How to Lower the Risk of Adverse Effects to Pollinators, Federally Protected Species, and other Non-Target Wildlife from Mosquito Management

Mosquito Management in Communities

Many communities implement a broad approach to mosquito control including management for nuisance issues in addition to public health concerns. Regardless of the driver, some mosquito control management techniques can result in unintended consequences to non-target wildlife species including insects that are of conservation concern. Non-target effects to sensitive species such as pollinators can be minimized by collaboration and advance planning with mosquito control district staff and local natural resource experts. Following Best Management Practices and an Integrated Pest Management (IPM) process for mosquito control lowers risk to non-target species. This document is intended primarily to provide input when and where discretion can be exercised in relatively routine mosquito management in areas beyond lands managed by the U.S. Fish and Wildlife Service. It is not intended to direct public health officials' decisions in the event of a public health emergency, although some elements may be useful in those situations as well.

U.S. Fish and Wildlife Service Perspective for Mosquito Management on USFWS lands and Waters

Mosquitoes are a part of the natural ecosystem in habitats in which they occur. The U.S. Fish and Wildlife Service (USFWS) has determined that mosquitoes may exist unimpeded on USFWS managed lands and waters unless they pose a specific threat to public health. The USFWS uses the Handbook for Mosquito Management on National Wildlife Refuges (USFWS 2018) which emphasizes prevention and the use of larval mosquito monitoring to help inform management decisions. Public health organizations must sometimes control mosquitoes to lower risk to the public from mosquito borne diseases and when control actions occur at USFWS managed facilities, we work with mosquito control districts so that they may accomplish this for public health protection while still minimizing impacts to non-target organisms.

Integrated Pest Management – The First Line of Defense

Integrated Pest Management (IPM) is a sustainable approach to managing pests, such as mosquitoes. It combines physical, biological, cultural and chemical tools to maximize pest control and minimize economic, health, and environmental risks. When IPM is followed we minimize effects on non-target organisms by reducing the use of broad-spectrum pesticides while still reducing the potential for pathogen transmission and controlling nuisance mosquito populations. Preventative measures following IPM principles throughout mosquito control programs are cost-effective and efficient first lines of defense. For example, mosquito adulticides can adversely impact a broad spectrum of species including pollinators, so the most effective way to minimize non-target impacts is to control mosquitoes at the larval stage. This will prevent adult mosquito populations from reaching thresholds where they require control. In addition, early season monitoring for mosquito species that can carry human pathogens can allow control measures to be efficiently targeted and timed.

Principles of Integrated Pest Management for Mosquitoes

1. **Understand the mosquito management objectives and establish short- and long-term priorities.** *(Examples: Short-term priority: reduce pathogen transmission by controlling adult mosquitoes. Long-term priority: reduce mosquito breeding habitats to minimize the need for mosquito adulticides.)*

2. **Prevent mosquitoes from becoming a pest at your site.** This is the first line of defense against any pest species. See the Centers for Disease Control and Prevention (CDC) websites: Prevent Mosquito Bites, Everyone Can Help Control Mosquitoes and Get Rid of Mosquitoes at Home)

3. **Identify and monitor the mosquito species, know the life history, and the conditions that support the mosquitoes.** To help guide management actions, it's important to know if mosquitoes in the area are nuisance biters, or if they are also active vectors of pathogens that cause disease. See the CDC website: What Mosquito Control Programs Do.

4. **Understand the physical and biological factors that affect the number and distribution of mosquitoes and their natural enemies. Conserve natural enemies** when implementing any pest management strategy. *(Examples: Encourage bats by posting bat boxes. Limit standing water, which is excellent mosquito breeding habitat.)*

5. **Establish the "Action Thresholds" at which mosquito management will be implemented.** Can you tolerate a few mosquitoes? Are you controlling mosquitoes to reduce a public health threat due to pathogens cycling in a mosquito population?

6. **Build partnerships with stakeholders, communities, decision-makers, and technical experts.** *(Example: know the local beekeepers and where they are located, communicate, if control of adult mosquitoes is necessary, provide early warning notice.)* See the CDC website: Everyone Can Help Control Mosquitoes.

7. **Review available tools and best practices for the management of the identified mosquitoes.** Tools and strategies can include: 1) taking no action and monitoring only, 2) physical controls (manual and mechanical), 3) cultural, 4) biological, and 5) chemical treatment.

8. **Implement the strategy.** Make a record of when, where, how and the strategy implemented.

9. **Monitor for change and evaluate the results of the action.** Decide if the objectives were achieved. *(Example: Did eliminating mosquito breeding habitat around the yard minimize nuisance mosquitoes)*

10. **Adapt and Modify strategies, if necessary.**

Consider if Habitat Management is Appropriate to Manage Mosquitoes in the Community

By working collaboratively with your county and state partners, areas on the landscape can be prioritized for modification to manage mosquitoes while restoring natural hydrology. For examples, flowing water disrupts the mosquito lifecycle, so restoring natural water circulation can minimize mosquito breeding habitat and reduce populations of mosquito eggs and larvae before they hatch to adults. Landscape modification can be extensive and potentially expensive, and while practicable in some locations may not always be possible or appropriate, so collaboration with partners is essential. A variety of landscape measures are used to reduce mosquito breeding areas and restore hydrologic function, including the following types of modifications:

- Removing or replacing weirs, dams, or missing or undersized culverts that inhibit natural water flow.
- Restoring high marsh ponds in coastal salt marshes to serve as reservoirs for fish (such as mummichog, Fundulus heteroclitus) and other native predators that control mosquito populations.
- Maintaining or restoring the natural hydrology in altered systems to prevent poorly drained, still or stagnant pools - the perfect mosquito breeding habitat.
- Manipulating water levels to manage wetlands, so that mosquito lifecycles are disrupted by timing flood-up and draw-down.

Consider Community Practices to Reduce Mosquitoes in Developed Areas

For homes and facilities, consider these practices to reduce mosquito breeding sites:

- Minimize standing water to the maximum extent possible
- Remove or otherwise manage tires, road ruts, tanks, or similar debris/containers
- Clean rain gutters to allow rainwater to flow freely.
- Turn over containers that can hold water when stored un-used outside.
- Check for trapped water in tarps used to cover boats/ equipment and arrange covers to drain water. Pump out boat bilges.
- Replace water in birdbaths and water troughs twice a week.
- Fix dripping outside water faucets
- Reference CDC website for additional practices: Mosquito Control Practices Outside Your Home and Get Rid of Mosquitoes at Home

When the Use of Pesticides for Mosquito Management is Necessary

Mosquito control pesticides can affect many types of non-target species that are sensitive to the effects of insecticides and any species that depends on them for food. Some of these non-target species may be federally listed as threatened or endangered under the Endangered Species Act (ESA) or be species of conservation concern to states. As part of contributing to an overall IPM plan, it is important to become familiar with the non-target species in your areas that may be affected by mosquito control pesticides before mosquito control is needed.

Best Management Practices when Pesticides Are Used

Best Practices are intended to help minimize risk to non-target resources whenever possible.

The Federal Insecticide, Fungicide and Rodenticide Act, implemented by the U.S. Environmental Protection Agency (USEPA), requires that a pesticide label be read and followed. Product labels contain legally mandatory instructions and recommendations for use. Product labels can be found on the USEPA Pesticide Product and Label System website. Although best management practices are often provided on product labels, not all labels are specific to sensitive species and may not be fully protective of all species in all locations. USFWS staff may provide conservation measures and technical assistance that is specific to the pesticide and the use pattern, species, timing, and location.

To reduce risk to wildlife, including sensitive species like many pollinators, use the lowest risk pesticide that allows you to accomplish your mosquito management goal (see Table).

How to Conserve Protected Species:

Do this before the mosquito management season begins:

- Refer to IPaC https://ipac.ecosphere.fws.gov/ to find out which federally listed endangered or threatened species might be present in the area that your mosquito management may impact. Here, you can draw a polygon around your mosquito management area to get a list of federally listed species in the areas.
- If your IPaC search indicates that one or more federally listed species may occur in the area of mosquito management, follow any species-specific guidance provided in IPaC and contact the USFWS Ecological Services Field Office that serves your area or state ((https://www.fws.gov/offices/). The USFWS can assist in determining whether the listed species may be adversely impacted by the mosquito management activities.
- If your IPAC search indicates that a National Wildlife Refuge or a Waterfowl Production Area is present in the area for your mosquito management, contact the refuge staff. In accordance with the Handbook for Mosquito Management on NWRs, the refuge may have restrictions for all mosquito spraying activities and/or other specific guidance. https://ecos.fws.gov/ServCat/DownloadFile/155620
- If there may be impacts, request that the local USFWS office provide:
    - A map of listed species occurrence or otherwise indicate sensitive or critically important habitats.
    - Information on listed species life history.
    - Information to minimize impacts, including preferred timing of management actions.
- Federal agencies, please note: if you are funding, authorizing or carrying out mosquito management activities, and determine those activities may affect ESA-listed species or critical habitat, you must consult with the USFWS pursuant to section 7 of the ESA.
- Use the U.S. Environmental Protection Agency Bulletins Live which is a tool that provides pesticide use limitation areas for pesticide active ingredients and products.

Larvicides and Pupacides

These products are applied to aquatic sites where mosquito larvae and pupae are found.

A robust larval mosquito monitoring program is critical to effective use of larvicides. See the Center for Disease Control and Prevent Integrated Mosquito Management website (accessed 3/24/2021). Larvicides should be the first choice, when possible and appropriate if mosquito control using pesticides is necessary. When used correctly, larvicides:

- Prevent and minimize the emergence of adult mosquitoes and midges.
- Can provide up to a month of control.
- Are less toxic to non-target species than mosquito adulticides.
- Are often applied to smaller and targeted spatial areas, thus exposing fewer non-target resources to the pesticide.

Lower risk larvicides: *Bacillus* or *Lysinibacillus* based larvicide products present a lower risk to non-target species than other currently available larvicides.

- *Bacillus thuringiensis israelensis* and *Lysinibacillius sphaericus* are generally active for approximately 14 days although some products can remain active for a month.
- *Bacillus/Lysinibacillus* based products are specific to mosquitoes, midges, and black flies due to their mode of action.
- These products are ingested by the insect and activated at a high pH that occurs almost solely in the gut of mosquitoes, midges, and black flies. See more information at https://www.epa.gov/mosquitocontrol/bti-mosquito-control.

Higher risk larvicides S-methoprene (an insect growth regulator) can impact a broad spectrum of macroinvertebrates that have aquatic larval stages.

Pupacides, such as surface oils, can impact a broad spectrum of aquatic macroinvertebrates, as well as aquatic-dependent species that can be adversely impacted by oiling. As such, pupacides generally have a greater risk of non-target impacts than larvicides and are less preferred.

Adulticides

Mosquito adulticide active ingredients are acutely toxic to a broad spectrum of insects and may harm other species in a short period of time. Insects are a vital component of foodwebs and pollinators are everywhere! To protect pollinators and other sensitive species, the use of mosquito adulticides should only occur when acutely necessary to avert the threat to public health due to mosquito vectored pathogens after other methods have failed to reduce risks sufficiently. If the IPM principles and BMPs have been followed and use of mosquito adulticides are still necessary to address human health concerns, the following Best Management Practices may help to reduce non-target impacts.

Mosquito adulticide applications use fine droplets that suspend in air to target flying mosquitoes. These droplets can drift beyond the application site and extend the area of non-target impact beyond the intended site boundaries. When the parameters of spray altitude, speed, and nozzle type are fixed, then wind speed dominates the droplet downwind travel distance.

When selecting adulticides mosquito control districts often rotate among a suite of active ingredients in order to balance effectiveness, risk to non-targets, and mosquito resistance to the active ingredients.

These Best Management Practices may help reduce risk to non-target species when using larvicides, pupacides, or adulticides.

Timing of application

- Apply when winds are low (3 to 7 mph) to minimize drift.

Location of Application

- Know which sensitive species, if any, occur in your mosquito control application area.
- Understand if they can be adversely impacted by the product, and, if so,
- Identify sensitive locations and avoid treating these locations.

Method of Application (Use Patterns)

- Use pre-programmed GPS referenced locations to avoid the sensitive resources.
- Use application equipment that will target and ensure accuracy of the treatment.
- Hand broadcast and backpack spraying applications offer greater control and lower exposure for non-target species and habitats.
- Use the lowest effective pesticide application rate for the targeted area. These rates are on the product label.

The following Best Practices are important to reduce risk to non-target species from the use of adulticides in addition to the BMPs above.

Timing of Application

- Apply mosquito adulticides late in the day or overnight when fewer pollinators are present.
- Monitor wind speed at the altitude and timing of application

Location of Application

- Implement a buffer around specific habitats to protect sensitive species including pollinators; the size of the buffer will depend on timing of application, application method, active ingredient, and the species present.
- Identify and implement a “No Spray Zone” to protect pollinator foraging, reproduction, nesting and overwintering area when necessary

Method of Application (Use Patterns)

- Review the USEPA website on pesticide drift reduction
- Target the application to the pest and turn off sprayers when moving between application sites by using pre-programmed GPS -referenced application sites
- Use the lowest effective labelled pesticide application rate.

Mosquito Control Active Ingredients (AIs) and Relative Risk for Non-Target Species.

Lower Risk AIs	Moderate Risk AIs	Higher Risk AIs
Larvicides	**Larvicides/Pupacides[2]**	**Adulticides[3]**
Lysinibacillus[1]	*S*-methoprene	Malathion
Bacillus thuringiensis israelensis[2]	Spinosad (spinosyn A and D)	Naled
	Oils	Prallethrin
	Films	Etofeuprox
	Diflubenzuron	Pyrethrins
		Permethrin
		Resmethrin
		Sumithrin

[1] These active ingredients specifically target mosquito and other dipteran larvae, and are preferred for larval mosquito control due to fewer anticipated non-target insect impacts.

[2] Methoprene and spinosads have modes of action that are common across insect species and may adversely impact a broad spectrum of non-target exposed insects. Oils and films create a barrier to the air-water interface that can suffocate a diversity of aquatic insects. These active ingredients are applied to water and pose risk to non-target aquatic insects. They may impact terrestrial insects indirectly.

[3] Mosquito adulticides may have adverse impacts to a diversity of taxa. Malathion and naled are organophosphates that impact a broad spectrum of insects over a relatively short period of time, and may impact other aquatic and terrestrial species. Prallethrin, etofenprox, pyrethrins, permethrin, resmethrin, and sumithrin are pyrethroids that are highly toxic to fish and aquatic invertebrates in addition to terrestrial invertebrates. Temephos: USEPA registrations for the mosquito control larvicide temephos, an organophosphate insecticide which affects the nervous system of insects, have been cancelled. According to the USEPA any purchased product stock in the hands of users prior to December 31, 2016 may still be used. Accessed 3/24/2021 https://www.epa.gov/mosquitocontrol/controlling-mosquitoes-larval-stage

References

- U.S. Environmental Protection Agency. Strategies for managing pesticide spray drift for aerial application, ground application, and when applying around the home: https://www.epa.gov/reducing-pesticide-drift/introduction-pesticide-drift#actions
- Centers for Disease Control and Prevention. Integrated Mosquito Management: https://www.cdc.gov/mosquitoes/mosquito-control/community/what-mosquito-control-programs-do.html

Checklist for USFWS Staff Reviewing Mosquito Control Plans for Non-USFWS Land and Waters

Prevention measures are included:

- Habitat management actions to reduce mosquitoes and benefit mosquito predators have been considered will be implemented where practicable over time
- Community measures – outreach, education, inspections are planned to reduce mosquito habitats around human use areas and minimize mosquito bites.

Mosquito control planning area is clearly defined.

Sensitive species of conservation concern that may be in the planning area are identified:

- Are relevant habitat types delineated?
- Are specific locations delineated, if known?
- Are there National Wildlife Refuges or other conservation areas in, near, or adjacent to the planning area?

Mosquito monitoring program provides sufficient information:

- To implement lowest risk mosquito control practices at the appropriate times.
- To evaluate results of the mosquito control and plan for future decisions.

Mosquito management objectives are Specific, Measurable, Achievable, Realistic, and Time-bound and based on results of monitoring.

- Are action thresholds established for different management actions (e.g. use of low-risk larvicides, use of higher risk larvicides and/or pupacides, use of adulticides).
- Does the monitoring plan include monitoring for adult female mosquitoes actively vectoring pathogens.

Review the site-specific application plans for use of BMPs, e.g. selection of low risk AI, do they address wind speed, nozzle size, time of day.

Stakeholders are engaged.

- Notification procedures before use of insecticides are adequate and include affected communities, beekeepers, organic farmers, and natural area managers in the application area as well as areas potentially impacted by drift in air or flow in water.
- If federally listed species may be present, USFWS is to be notified in advance of the application.
- Advance notice should be sufficient to allow for residents and land managers to take additional protective measures.

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