Adulticide Environmental Impacts and Efficacy - Literature Review

Abbene IJ, Fisher SC, Terracciano SA. 2005. Concentrations of insecticides in selected surface water bodies in Suffolk County, New York, before and after mosquito spraying, 2002-04 (No. 2005-1384). **A study to measure contamination in surface waters by pyrethroids (resmethrin and sumithrin) before and following aerially-applied and truck-mounted ULV applications for West Nile Virus control was conducted in Suffolk County, New York. Among the samples taken following truck-mounted applications, none of the chemicals were detected.**

Boyce WM, Lawler SP, Schultz JM, McCauley SJ, Kimsey LS, Niemela MK, Nielsen CF, Reisen WK. 2007. Nontarget effects of the mosquito adulticide pyrethrin applied aerially during a West Nile virus outbreak in an urban California environment. *Journal of the American Mosquito Control Association 23*(3): 335-339. **Examined the impact of ULV on honey bees, butterflies and dragonflies. The researchers observed little impact on these insects in the study, likely due to the very low amounts of pesticide.**

Breidenbaugh, M.S., and F.A. de Szalay. 2010. Effects of aerial applications of naled on nontarget insects at Parris Island, South Carolina. Environmental Entomology 39:591-599. **A Before-After Control-Impact analysis at each location was conducted to compare changes. There were no significant changes in numbers of common taxa or total numbers in 2005. Shannon diversities (H') were not different in either year indicating that sprays had minimal impact on overall community biodiversity. In contrast, populations of pestiferous biting midges (*Culicoides* spp.) collected in CDC-style traps were reduced by 94-99% after spraying in both years; mosquito numbers declined by 88.2% in 2003 and 92.5% in 2005, after sprays.**

Carney, RM, et al. 2008. Efficacy of Aerial Spraying of Mosquito Adulticide in Reducing Incidence of West Nile Virus, California, 2005. *Emerging Infectious Diseases*. 14(5): 747-754. **– Results from study provide direct evidence that adult mosquito control spray applications are effective in reducing human illness and potential death from West Nile Virus infection.**

Caron DM. 1979. Effects of some ULV mosquito abatement insecticides on honey bees. *Journal of Economic Entomology 72*(1): 148-151. **Evaluated malathion, pyrethrum & naled. Caged bees exposed to malathion suffered significant mortality. Night applications of the chemicals had no observable effect on bee colonies.**

Centers for Disease Control and Prevention. 2005. Human Exposure to Mosquito Control Pesticides – Mississippi, North Carolina, and Virginia, 2002 and 2003. *Morbidity and Mortality Weekly Report*. 54(21): 529-532. – **Ground based truck applications of adult mosquito control products did not produce any detectable exposure in humans.**

Chaskopoulou A, Thrasyvoulou A, Goras G, Tananaki G, Latham MD, Kashefi J, Pereira RM, Koehler PG. 2014. Nontarget effects of aerial mosquito adulticiding with water-based unsynergized pyrethroids on honey bees and other beneficial insects in an agricultural ecosystem of north Greece. *Journal of Medical Entomology 51*(3): 720-724. **Tested two aquatic pyrethroid insecticides applied from rotary wing. Assessed impact on honey bees, ladybugs and lacewings. No non-target mortalities observed and bee hives showed no detrimental effects.**

Chung, WM, et al. 2013. The 2012 West Nile Encephalitis Epidemic in Dallas, Texas. *Journal of the American Medical Association*. 310(3): 297-307. **– An eight (8) day period of aerial spraying to stop a West Nile Virus epidemic in Dallas did not result in any detectable increase in respiratory ailments or skin rashes in emergency rooms.**

Davis RS, Peterson RKD. 2008. Effects of single and multiple applications of mosquito insecticides on non-target arthropods. *Journal of the American Mosquito Control Association* 24: 270-280. **Efforts to measure the impact of single and multiple ULV applications of permethrin on aquatic invertebrates such as amphipods and *Daphnia pulex* took place in Benton Lake National Wildlife Refuge in Montana. Observed few if any deleterious effects and concluded that persistent biological impacts were very unlikely to occur.**

Davis RS, Peterson RKD, Macedo PA. 2007. An ecological risk assessment for insecticides used in adult mosquito management. *Integrated Environmental Assessment and Management* 3: 373-382. **Conducted an ecological risk assessment of common pyrethroids, including permethrin used for mosquito control. Monitored for potential effects on aquatic vertebrates as well as invertebrates. Risk quotients from the assessment were small and insignificant for both chronic and acute effects. For instance, they measured the insecticide residues to be more than ten orders of magnitude below toxic levels for trout.**

Duprey, Z., et al. 2008. Community Aerial Mosquito Control and Naled Exposure. *Journal of the American Mosquito Control Association*. 24(1): 42-46. – **Aerially applied adult mosquito control products did not produce any detectable exposure in humans.**

Elnaiem, DE, et al. 2008. Impact of aerial spraying of pyrethrin insecticide on *Culex pipiens* and *Culex tarsalis* (Diptera: Culicidae) abundance and West Nile Virus infection rates in an urban/suburban area of Sacramento County, California. *Journal of Medical Entomology*. 45(4): 751-757. **– Aerial application of adult mosquito control products were effective at reducing abundance and infection rates for West Nile Virus in mosquito populations, lowering transmission intensity and decreasing risks of human infections.**

Farajollahi, A., et al. 2012. Effectiveness of Ultra-Low Volume Nighttime Applications of an Adulticide against Diurnal *Aedes albopictus*, a Critical Vector of Dengue and Chikungunya Viruses. *PLOS ONE*. 7(11): e49181. **– Nighttime ground-based truck applications of adult mosquito control products are effective at reducing populations of a difficult to control mosquito species.**

Geraghty, EM, et al. 2013. Correlation Between Aerial Insecticide Spraying to Interrupt West Nile Virus Transmission and Emergency Department Visits in Sacramento County, California. *Public Health Reports*. 128(3): 221-230. **– Aerially applied adult mosquito control products are not associated with any increase in respiratory, gastrointestinal, skin, eye, or neurological complaints in emergency departments.**

Hester PG, Shaffer KR, Tietze NS, Zhong H, Griggs NL. 2001. Efficacy of ground-applied ultra-low-volume malathion on honey bee survival and productivity in open and forest areas. *Journal of the American Mosquito Control Association* 17(1): 2-7. **Some mortality if within 7-15 m from spray for bees outside hive. No observable effects on overall colony health and honey production.**

Jensen T, Lawler SP, Dritz DA. 1999. Effects of ultra-low volume pyrethrin, malathion, and permethrin on nontarget invertebrates, sentinel mosquitoes, and mosquitofish in seasonally impounded wetlands. *Journal of the American Mosquito Control Association* 15(3): 330-338. **Evaluated effects on non-target aquatic invertebrates and mosquito fish to permethrin over two seasons in a wetland. No observable reduction in abundance of invertebrates was detected, although caged mosquitoes placed in the area sprayed were effectively killed. Furthermore, no mortality among fish was observed.**

Karpati, A., et al. 2004. Pesticide Spraying for West Nile Virus Control and Emergency Department Asthma Visits in New York City, 2000. *Environmental Health Perspectives*. 112(111): 1183-1187. **– Ground based truck applications of adult mosquito control products did not result in increased emergency room visits for asthma.**

Knepper RG, Walker ED. 2001. Preliminary studies of the occurrence of Cottony Maple Scale (CMS) in five Michigan counties. *Wingbeats* 12(2): 14. **Study evaluated if mosquito control ULV applications result in outbreaks of CMS due to mortality of natural predators. Found higher CMS in Saginaw County, with mosquito control (MC) than areas without MC. However, abundance of CMS did not correlate with the abundance of sprays as years with more spraying also had fewer CMS.**

Knepper RG, Walker ED, Wagner SA, Kamrin MA, Zabik MJ. 1996. Deposition of malathion and permethrin on sod grass after single, ultra-low volume applications in a suburban neighborhood in Michigan. *Journal of the American Mosquito Control Association* 12(1): 45-51. **Measured deposition on grass following ULV. Found that materials quickly break down following application. Did not assess human exposure risk but results were similar to other studies that have shown minimal risk.**

Kwan JA, Novak MG, Hyles TS, Niemela MK. 2009. Mortality of nontarget arthropods from an aerial application of pyrethrins. Journal of the American Mosquito Control Association 25(2):218–220DOI 10.2987/08-5858.1. **Study evaluated mortality of non-target arthropods from ULV aerial application of pyrethrins from ground tarp collections. Treated areas displayed ten-fold mortality versus control areas, but all mortality was observed in small bodied insects primarily from the Chironomidae and Formicidae families. No large bodied insects were recovered. The largest insect affected was an 8mm long pillbug (Isopoda).**

Lawler SP, Dritz DA, Johnson CS, Wolder M. 2008. Does synergized pyrethrin applied over wetlands for mosquito control affect *Daphnia magna* zooplankton or *Callibaetis californicus* mayflies? *Pest Management Science* 64(8): 843-847. **Repeated applications of permethrin were made directly over a wetland area and effects measured on *Daphnia magna* and mayfly nymphs. Though they were able to measure residue of the insecticide in water samples, no detectible deleterious effects were observed to these non-target organisms.**

Macedo, PA, et al. 2010. Evaluation of efficacy and human health risk of aerial ultra-low volume applications of pyrethrins and piperonyl butoxide for adult mosquito management in response to West Nile virus activity in Sacramento County, California. *Journal of the American Mosquito Control Association*. 26(1): 57-66. **– Aerial application of adult mosquito control products were below human health concern levels and were effective at reducing abundance and infection rates for West Nile Virus in mosquito populations.**

O'Sullivan, B., et al. 2005. The Effect of pesticide Spraying on the Rate and Severity of ED Asthma. *The American Journal of Emergency Medicine*. 23(4): 463-467. **– Ground based truck applications of adult mosquito control products did not increase the rate or severity of asthma presentations in emergency departments.**

Oberhauser KS, Manweiler SA, Lelich R, Blank M, Batalden RV, De Anda A. 2009. Impacts of ultra-low volume resmethrin applications on non-target insects. *Journal of the American Mosquito Control Association* 25(1): 83-93. **Some mortality observed among Monarch larvae and adults within 150m of spray.**

Peterson, R.K.D., C.J. Preftakes, J.L. Bodin, C.R. Brown, A.M. Piccolomini, and J.J. Schleier. 2016. Determinants of acute mortality of Hippodamia convergens (Coleoptera: Coccinellidae) to ultra-low volume permethrin used for mosquito management. PeerJ DOI 10.7717/peerj.2167 **Results demonstrated the importance of considerations of exposure that go well beyond deposition of ULV insecticides on surfaces and the extrapolation of that deposition to risk to non-target insects.**

Phillips BM, Anderson BS, Voorhees JP, Siegler K, Denton D, TenBrook P, Larson K, Isorena P, Tjeerdema RS. 2014. Monitoring the aquatic toxicity of mosquito vector control spray pesticides to freshwater receiving waters. *Integrated Environmental Assessment and Management* 10(3): 449-455. **Some water and sediment samples toxic following ULV spray, mostly associated with naled rather than pyrethroids. PBO thought to contribute to some toxic samples due to synergy with background pyrethroids in water/sediment. Overall concluded that most ULV applications of adulticides do not pose a significant acute risk to aquatic organisms.**

Piccolomini, A.M., M.L. Flenniken, K.M. O'Neill, and R.K.D. Peterson. 2018. The effects of an ultra-low-volume application of etofenprox for mosquito management on *Megachile rotundata* (Hymenoptera: Megachilidae) larvae and adults in an agricultural setting. Journal of Economic Entomology, in press, doi: 10.1093/jee/tox343. **There was no significant difference in the proportion of dead and live larvae when the control group was compared with the group directly treated with etofenprox. Also did not observe a significant difference in the number of emerged adults reared from the treated shelters, and the number of completed cells after exposure to the insecticide continued to increase throughout the summer, indicating that provisioning adults were not affected by the insecticide treatment. The results suggest that the amount of etofenprox reaching nest shelters was not sufficient to cause significant mortality.**

Pokhrel V, DeLisi NA, Danka RG, Walker TW, Ottea JA, Healy KB. 2018. Effects of truck-mounted, ultra low volume mosquito adulticides on honey bees (*Apis mellifera*) in a suburban field setting. *PLoS ONE*,

https://doi.org/10.1371/journal.pone.0193535. **Three synergized pyrethroids applied by truck-mounted ULV for mosquito control resulted in little to no exposure and therefore had minimal effects on domestic honeybees.**

Preftakes, CJ, et al. 2011. Bystander Exposure to Ultra-Low Volume Insecticide Applications Used for Adult Mosquito Management. *International Journal of Environmental Research and Public Health*. 8: 2142-2152. **– Ground based truck applications of adult mosquito control products are below human exposure levels of regulatory concern.**

Relyea, RA, et al. 2005. Pesticides and Amphibians: the Importance of Community Context. *Ecological Applications*. 15(4): 1125-1134. **– Pond mesocosm field studies showed in the presence of other predators, malathion had a positive impact on tadpole survival and biomass.**

Rinkevich FD, Margotta JW, Pokhrel V, Walker TW, Vaeth RH, Hoffman WC, Fritz BK, Danka RG, Rinderer TE, Aldridge RL, Linthicum KJ, Ottea JA, Healy KB. 2017. Limited impacts of truck-based ultra-low-volume applications of mosquito adulticides on mortality in honey bees (*Apis mellifera*). *Bulletin of Entomological Research* 107(6): 724-733. **A semi-field study involving pyrethroids and an organophosphate adulticide assessing the impact of truck-based ULV mosquito adulticide applications on honey bees found minimal bee mortality compared to mosquito mortality.**

Schleier III JJ, Davis RS, Shama LM, Macedo PA, Peterson RKD. 2008. Equine risk assessment for insecticides used in adult mosquito management. *Human and Ecological Risk Assessment* 14: 392-407. **Assessed risk of horse exposure to three pyrethroids and two organophosphates applied by ULV. Concluded that risk well below levels of concern based on risk quotients.**

Schleier III JJ, Peterson RKD, Macedo PA, Brown DA. 2008. Environmental concentrations, fate, and risk assessment of pyrethrins and piperonyl butoxide after aerial ultralow-volume applications for adult mosquito management. *Environmental Toxicology and Chemistry* 27: 1063-1068. **Measured deposition of pyrethrins following aerial ULV applications. No pyrethrins were detectable in water samples. Where pyrethrins were detected, the risk quotients for aquatic surrogate species did not reach the U.S. EPA level of concern for endangered aquatic organisms and returned to baseline levels within 36 hours.**

Schleier III JJ, Peterson RKD. 2010. Deposition and air concentrations of permethrin and naled used for adult mosquito management. *Archives of Environmental Contamination and Toxicology* 58: 105-111. **Study confirmed that risk assessment models used to estimate environmental deposition of ULV insecticides sufficiently overestimate concentrations (i.e. are sufficiently conservative).**

Schleier III, J.J., and R.K.D. Peterson. 2010. Toxicity and risk assessment of permethrin and naled to non-target terrestrial insects after adult mosquito management. Ecotoxicology 19:1140-1146. **Risk assessments using actual environmental concentrations are supported by field bioassays that suggest a single ULV application of synergized or unsynergized permethrin and naled most likely will not result in population impacts on medium-to large-bodied insects.**

Schleier III JJ, Peterson RKD. 2013. A refined aquatic ecological risk assessment for a pyrethroid insecticide used for adult mosquito management. *Environmental Toxicology and Chemistry* 32: 948-953. **Developed an aquatic risk assessment for pyrethroid insecticides and estimated that the projected concentrations from ULV application would amount to less than 0.0001% of aquatic organisms potentially affected with a lethal concentration.**

Solomon KR, Giddings JM, Maund SJ. 2001. Probabilistic risk assessment of cotton pyrethroids: I. Distributional analyses of laboratory aquatic toxicity data. *Environmental Toxicology and Chemistry* 20(3): 652-659. **Regarding the relative risk to aquatic organisms, permethrin was measured among the lowest in aquatic toxicity of the various pyrethroids.**

Stevenson HR. 1980. A review on the effects of ultra low volume insecticide treatments to honey bees, *Apis mellifera* (L.). *Proceedings of the Florida Anti-Mosquito Association* 51: 11-14. **Except for chlorpyrifos, ULV insecticides, under ideal conditions, will not subject honey bees to lethal doses.**

Weston DP, Holmes RW, You J, Lydy MJ. 2005. Aquatic toxicity due to residential use of pyrethroid insecticides. *Environmental Science & Technology* 39(24): 9778-9784. **Investigated the source of toxic levels of pyrethroids in water and sediment in Roseville, California. The evidence pointed to residential lawn applications and against mosquito control as the specific pyrethroid used by mosquito control (resmithrin) was not detected in any of the samples.**