Insecticide Exposure Risk for Grassland Wildlife on Public Lands[1]

2016 Annual Report

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Abstract: There is growing concern about the potential effects of insecticides on grassland wildlife that inhabit landscapes dominated by agriculture. In the agricultural region of southern and western Minnesota, there is particular concern about the risk of exposure of wildlife on public lands to insecticides used to control soybean aphids. Our objectives are to assess the direct and indirect exposure risks of grassland birds and their insect food resources to insecticides encountered via aerial drift. We will quantify chemical residues in public grasslands, measure chemical residues on invertebrates, and assess effects of insecticide exposure to invertebrate abundance near sprayed fields before and after routine applications of insecticides are used to control soybean aphids. We have secured funding for this project, recruited a graduate student, and identified the chemicals that we will focus our sampling efforts on. We are in the process of determining study sites, requesting landowner cooperation with our project, and refining the details of the study design. Our research will inform land managers and private landowners on how best to manage grasslands to reduce risks of wildlife to insecticide drift.

INTRODUCTION

Grassland habitat loss and fragmentation is a major concern for grassland-dependent wildlife throughout the Midwestern United States. Increasing evidence suggests that acute toxicity to pesticides may be a greater threat to grassland bird populations than habitat loss due to agricultural intensification (Mineau and Whiteside 2013). In Minnesota, many remaining grasslands are highly fragmented and surrounded by row crops, including over 3 million hectares of soybeans (USDA 2016b). The insecticides used to combat soybean aphids, namely chlorpyrifos, lambda-cyhalothrin, and bifenthrin, have been shown to be highly toxic to non-target organisms such as birds and pollinators (Christensen et al. 2009, NPIC 2001, Johnson et al. 2010). Members of the public and Minnesota Department of Natural Resources (MNDNR) wildlife managers have observed fewer birds and insects after these insecticides are applied in late summer, raising concerns regarding the impacts of these chemicals on populations of grassland wildlife. However, little is known about the deposition of these pesticides in grasslands and the exposure risk to wildlife in an agricultural matrix under typical application conditions.

Restoring grasslands within the agricultural matrix is a priority conservation concern in western Minnesota. Information about risk of exposure of grassland wildlife to insecticides in this landscape is lacking, but this knowledge would help managers with grassland conservation efforts. Agricultural practices and policies that influence cover-type composition (e.g., a 2016 Minnesota law that requires perennial vegetation buffers up to approximately 15 m (50 ft) wide along public waters and ditches) may result in addition of grasslands to the landscape. However, how and to what extent grassland birds, their insect prey, and beneficial insects such as pollinators using these buffers are exposed to spray drift from adjacent field operations is unknown. Similarly, Minnesota's Pheasant Summit Action Plan and Prairie Conservation Plan both aim to offset grassland cover losses due to declining Conservation Reserve Program (CRP) enrollments by establishing grassland/wetland habitat complexes within the agricultural matrix.

One important avenue of exposure of grassland wildlife to agricultural insecticides is through aerial drift. Drift occurs when insecticides are sprayed on crops but environmental factors result in their transport to areas beyond the targeted application area. Distance of travel for insecticide drift is highly dependent on factors such as humidity, wind speed, and application method. Furthermore, the reported drift distances vary widely, ranging from 5 m to 1,600 m (Davis and Williams 1990, E. Runquist, personal communication). For many standard insecticide application regimes in agricultural landscapes, there is little or no information about drift and exposure risk to wildlife in grasslands - information necessary to effectively design grasslands set aside and managed for wildlife.

The objectives of our research are to assess the direct and indirect exposure risks of grassland birds and their insect food resources to soybean aphid insecticides in Minnesota's farmland region. First, we will quantify the concentration of insecticides along a gradient from soybean field edge to grassland interior to assess the potential for grassland wildlife to be directly exposed to chemicals via contact with insecticides resulting from spray drift. Second, we will quantify the chemical residue on invertebrates that serve as prey items of grassland birds, predatory insects, and other insectivores. This will allow us to assess the indirect exposure risk of birds and other wildlife to these chemicals through consumption of invertebrates. Finally, we will quantify and compare the relative abundance, richness, diversity, and biomass of invertebrates along a gradient from soybean field edge to grassland interior prior to and post-application to assess the indirect impact of insecticides on food availability for grassland nesting birds and other wildlife. Our research will allow us to inform decision-making by land managers and private landowners so they can better design grasslands and buffers, thus reducing the impacts of spray drift on wildlife in these habitats.

STUDY AREA

We are currently evaluating potential study sites on Wildlife Management Areas (WMAs) in the west-central (WC), central (C), southwest (SW), and south-central (SC) agricultural regions of Minnesota (Fig. 1). These WMAs are owned by the MNDNR and are managed with the intent of providing high quality habitat for wildlife. Corn and soybean fields account for approximately 50% of the landscape in these four regions. The SW and SC regions are the most intensively farmed; corn and soybeans are planted on 75% of those landscapes (USDA 2016a, USDA 2016b).

Each treatment study site will consist of a WMA including upland grassland directly adjacent to and downwind of a soybean field. We have been consulting area wildlife managers and will be contacting private landowner cooperators to choose 5-7 treatment study sites. We will prioritize sites dominated by a diverse mesic prairie mix containing warm-season grasses and forbs because this mix is commonly used by MNDNR managers and agency partners in the farmland zone to restore habitats for the benefit of grassland birds and beneficial insect species. The treatment study sites will be adjacent to fields sprayed by the same application method (i.e., either ground boom or plane). We will also choose 2 control study sites with similar site characteristics except that control sites will not be sprayed with any chemicals to control aphids.

METHODS

Within each treatment study site, we will conduct sampling at stations placed at multiple distances (<5 m to ≥100 m) along each of 3 transects extending from a treated soybean field edge to an adjacent grassland interior (Fig. 2). We will align transects perpendicular to the soybean field edge and space them ≥200 m apart to reduce the likelihood of duplicate insecticide exposure during the spraying event. We will conduct sampling to assess both direct and indirect exposure risks to grassland wildlife, especially birds and insects, immediately after spraying and at additional periods post-application. As a control, we will also sample invertebrates in grasslands adjacent to untreated soybean fields. We will use portable weather stations or pocket weather meters to estimate relevant weather data (e.g., temperature, wind speed, wind direction, humidity, dew point) near the time of spraying and at several periods post-spraying, including insect sampling periods.

Direct Exposure Risk

To assess the potential for direct exposure of birds and other wildlife to soybean aphid insecticides, we will measure the amounts of chemicals deposited in grasslands during and after soybean fields are sprayed. We are evaluating the most appropriate method by which this will be accomplished. One option is to measure the amount of organic chemicals passively adsorbed to a hydrophobic silicone surface (Wennrich et al. 2002, T. Johnston, personal communication). We may use feather-covered samplers instead to simulate chemical accumulation on the body of birds, as pesticide concentrations have been shown to be detectable in bird feathers (Abbasi et al. 2016). Alternatively, we may analyze insecticide residues on grassland vegetation. We will take samples within 24 hours of spraying and properly store them for later chemical analysis. At control study sites, we will sample at 4 stations. We will collect these samples within the same timeframe as at treatment study sites and store them for later analysis.

Indirect Exposure Risk

To assess the potential for birds and other insectivorous wildlife to be exposed to insecticides indirectly, we will examine the chemical residues on invertebrates collected once prior to spraying and several days post-spraying at each treatment study site. We will sample ground-dwelling invertebrates using pitfall traps and canopy dwelling invertebrates via sweep netting (Brown and Matthews 2016, Doxon et al. 2011). We will combine pitfall trap and sweep net samples taken from the same station during the same period into 1 sample and properly store them for later chemical analysis.

Indirect Effects of Exposure
To quantify and compare the abundance, richness, diversity, and biomass of invertebrate prey items before and after spraying, we will collect additional pitfall trap and sweep net samples at the same stations. We will store them for later sorting and identification to at least the family level. We will place emphasis on invertebrate orders important in the diets of grassland nesting birds, including: Araneae (spiders), Orthoptera (grasshoppers, crickets, and katydids), and Coleoptera (beetles).

We will send samples that require chemical analysis to a lab that is to be determined. Samples will undergo a thermal desorption gas chromatography-mass spectrometry (GC-MS) process in which concentrations of each insecticide are determined by comparing peaks and retention times of standards to samples. An alternative analytical method may be used for the invertebrate samples. This alternative method will chemically extract the target chemicals from invertebrate samples prior to the GC-MS analysis. This will require dilution of the samples, however, and will result in less sensitive measurements. Although our experimental design will focus on soybean fields sprayed with chlorpyrifos, lambda-cyhalothrin, and/or bifenthrin, the chemical analyses are designed to allow us to quantify additional pesticides present in the samples.

The specifics of the experimental design and statistical analysis are being developed by the graduate student in cooperation with the project's principal investigators and collaborators.

RESULTS

To date, we have (1) established the intra-agency agreements that support this project at the Minnesota Cooperative Fish and Wildlife Research Unit, (2) secured funding for this project through the Minnesota Environment and Natural Resources Trust Fund (ENRTF) as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR), (3) recruited a graduate student currently working on this project at the University of Minnesota, (4) contacted representatives at 12 farmer cooperatives across 5 counties to gather information about current spraying methods used in our study area, (5) identified the insecticides that will constitute the focus of our sampling efforts, (6) identified 25 WMAs that fit our criteria as potential treatment study sites, (7) compiled a list of 180 landowners who own property adjacent to these WMAs, (8) drafted a research summary letter and survey to be sent to these landowners to request their cooperation with our project, and (9) introduced our research project to MNDNR Wildlife Managers and other researchers with LCCMR/ENRTF funding for projects relating to pollinators. During spring 2017, we will introduce this project at the annual meeting of the Minnesota Chapter of The Wildlife Society and Midwest Fish and Wildlife Conference, identify additional potential study sites, send research intent letters and surveys to landowners, complete the project design, organize logistics, and purchase equipment. We will initiate data collection in summer 2017.

Literature Cited

Abbasi, N. A., Eulaers, I., Jaspers, V. L. B., Chaudhry, M. J. I., Frantz, A., Ambus, P. L., Covasi, A., and R. N. Malik. 2016. Use of feathers to assess polychlorinated biphenyl and organochlorine pesticide exposure in top predatory bird species of Pakistan. Science of the Total Environment 569–570:1408–1417.

Brown, G. R., and I. M. Matthews. 2016. A review of extensive variation in the design of pitfall traps and a proposal for a standard pitfall trap design for monitoring ground-active arthropod biodiversity. Ecology and Evolution 6:3953–3964.

Christensen, K., Harper, B., Luukinen, B., Buhl, K., and D. Stone. 2009. Chlorpyrifos Technical Fact Sheet. National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/archive/chlorptech.html. Accessed 13 September, 2016.

Davis, B. N. K. and C. T. Williams. 1990. Buffer zone widths for honeybees from ground and aerial spraying of insecticides. Environmental Pollution 63:247–259.

Doxon, E. D., Davis, C. A., and S. D. Fuhlendorf. 2011. Comparison of two methods for sampling invertebrates: vacuum and sweep-net sampling. Journal of Field Ornithology 82:60–67.

Johnson, M., Luukinen, B., Gervais, J., Buhl, K., and D. Stone. 2010. Bifenthrin Technical Fact Sheet. National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/archive/biftech.html. Accessed 15 September, 2016.

Mineau, P. and M. Whiteside. 2013. Pesticide acute toxicity is a better correlate of U.S. grassland bird declines than agricultural intensification. PLoS ONE 8(2):e57457:1-8.

National Pesticide Information Center. 2001. Lambda-cyhalothrin Technical Fact Sheet. National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/l_cyhalogen.pdf. Accessed 13 September, 2016.

U. S. Department of Agriculture. 2016a. 2015 Corn County Estimates: Corn for Grain Yield. Minnesota Ag News. Upper Midwest Region - Minnesota Field Office, St. Paul, MN.

U. S. Department of Agriculture. 2016b. 2015 Soybean County Estimates. Minnesota Ag News. Upper Midwest Region - Minnesota Field Office, St. Paul, MN.

Wennrich, L., Popp, P., and C. Hafner. 2002. Novel integrative passive samplers for the long-term monitoring of semivolatile organic air pollutants. Journal of Environmental Monitoring 4:371–376.

Figure 1. Minnesota's agricultural regions as outlined in Minnesota Department of Natural Resources (MNDNR) annual August Roadside Surveys. The study sites for this project will include Wildlife Management Areas owned and managed by the MNDNR in the west-central (WC), central (C), southwest (SW), and south-central (SC) regions.

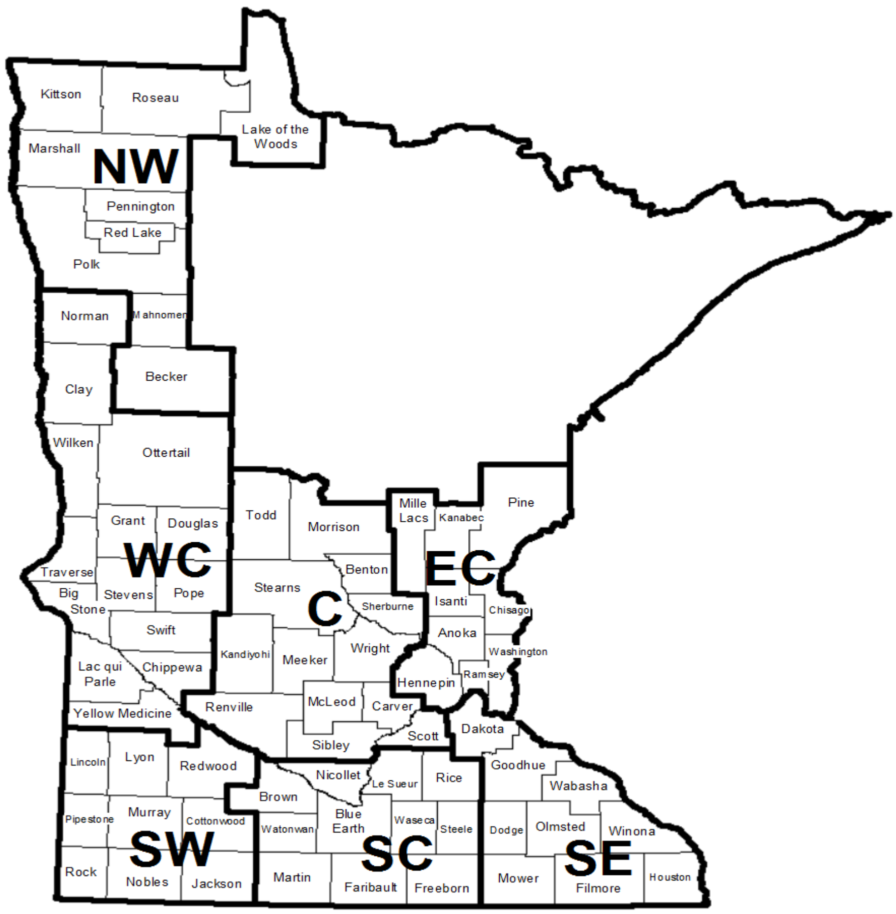

Figure 2. Example field sampling design that will be used to assess the exposure risk of grassland wildlife to soybean aphid insecticides. Sampling will be conducted on Wildlife Management Areas (outlined in black) adjacent to privately-owned soybean fields sprayed for aphid infestations. White lines indicate sampling transects established perpendicular to the soybean field edge and extending ≥100 m into the grassland.