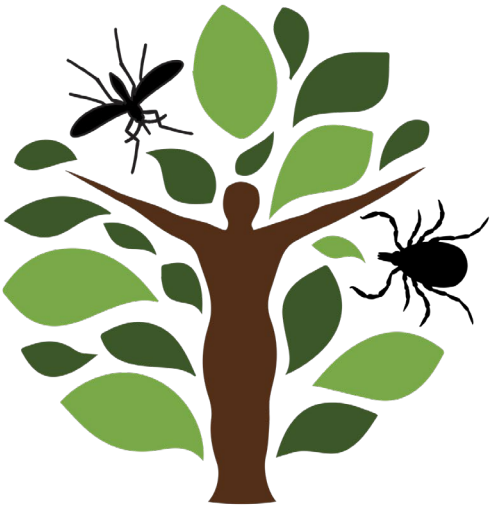

NEVBD

NORTHEAST REGIONAL CENTER FOR EXCELLENCE IN VECTOR-BORNE DISEASES

# 2019 Pesticide Use and Resistance Monitoring in the Northeastern United States

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# Project Background

**Pesticide resistance** in mosquitoes is an emerging global issue and has been linked to control failures in Africa[1] and Brazil[2]. In addition, recent wide-spread pyrethroid resistance slowed the Zika vector control response in Florida, United States (US)[3]. Resistance can emerge in a mosquito population when pesticide application dose, duration and frequency (selection pressure) is high and resistant individuals survive pesticide applications. Surviving mosquitoes may impart resistant traits to their offspring, enabling them to out-compete susceptible individuals under sustained pesticide selection pressure[4]. Pesticide resistance monitoring is limited in the US[3,5]. As the burden of vector-borne disease spreads in the US, it is crucial to monitor for pesticide resistance to ensure efficacy of control efforts.

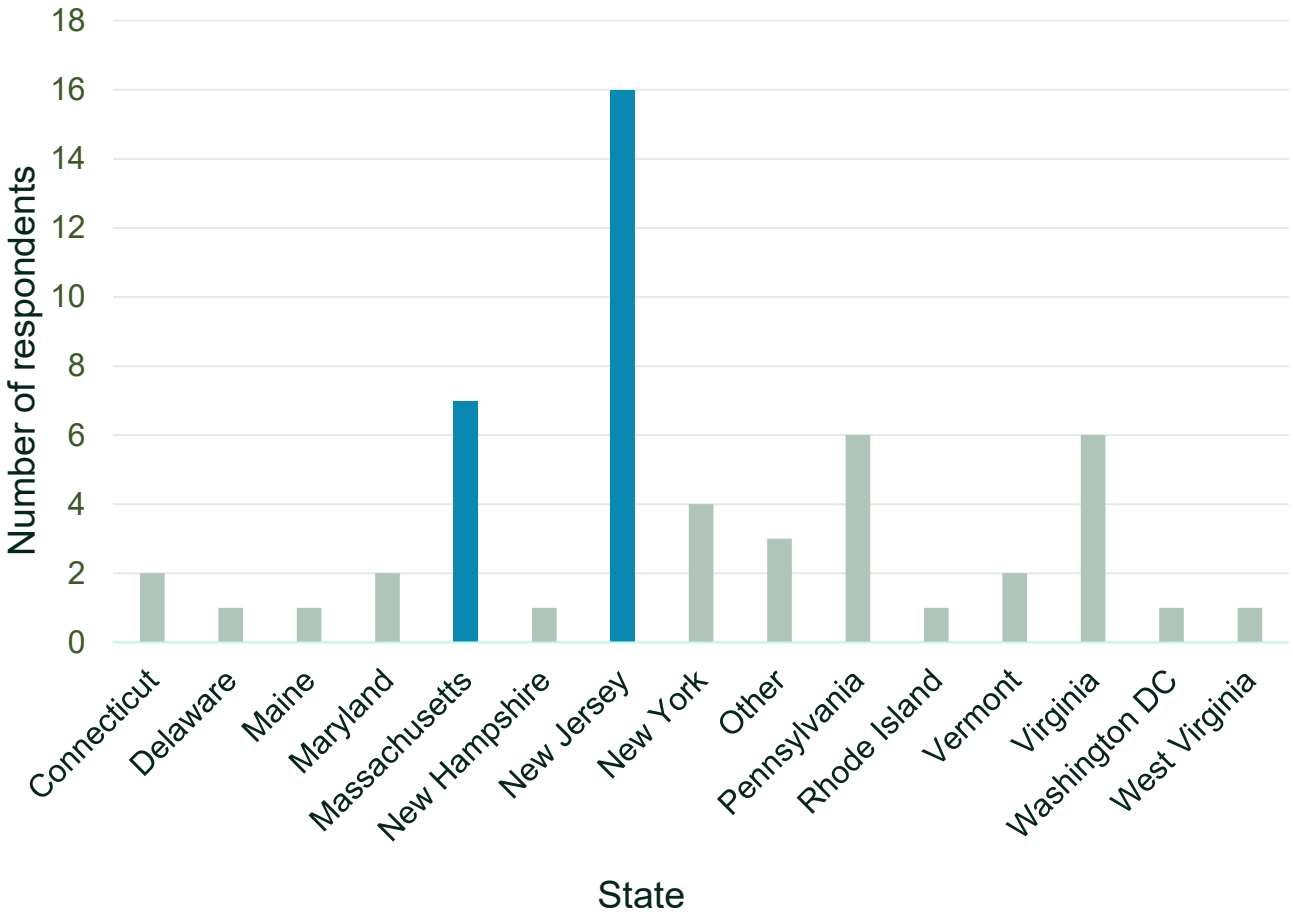
The National Association of County and City Health Officials (NACCHO) conducted a survey in 2017 to determine core competencies of vector control agencies in the US. According to that report, 98% of vector control agencies lacked the ability to monitor pesticide resistance[5]. In the Northeastern US, control efforts targeting vectors of Eastern equine encephalitis virus (EEEV), and West Nile virus (WNV) are potentially threatened by resistance emergence in mosquito populations. The status of pesticide resistance monitoring practices in the Northeast region are unclear, highlighting the critical need for region wide assessment.

In February 2019, the Northeast Regional Center of Excellence in Vector Borne Diseases (NEVBD) distributed **a pesticide use and resistance Qualtrics™ survey** to vector control organizations and public health departments operating within the region. The survey was distributed through the Northeastern Mosquito Control Association (NMCA) and NEVBD listservs and on Twitter. The goals of the survey were to: **(1)** determine the current extent of pesticide use and resistance monitoring within the region; **(2)** determine roadblocks preventing the expansion of regional pesticide resistance monitoring programs; and **(3)** assess how NEVBD can assist the public health community and expand pesticide resistance monitoring activities.

# Overview of Respondents

- Respondents were from **all states** within the Northeast region and the District of Columbia (Figure 1).
- **New Jersey (29%)** and Massachusetts (14%) had the most respondents (Figure 1).

Figure 1. Number of respondents by state jursidiction.

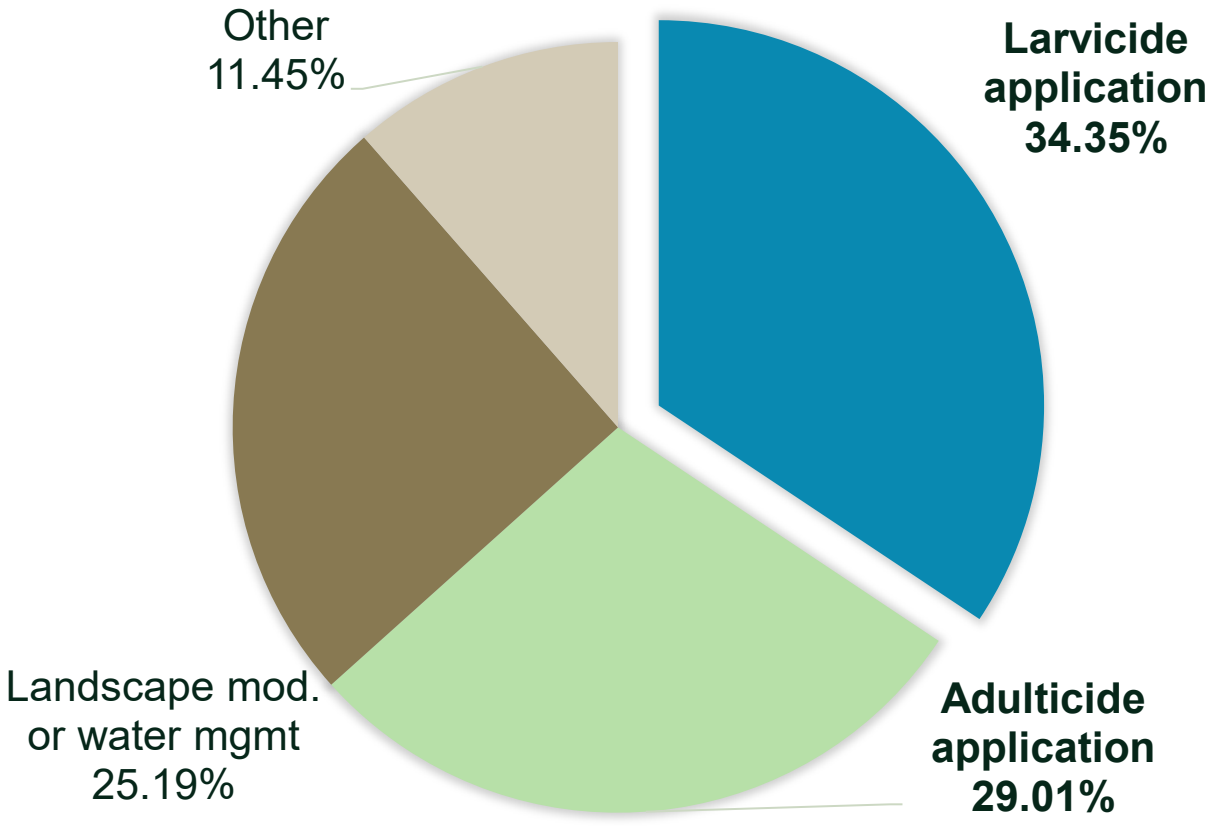



n = 58

# Prevailing Mosquito Control Methods in the Northeast

- **Larvicide application** is the most common form of mosquito control in the Northeast (Figure 2).
- **Adulticide application** and landscape modification are also commonly deployed methods for mosquito control (Figure 2).

Figure 2. Mosquito control methods employed by respondent agencies.

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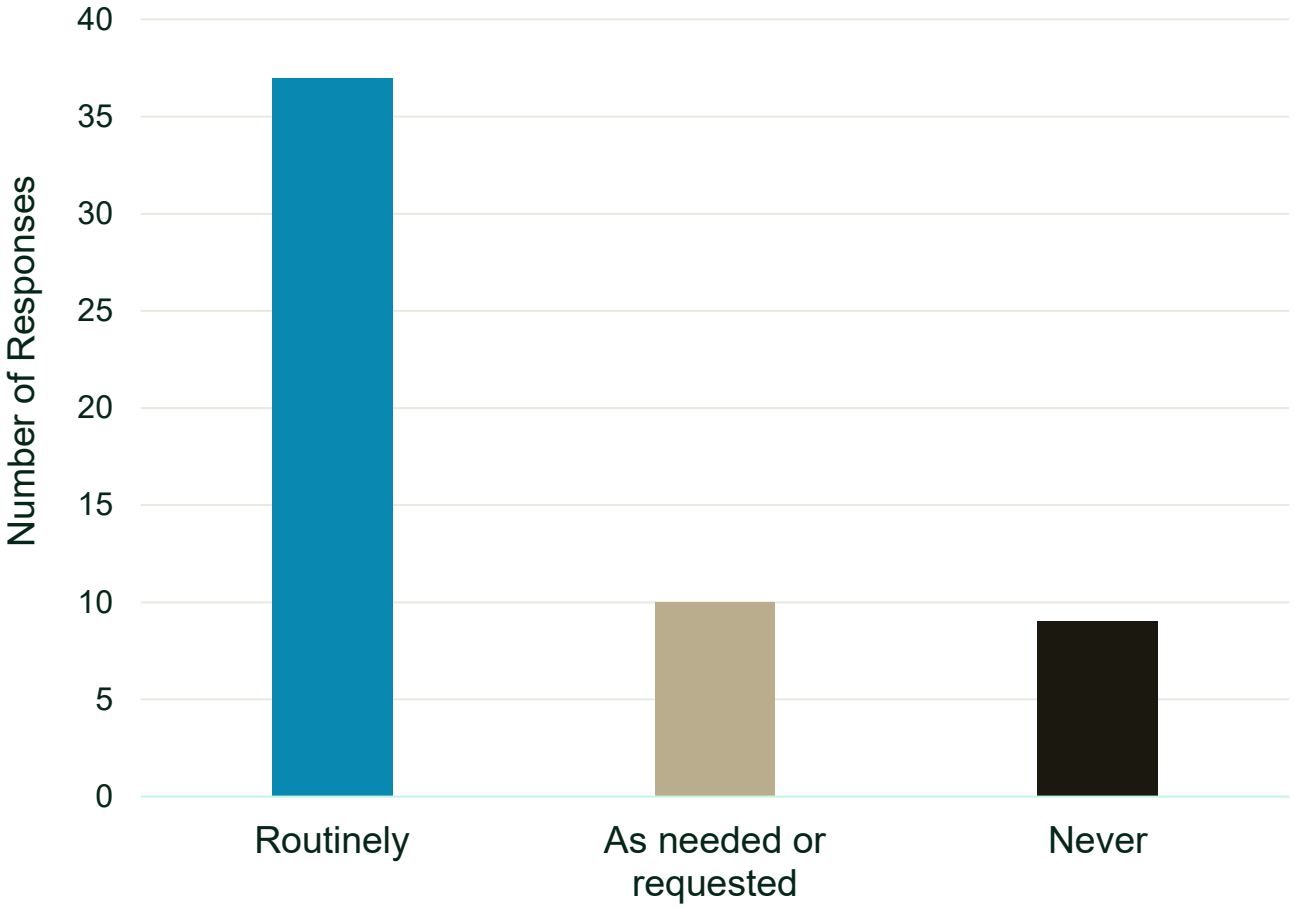
# Frequency of Mosquito Control Operations

- **Routine** mosquito control operations are conducted more often than reactive or requested operations (Figure 3).
- Not all respondents are involved in mosquito control (Figure 3).

Figure 3. Frequency of mosquito control operations employed by respondent agencies.

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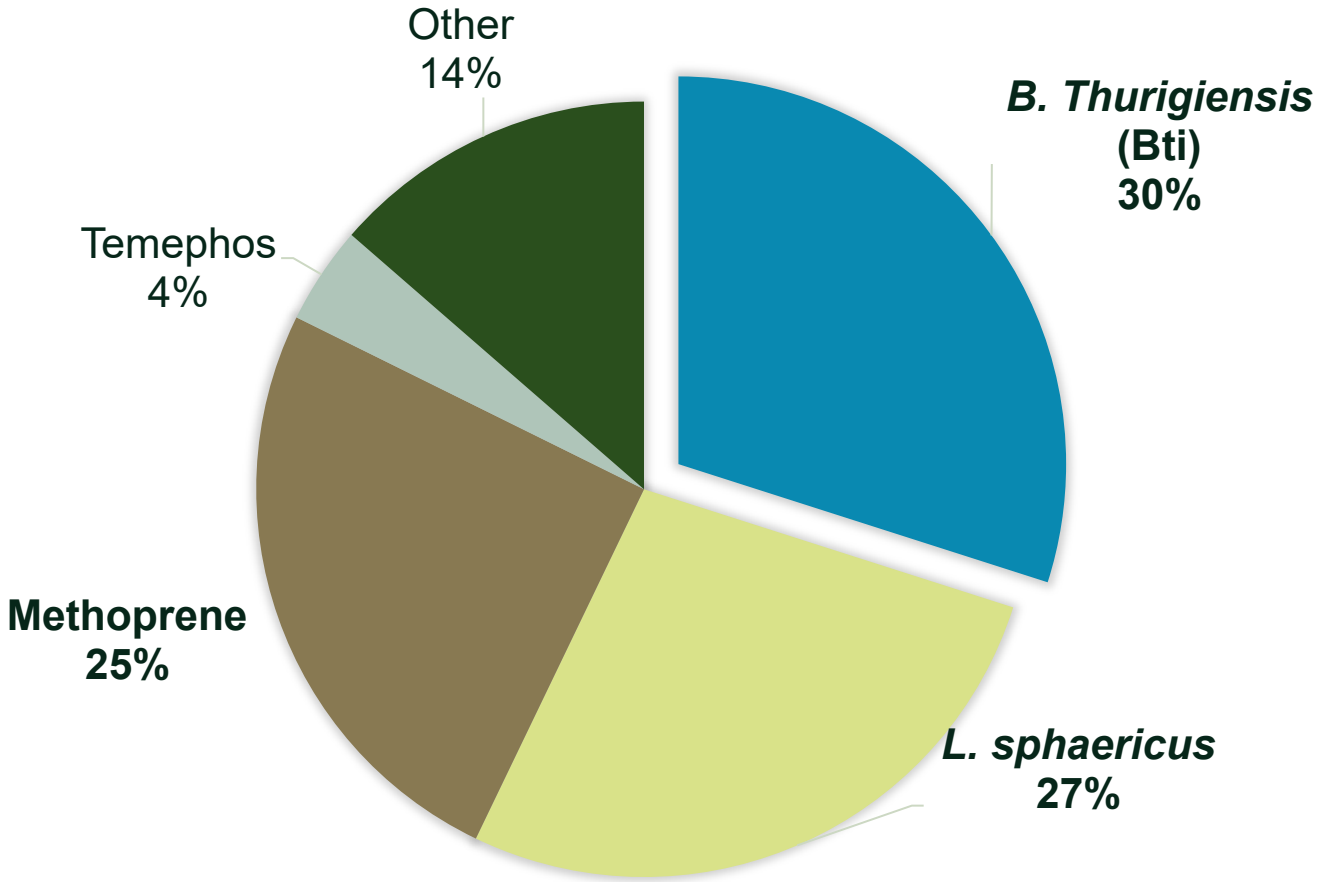
# Larvicides are applied by 34% of respondents in the Northeast

- The majority (57%) of respondents conducting larval control reported using biopesticides (***B. thuringiensis israelensis*** and ***L. sphaericus***) (Figure 4).
- **Methoprene**, a juvenile hormone regulator, is the third most-common larvicide deployed. It was used by 25% of respondents conducting larval control (Figure 4).

Figure 4. Active ingredients used in larval control.

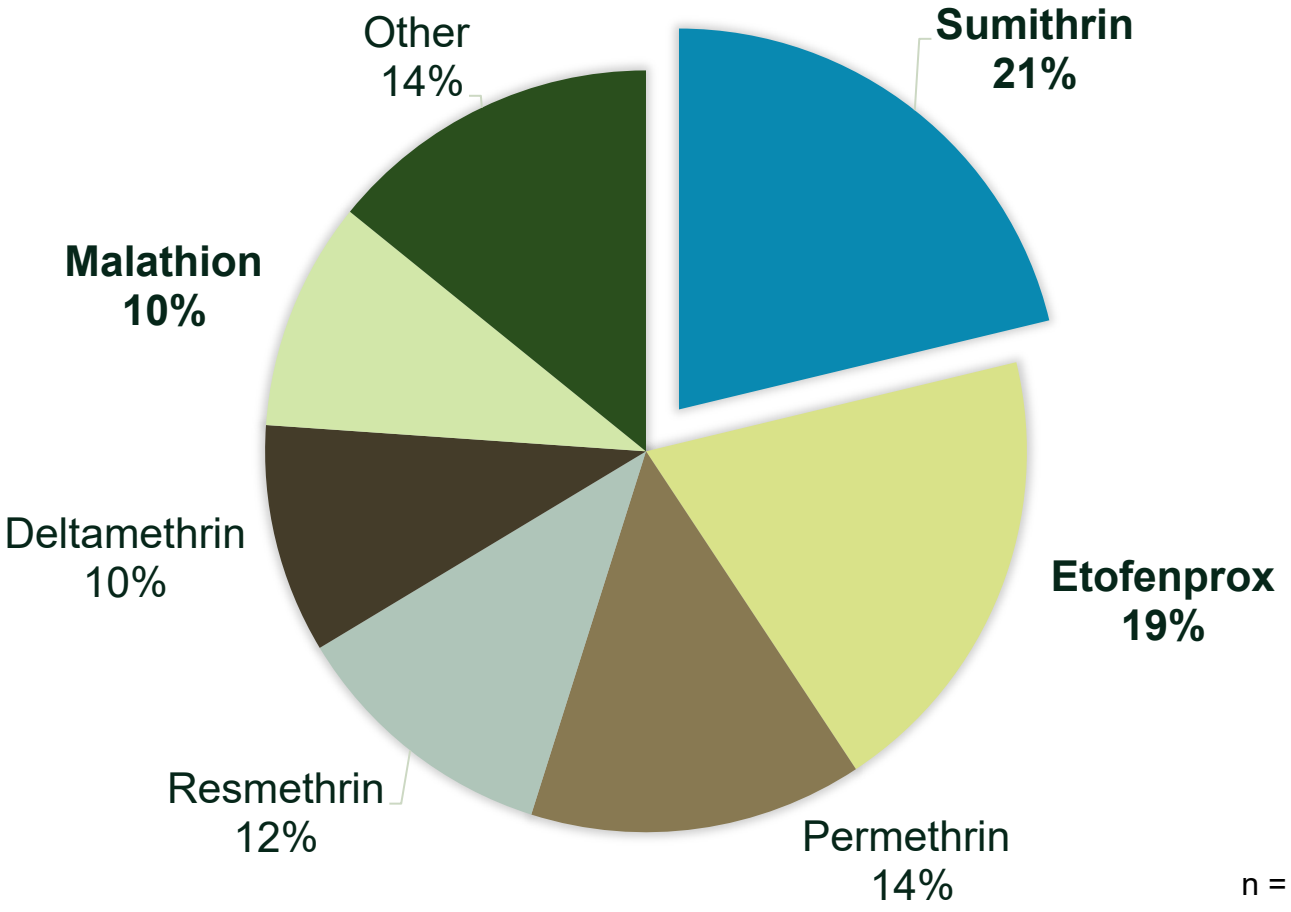



n = 54

# Adulticides are applied by 29% of respondents in the Northeast

- The majority (76%) adult mosquito control in the region is conducted using **pyrethroids** (Figure 5).
- **Malathion** is the only organophosphate used in the region and is only used by 10% of respondents conducting adult mosquito control (Figure 5).

Figure 5. Active ingredients used in adult mosquito control.

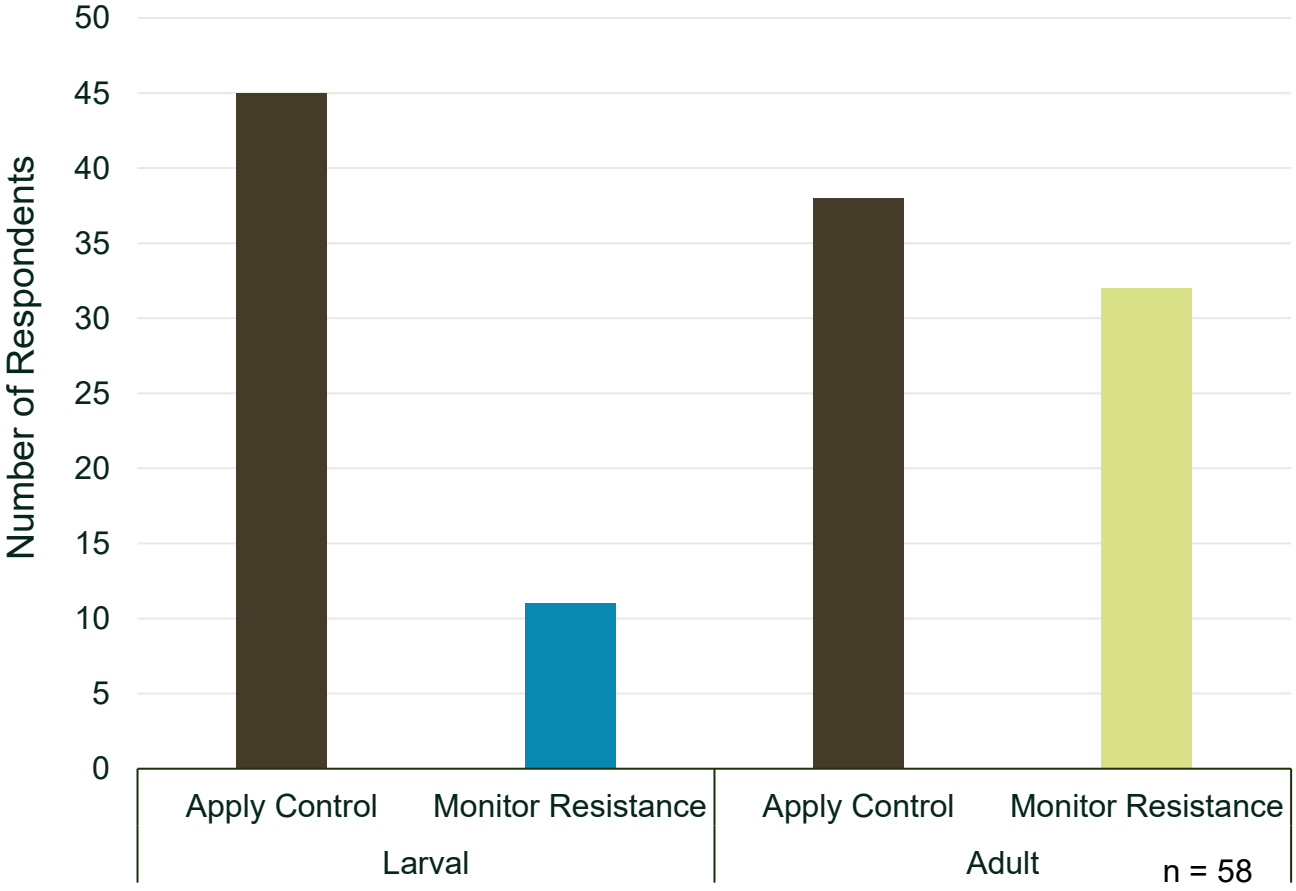



n = 45

# Northeast Resistance Monitoring

- Pesticide resistance monitoring **is not conducted** with the same regularity as mosquito control in the Northeast (Figure 6).
- Only 24% of agencies that apply larval mosquito control are monitoring for **pesticide resistance to larvicides** (Figure 6).
- Resistance monitoring for adulticides is conducted **more frequently** than testing for larvicides (Figure 6).

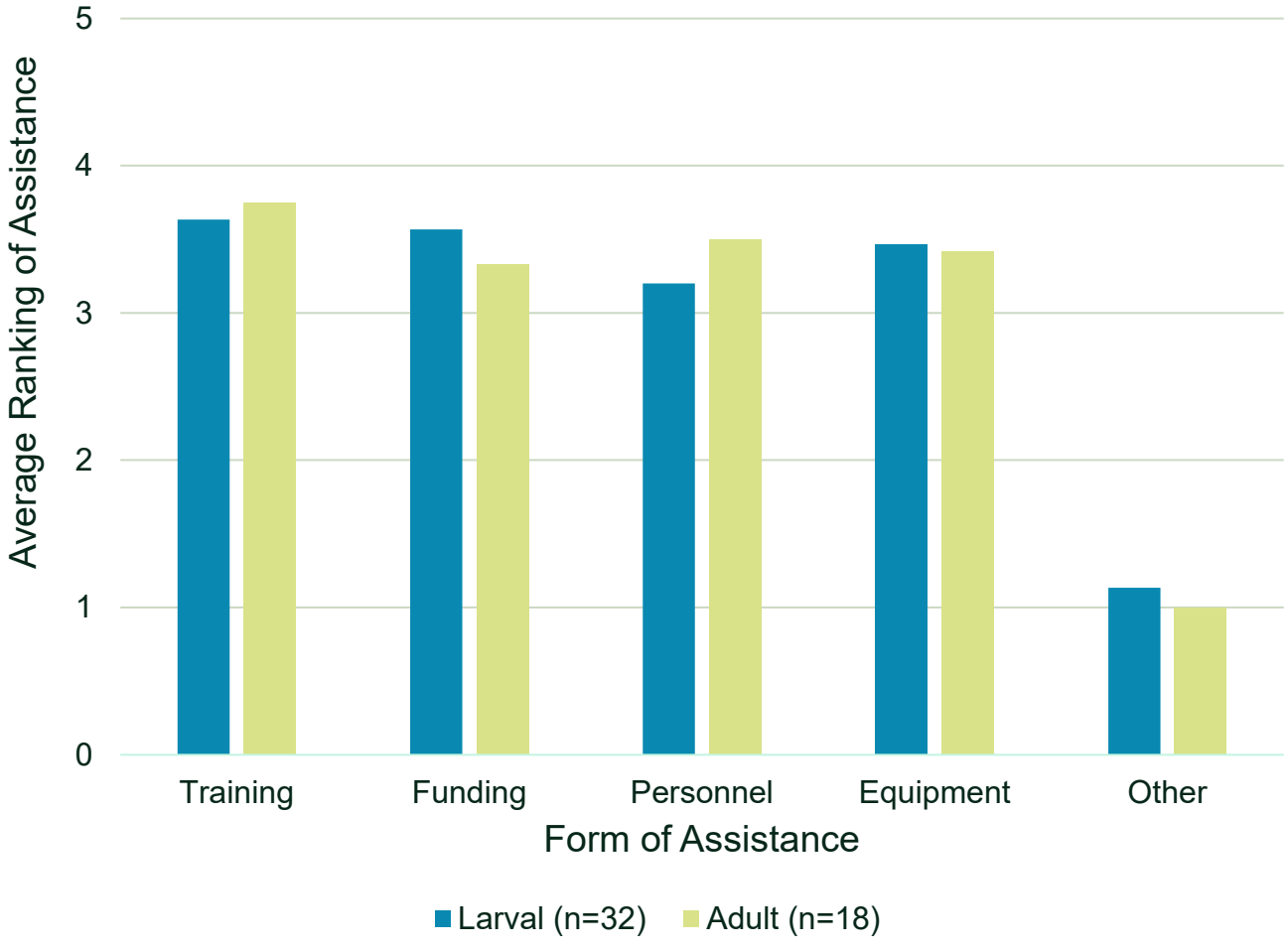
Figure 6. Number of respondents conducting mosquito control compared to pesticide resistance monitoring by mosquito life stage.



# Roadblocks to Resistance Monitoring in Mosquitoes

- A lack of **training,** equipment and personnel are major barriers to pesticide resistance testing (Figure 7).
- An increase in **funding** may help address these issues and allow for more pesticide resistance monitoring.

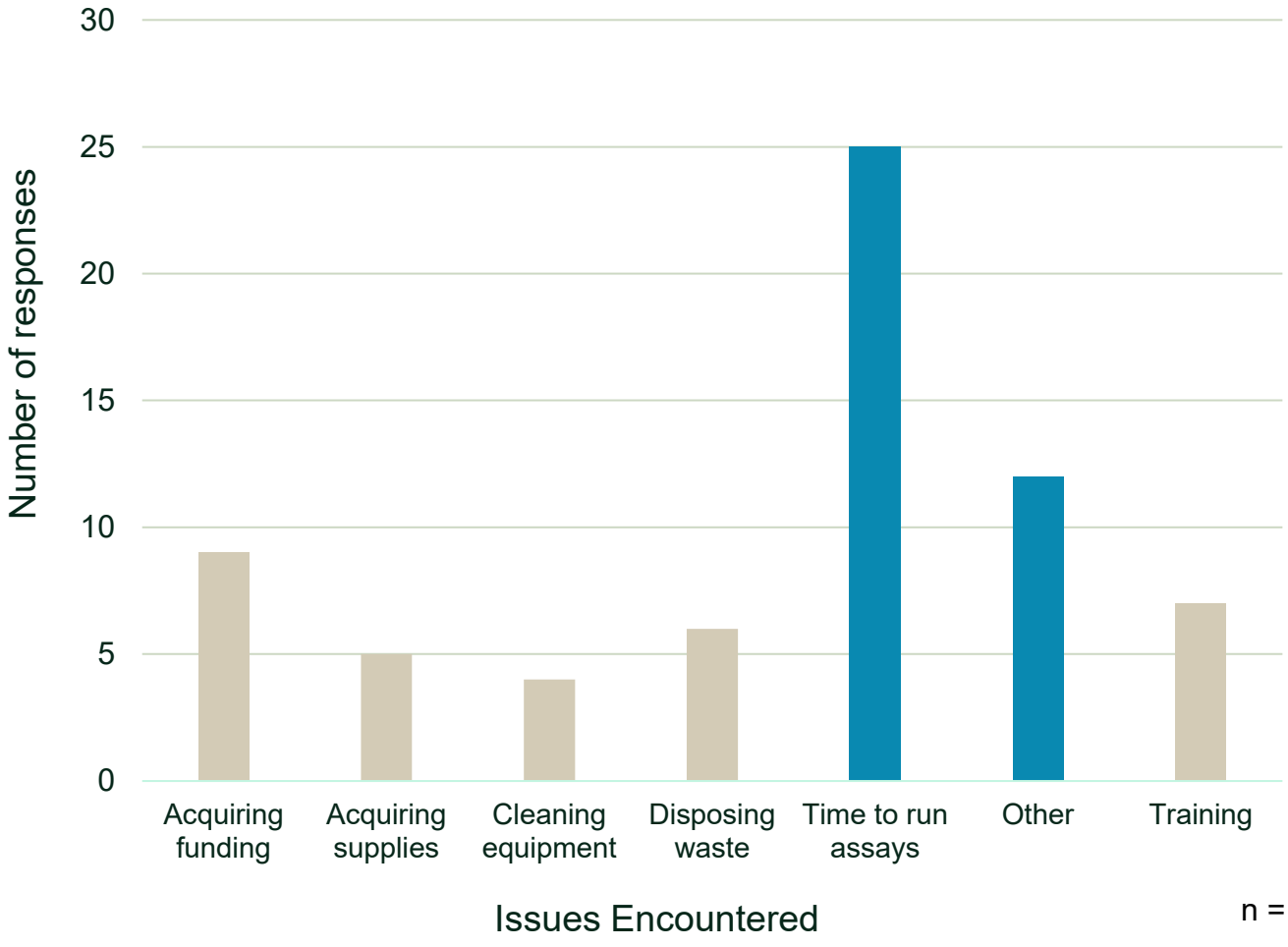
Figure 7. Ranked forms of assistance that would help to increase pesticide resistance monitoring.



# Commonly Encountered Issues when Testing for Resistance

- Outside of funding and training barriers, the inability to make **time to run assays** also limits the capacity of programs to conduct resistance testing (Figure 8).
- 33% of respondents selecting 'other' mentioned the inability to **rear mosquitoes in colony** as a limiting factor in their ability to conduct resistance testing.

Figure 8. Commonly encountered issues when conducting resistance tests.

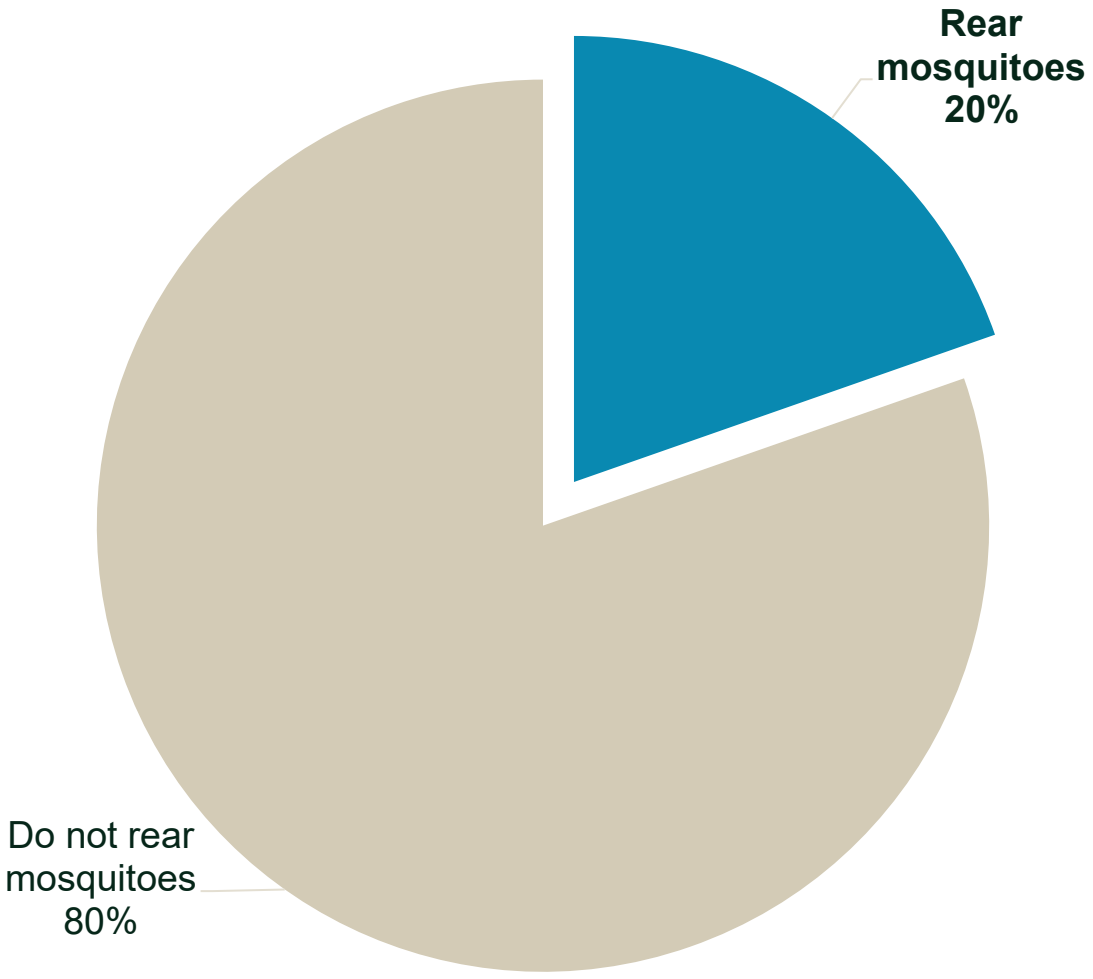



n = 43

# Rearing Capacity in the Northeast as a Barrier

- Only **20%** of respondents are able to rear mosquitoes in colony (Figure 9).
- Increasing this capacity will make it **easier** to conduct resistance testing.

Figure 9. Respondent agencies that rear mosquitoes.

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# Discussion

To date, there are very few published studies on pesticide resistance in the Northeastern US. This is in part due to a lack of standardized methods for resistance testing to larvicides, along with infrequent larvicide and adulticide testing. Without routine testing, public health and vector control programs are not documenting emerging resistance and this will lead to control failures with time. Published literature from outside the region has demonstrated that *Bti* resistance is rare[6,7], while resistance to methoprene and *L. sphaericus* has been detected frequently[8,9,10]. Even though adult resistance testing occurs in some states, most organizations lack the resources to conduct routine monitoring (Figure 6).

Furthermore, resistance to multiple pyrethroid active ingredients in the Northeastern US is likely to occur given dependence on sumithrin, etofenprox and permethrin (Figure 5) by many control programs. Organophosphates (OP) are rarely used in vector control, however, testing mosquitoes for OP resistance remains essential to determine if this chemical class can be used during a public health emergency when confronted with high pyrethroid resistance levels.

**With limited modes of action available for vector control, conducting routine resistance testing is crucial for informed mosquito control efforts in the region.**

# NEVBD Response

NEVBD has used the information provided by this survey to understand the constraints of pesticide resistance monitoring within the Northeast, with the goal of providing meaningful interventions. Respondents indicated that funding, equipment, and time to run bioassays (Figure 7, 8, 9) were all important factors preventing resistance monitoring in mosquito populations. In response to these issues, NEVBD developed training workshops, resistance testing kits, as well as guidelines for conducting bioassays and mosquito rearing. **These strategies and services are designed to expand the regional capacity to conduct resistance testing by our public health and vector control collaborators**. In addition, NEVBD regularly conducts and supports advocacy efforts to increase sustainable financial support for this and other vital vector control functions.

## NEVBD Approach

NEVBD implemented these interventions on a regional scale through a Pesticide Resistance Monitoring Program. This program includes a free, centralized specimen submission system for pesticide resistance monitoring. The NEVBD resistance testing laboratory is housed within Dr. Laura Harrington's laboratory at Cornell University's Department of Entomology. The team developed diagnostics for resistance to the most common larvicides deployed in the region targeting *Aedes albopictus* and *Culex pipiens*. Alongside larvicide bioassays, the CDC bottle bioassay is used to test specimens submitted to the NEVBD testing laboratory by public health practitioners. This centralized approach allows for standardized testing methods across the region, and reduces the time, effort and expense required by practitioners to collect resistance data. NEVBD also provides support and guidance for projects evaluating the effectiveness of mosquito control operations by offering specialized lab space, personnel, and a large capacity for mosquito rearing.

## 2019 Season Results

Vector control and public health partners used NEVBD collection kits to ship over 15,000 *Cx. pipiens* and *Ae. albopictus* specimens for resistance testing during the 2019 field season. As a free service, the submission system reduced up-front costs for collaborators in addition to alleviating time, equipment and personnel constraints. These results were summarized and reported by NEVBD at annual mosquito control meetings throughout the region, increasing awareness of the general resistance status in mosquito populations in the Northeast.

## Future Program Plans

NEVBD offers training to professionals currently working in the field through workshops, webinars, bootcamps, and on-request assistance. The intended outcomes of these workshops are to directly increase the regional capacity for resistance monitoring by teaching practitioners to conduct both larvicide and CDC bottle bioassays and to interpret results. These workshops also help to increase communication and collaborations across administrative boundaries.

NEVBD is training students to enter the workforce through a Master of Science (MS) in Vector-Borne Disease Biology at Cornell University's Department of Entomology. NEVBD MS students are trained in public health entomology and have the skills needed to rear mosquito colonies, conduct and interpret resistance monitoring, along with other relevant public health and entomology skills. These students will further bolster the regional and national capacity to monitor pesticide resistance and help train others in these skills throughout their careers.

Finally, NEVBD sent out a new survey in January 2020 to continue to shape the program. NEVBD will continue to collect data on emerging pesticide resistance and create guidelines to support the community of practice in our region. These actions aim to increase the regional capacity to monitor pesticide resistance and prevent control failures from affecting human health.

# Conclusion

Pesticide resistance monitoring is a core component of any vector control effort, and NEVBD can assist our region in monitoring for pesticide resistance as mosquito control is applied. Vector control and public health collaborators are central to our current efforts and to the viability of long-term pesticide resistance monitoring in the Northeast.

If you would like to learn more about the NEVBD Pesticide Resistance Monitoring Program, visit the NEVBD website. Please contact us directly if you have any questions or would like to learn more about our work on pesticide resistance monitoring in the Northeast.

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