



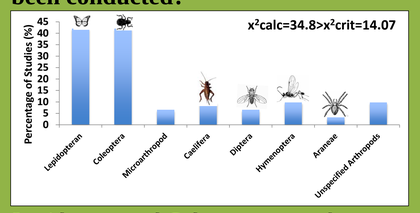
- The majority of the studies were concentrated in Wisconsin and Minnesota.

On what types of fire have studies been conducted?



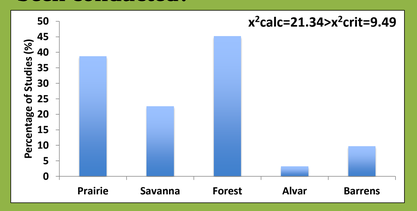
- Few studies address wildfire effects on arthropods; the majority address prescribed fire.

On what arthropod orders have studies been conducted?



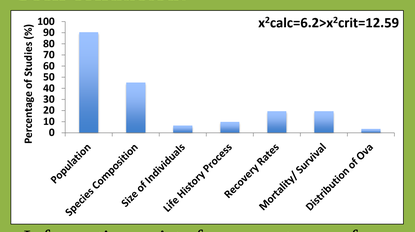
- Lepidoptera and Coleoptera were the most frequently studied Orders.

In what ecosystem types have studies been conducted?



- Previous research has concentrated on prairie, savanna and forest ecosystems.

On what response variables have studies been conducted?



- Information exists for seven types of response variables. Most studies report fire effects on arthropod population size.

Example species for arthropod orders reported by publications located by this study:

Arthropod Order	Example Species
Lepidoptera	moths, butterflies
Coleoptera	beetles
Caelifera	locusts, crickets
Diptera	flies
Hymenoptera	wasps, bees
Araneae	spiders

Discussion

- Studies of prescribed fire effects were more common than studies of wildfire effects. This is most likely because it is much easier to study a fire when you have control over when it starts and stops versus a wildfire that cannot be predicted.
- Lepidoptera (butterflies and moths) and Coleoptera (beetles) were the most common orders studied. The large number of studies done on the order Lepidoptera may be because there are a large number of species in this order that are currently endangered or threatened within the Lake States Region; therefore, they get a lot of attention from researchers.
- Most studies were conducted in prairie, savanna or forest ecosystems, and few studies in alvar or pine barrens exist. This can be attributed to the study area that we are focusing on. In the Lake States Region it is more likely to find these types of ecosystem types versus others such as alvar.
- Ninety percent of studies reported fire effects on arthropod population, whereas few studies address other factors that influence population, such as recovery rates and survival or mortality. Effective conservation and management efforts will require that future researchers reach beyond the population variable and investigate additional variables such as reproduction rate. With so many arthropod species on the threatened and endangered list in the Lake States Region, understanding fire effects on reproduction could be very valuable.

References

Relevant publications located by this study:

Andrew, C., & Leach, M. K. (2006). Are prescribed fires endangering the endangered silphium borer moth (Papaipema silphii)? *Ecological Restoration* 24:231–235.

Beaudry, S., Duchesne, L. C., & Cote, B. (1997). Short-term effects of three forestry practices on carabid assemblages in a jack pine forest. *Canadian Journal of Forest Research* 27:2065–2071.

Catling, P. M., Goulet, H., & Kostiuk, B. (2008). Decline of Two Open Champlain Sea Dune Systems in Eastern Ontario and Their Characteristic and Restricted Plants and Insects. *Canadian Field Naturalist* 122:99–117.

Catling, P. M., Goulet, H., Bennett, R., & Kostiuk, B. (2010). Orthopterans (Orthoptera), ground beetles (Coleoptera: Carabidae), and spiders (Araneae) in burned and unburned alvar woodlands - the importance of postfire succession to insect diversity. *Journal of the Entomological Society of Ontario* 141:27–37.

Dana, R. P. (1991). Conservation management of the prairie skippers Hesperia dacotae and Hesperia ottoe. *Station Bulletin - Minnesota, Agricultural Experiment Station*, (594), 63 pp.

DeSantis, R. D., & Storer, A. J. (2007). Characterizing Mechanical and Prescribed Fire Treatments Following Clear-Cutting of Jack Pine and Short-Term Treatment Effects on Insect Communities. *23rd Tall Timbers Fire Ecology Conference: Fire in Grassland and Shrubland Ecosystems* (pp. 129–139). Tallahassee: Tall Timbers Research Station.

Duchesne, L. C., & McAlpine, R. S. (1993). Using carabid beetles (Coleoptera: Carabidae) as a means to investigate the effect of forestry practices on soil diversity. *PNFI Technical Reports* (10 pp.).

Gandhi, K. J. K., Gilmore, D. W., Haack, R. A., Katovich, S. A., Krauth, S. J., Mattson, W. J., Zasada, J. C., et al. (2009). Application of Semiochemicals to Assess the Biodiversity of Subcortical Insects following an Ecosystem Disturbance in a Sub-boreal Forest. *Journal of Chemical Ecology* 35:1384–1410.

Gardiner, L. M. (1957). Deterioration of Fire-killed Pine in Ontario and the causal Wood-boring Beetles. *Canadian Entomologist* 89:241–263.

Holliday, N. J. (1984). Carabid beetles (Coleoptera: Carabidae) from a burned spruce forest (Picea spp.). *The Canadian Entomologist* 116:919–922.

Holliday, N. J. (1991). Species Responses of Carabid Beetles (Coleoptera, Carabidae) During Postfire Regeneration of Boreal Forest. *The Canadian Entomologist* 123:1369–1389.

Holliday, N. J. (1992). The carabid fauna (Coleoptera: Carabidae) during postfire regeneration of boreal forest: properties and dynamics of species assemblages. *Canadian Journal of Zoology* 70:440–452.

King, R. S. (2003). Habitat management for the Karner blue butterfly (Lycaeides melissa samuelis): evaluating the short-term consequences. *Ecological Restoration* 21:101–106.

Lombardero, M. J., Ayres, M. P., & Ayres, B. D. (2006). Effects of fire and mechanical wounding on Pinus resinosa resin defenses, beetle attacks, and pathogens. *Forest Ecology and Management* 225:349–358.

Lussenhop, J. (1981). Microbial and microarthropod detrital processing in a prairie soil. *Ecology* 62:964–972.

Lussenhop, J., & Wicklow, D. T. (1984). Changes in spatial distribution of fungal propagules associated with invertebrate activity in soil. *Soil Biology & Biochemistry* 16:601–604.

Miller, W. E. (1978). Use of prescribed burning in seed production areas to control red pine cone beetle. *Environmental Entomology* 7:698–702.

Nicolai, V. (1991). Reactions of the fauna on the bark of trees to the frequency of fires in a North American savanna. *Oecologia* 88:132–137.

Nicolai, V. (1993). The effect of fire in North American oak savannah on the arthropod communities of the bark of oak species typical of the habitat. Der Einfluss von Feuer in nordamerikanischen Eichensavannen auf die Arthropodengemeinschaften des Stammbereiches bestandestypi. *Mitteilungen der Deutschen Gesellschaft fur Allgemeine und Angewandte Entomologie* 8:499–504.

Panzer, R. (2002). Compatibility of prescribed burning with the conservation of insects in small, isolated prairie reserves. *Conservation Biology* 16:1296–1307.

Panzer, R. (2003). Importance of in situ survival, recolonization, and habitat gaps in the postfire recovery of fire-sensitive prairie insect species. *Natural Areas Journal* 23:14–21.

Panzer, R., & Schwartz, M. (2000). Effects of management burning on prairie insect species richness within a system of small, highly fragmented reserves. *Biological Conservation* 96:363–369.

Parmelee, F. T. (1941). Long-horned and flat-headed borers attacking fire-killed coniferous timber in Michigan. *Journal of Economic Entomology* 34:377–380.

Pickens, B. A., and K. V. Root. 2009. Behavior as a tool for assessing a managed landscape: a case study of the Karner blue butterfly. *Landscape Ecology* 24:243-251.

Richardson, R. J., & Holliday, N. J. (1982). Occurrence of carabid beetles (Coleoptera: Carabidae) in a boreal forest damaged by fire. *Canadian Entomologist* 114:509–514.

Santoro, A. E., Lombardero, M. J., Ayres, M. P., & Ruel, J. J. (2001). Interactions between fire and bark beetles in an old growth pine forest. *Forest Ecology and Management* 144:245–254.

Siemann, E., Haarstad, J., & Tilman, D. (1997). Short-term and long-term effects of burning on oak savanna arthropods. *American Midland Naturalist* 137:349–361.

Simmons, G. A., Mahar, J., Kennedy, M. K., & Ball, J. (1977). Preliminary test of prescribed burning for control of maple leaf cutter (Lepidoptera: Incurvariidae). *Great Lakes Entomologist* 10:209–210.

Swengel, A. B. 1996. Effects of fire and hay management on abundance of prairie butterflies. *Biological Conservation* 76:73-85.

Swengel, A. B. (2001). A literature review of insect responses to fire, compared to other conservation managements of open habitat. *Biodiversity and Conservation*, *10*(7), 1141–1169.

Swengel, A. B., & Swengel, S. R. (2001). Effects of prairie and barrens management on butterfly faunal composition. *Biodiversity and Conservation* 10:1757–1785.

Swengel, A. B., & Swengel, S. R. (2009). Spatiotemporal variation of violet-feeding large fritillaries (Euptoieta, Speyeria) (Lepidoptera: Nymphalidae) in central and northern Wisconsin. *Great Lakes Entomologist* 42:121–138.

Additional Citations:

Joint Fire Science Program (JFSP) 2012, http://www.firescience.gov/AFPs/13-1-01/13-1-01_RFA_Announcement.pdf, Date of access: 11/09/12

Pyne, S.J. *Introduction to Wildland Fire: Fire Management in the United States* (New York: Wiley, 1984)

Rabe, M.L. 2001. Special animal abstract for Lycaeides melissa samuelis (Karner blue). Michigan Natural Features Inventory. Lansing, MI. 6 pp.

Acknowledgements

Funding for this project was provided by the Joint Fire Science Program