Final Report:
Mosquito Control Task Force Study

Lauren Brown
Eastern Research Group
September 2, 2021

Agenda

- Goal and Scope of Report
- Overview of Reports
  - Scope
  - Methods
  - Key takeaways
- Reports and Subcommittees
- Questions

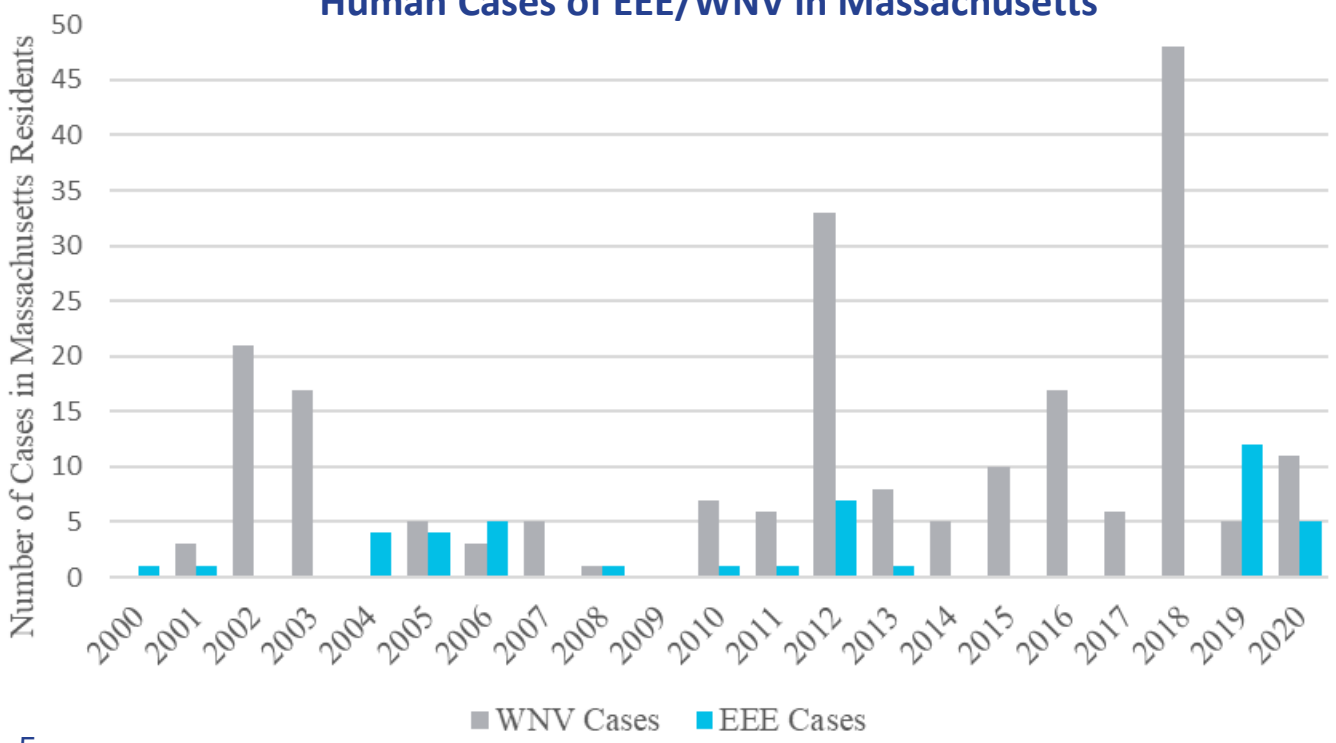
Goal and Scope of Report

- Scope:
  - Address all subject areas requested in the request for responses In considering current practices
  - Focus of research was on state run mosquito control operations.
- Goal:
  - Provide a foundation by which the task force can build upon to make informed recommendations for mosquito control moving forward in MA

REPORT 1: ARBOVIRUS HISTORY IN MASSACHUSETTS

1. History of West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) in Massachusetts

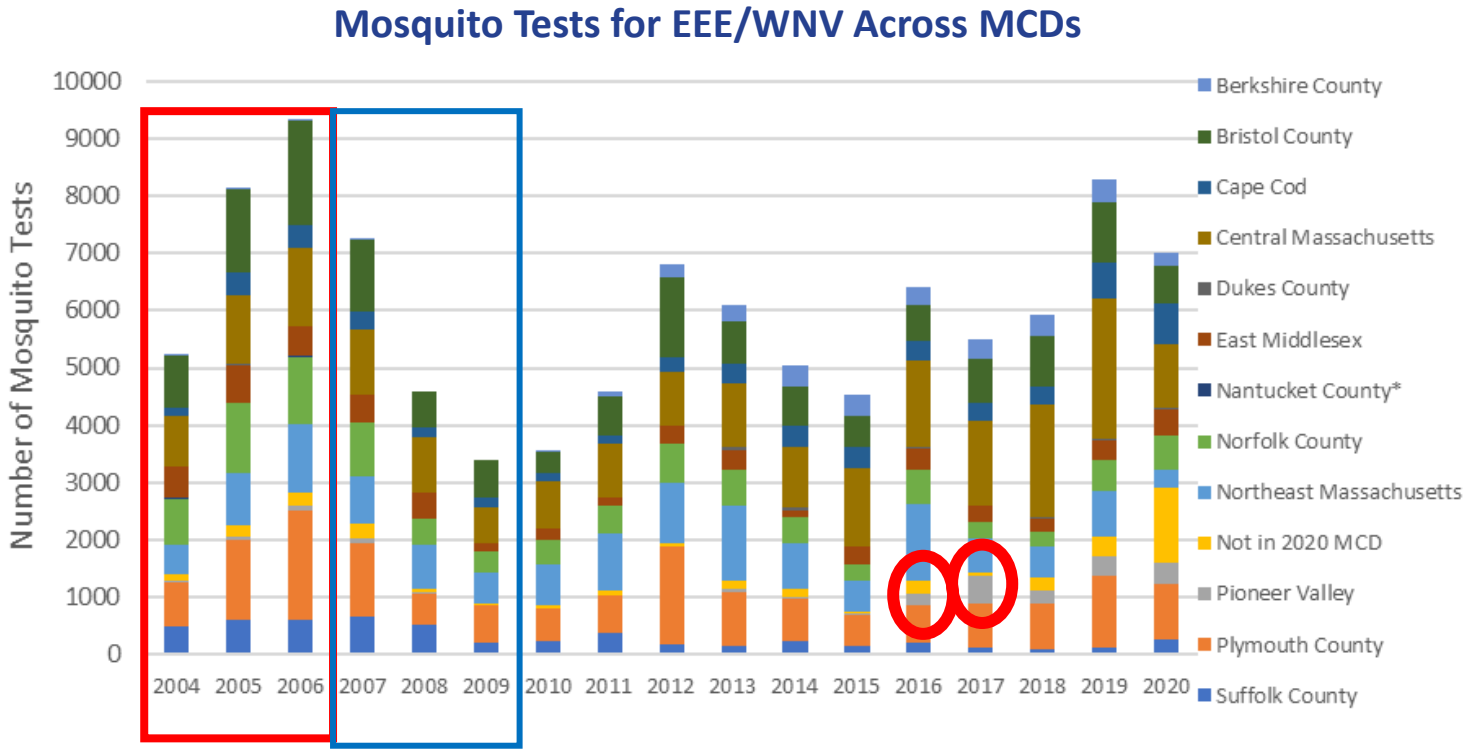
- **Overview of Scope:** Data-driven history of WNV and EEE in Massachusetts (MA).
- **Information Source:** EEE/WNV data from DPH (human cases, mosquito, and trap location)

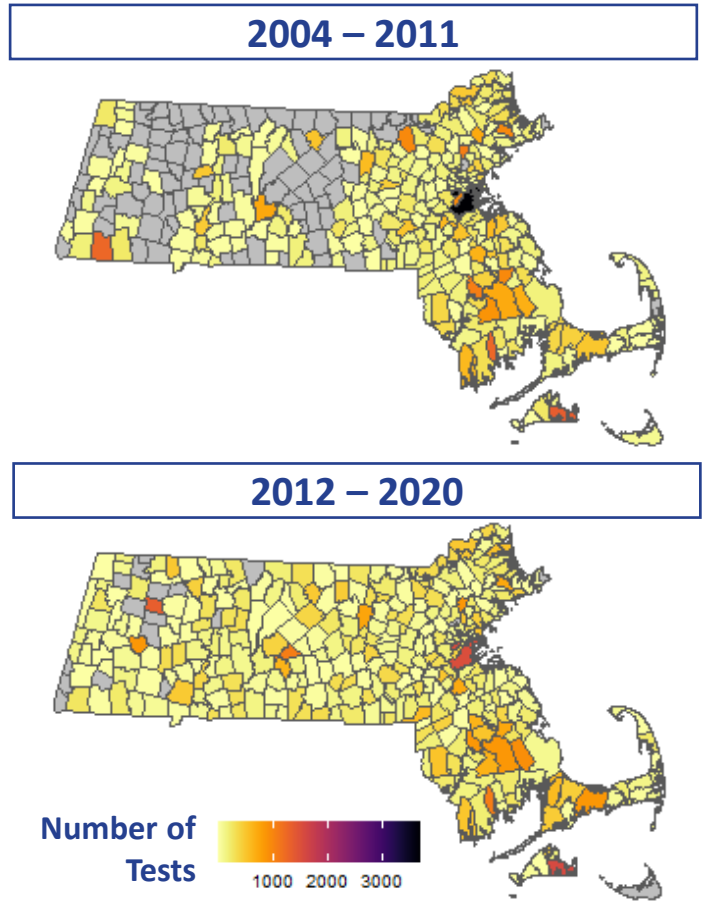


Reported Human Cases of EEE in Massachusetts		
Year(s)	Cases	Deaths
1938–1939	35	25
1955–1956	16	9
1973–1974	6	4
1982–1984	10	3
1990–1992	4	1
2000–2001	2	0
2004–2006	13	8
2008	1	1
2010–2013	10	5
2019	12	6
2020	5	1
Total	**114**	**63**

1. History of West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) in Massachusetts

- **Findings:** Mosquito testing increases in municipalities that join MCDs. Testing expanded across the Commonwealth in recent years.

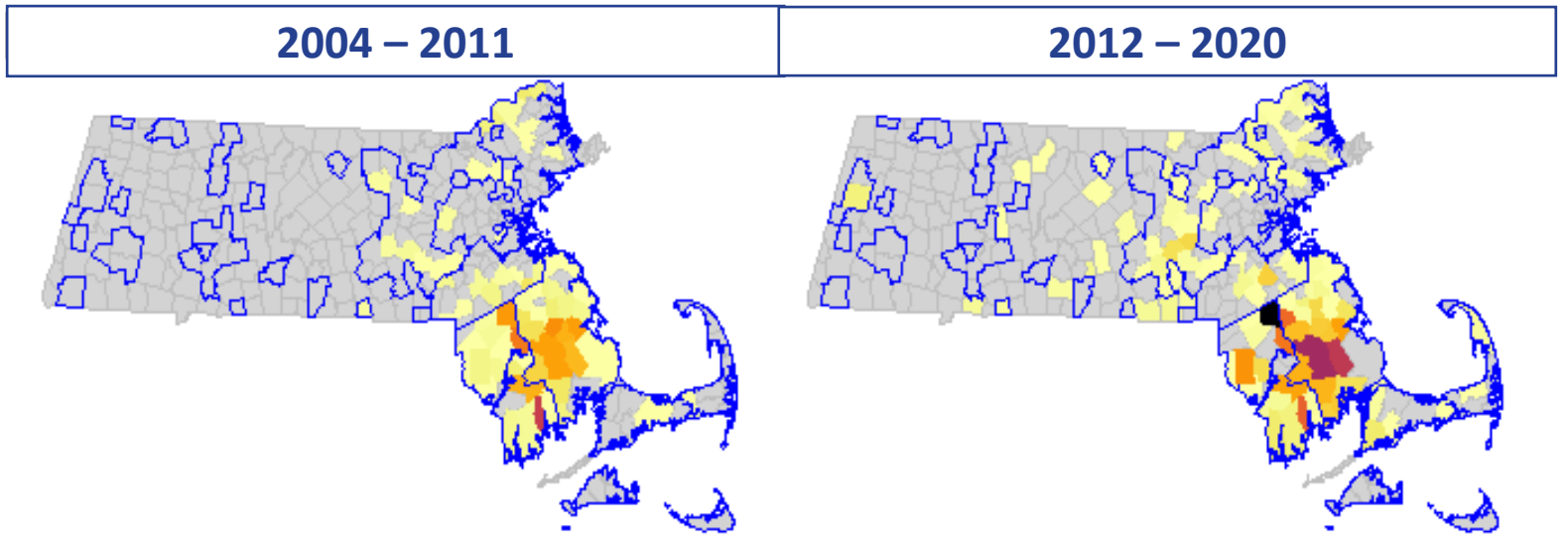




1. History of West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) in Massachusetts

- **Findings:** The highest rates of positive EEE mosquito tests, human cases, and EEE mosquito habitat are in Plymouth and Bristol counties. Recently, mosquito positivity has increased in and out of MCDs.

Mosquito EEE Positivity			EEE Mosquito Habitat
MCD	2004–2011	2012–2020	Acres
Plymouth County	2.7%	4.7%	76,767
Bristol County	2.4%	4.2%	61,687
Norfolk County	0.5%	0.7%	31,279
Cape Cod	0.10%	0.50%	23,313
Central MA	0.20%	0.40%	52,680
Northeast MA	0.40%	0.40%	52,938
Berkshire County	0%	0.20%	19,576
East Middlesex	0.10%	0.20%	20,888
Pioneer Valley	0%	0.10%	13,754
Dukes County	0%	0%	2,281
Suffolk County	0%	0%	753
Nantucket County	0%	-	2,621
All MCDs	**1.10%**	**1.60%**	
Not in 2020 MCDs	**0%**	**1.20%**	

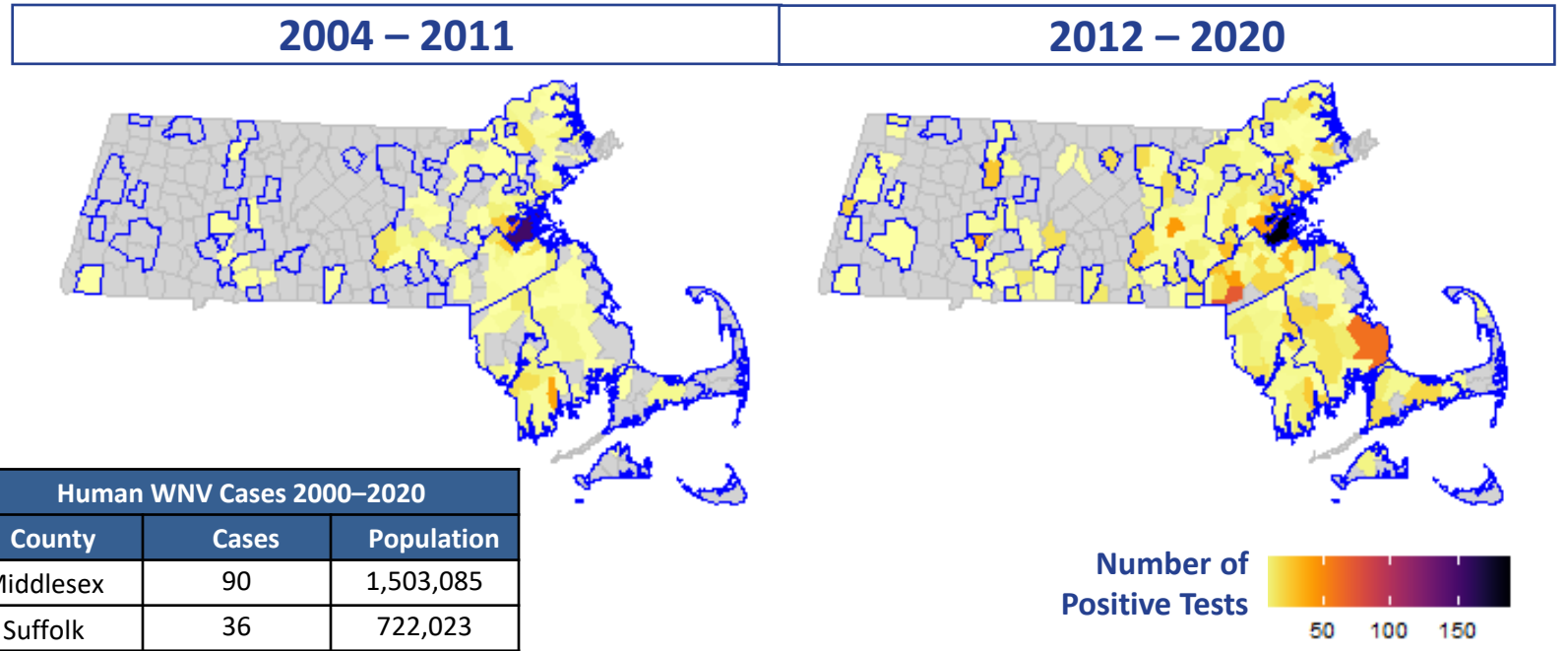


Human EEE Cases 2000–2020	
County	Cases
Plymouth County	15
Bristol County	7
All other Counties	0–4

1. History of West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) in Massachusetts

- **Findings:** The highest rates of positive WNV mosquito tests, human cases are in dense populations. Recently, mosquito positivity has increased in and out of MCDs.

	2004–2011	2012–2020
MCD	WNV Positivity Rate	WNV Positivity Rate
Suffolk County	4.2%	13.8%
East Middlesex	4.2%	13.6%
Pioneer Valley	1.4%	9.2%
Berkshire County	0.50%	5.0%
Bristol County	1.4%	3.6%
Norfolk County	1.8%	3.5%
Northeast MA	1.9%	3.5%
Central MA	0.90%	2.6%
Dukes County	2.7%	2.2%
Plymouth County	0.70%	2.0%
Cape Cod	0.30%	1.8%
Nantucket County	0.00%	-
All MCDs	**1.70%**	**3.70%**
Not in 2020 MCDs	**1.00%**	**2.30%**



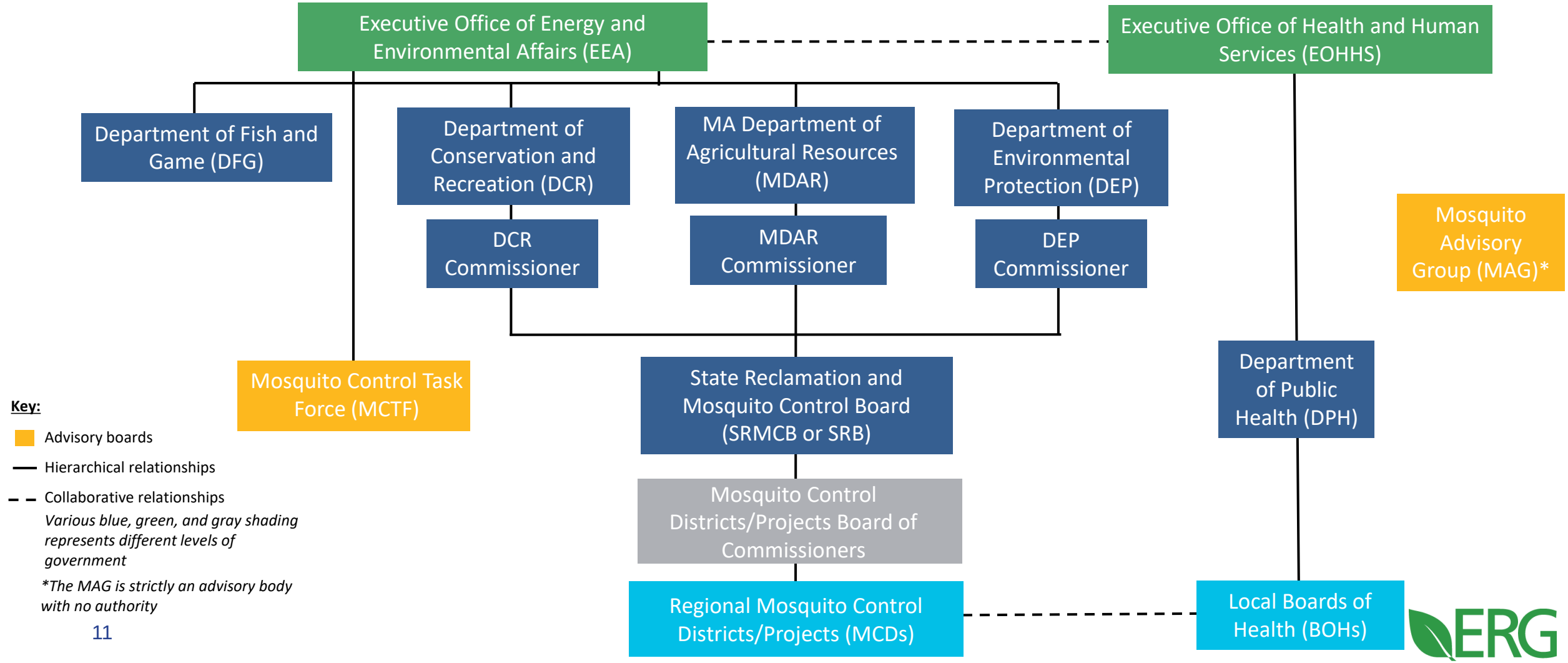
Human WNV Cases 2000–2020		
County	Cases	Population
Middlesex	90	1,503,085
Suffolk	36	722,023
Worcester	20	798,552
Essex	14	743,159
Norfolk	13	670,850
Bristol	11	548,285
All Others	<10	<500,000

REPORT 2: EXISTING MOSQUITO CONTROL POLICY STRUCTURE AND ITS EFFECTIVENESS, CHALLENGES EXPERIENCED

2. Mosquito Policy: Structure, Effectiveness, and Challenges on Public and Private Lands

- **Overview of Scope:** Describe existing policy structure (including entities involved and major legislation), evaluate the effectiveness of the program, and discuss challenges to mosquito control on state, federal, and privately owned land.
- **Methods:**
  - Reviewed **51 documents** related to existing policy, lessons learned, challenges, and best practices.
  - Conducted **18 interviews with 21 respondents.**
  - Developed a **detailed organizational chart and logic model** for the mosquito control program that illustrates roles and responsibilities, program inputs, activities, outputs and outcomes.

2. Mosquito Policy: Structure, Effectiveness, and Challenges on Public and Private Lands (*Cont'd*)



2. Mosquito Policy: Structure, Effectiveness, and Challenges on Public and Private Lands (*Cont'd*)

Decision-Making and Management Effectiveness:

Activity	Activities by MCDs	When to Conduct Aerial Spraying at the State Level	When to Survey Mosquito Populations	Funding MCDs	Establishing MCDs	Oversight of Activities	Finances	Public Participation	Control of Disease Carrying Mosquito Populations	Ensuring Local Options and Choices in Services Received
Rating	**Moderate**	**Moderate**	**Moderate**	**Poor**	**Poor**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Poor**
Average Score	3.7	3.3	3.2	2.4	2.2	3.9	3.7	3.3	3.1	2.6
Range	1 - 5	2 - 5	1 - 5	1 - 4	1 - 4	1 - 5	1 - 5	0 - 5	1 - 5	0 - 5

- Perspectives regarding effectiveness of the current policy structure were deeply divided
- Over three quarters suggested improvements to the decision-making and management structure:
  - Overhauling the SRB to create a more centralized, standardized structure for mosquito control
  - Increasing transparency about the decision-making process and activities
  - Extending mosquito control and surveillance activities to areas without established MCDs

2. Mosquito Policy: Structure, Effectiveness, and Challenges on Public and Private Lands (*Cont'd*)

Challenges

- Concern about chemical treatment on private property
- Difficulty conducting mosquito control and surveillance on public lands
- Endangered species and critical habitat protection
- Restrictions under the Children and Families Protection Act

Potential Solutions

Increased awareness of management options

Strengthened understanding of public perspectives

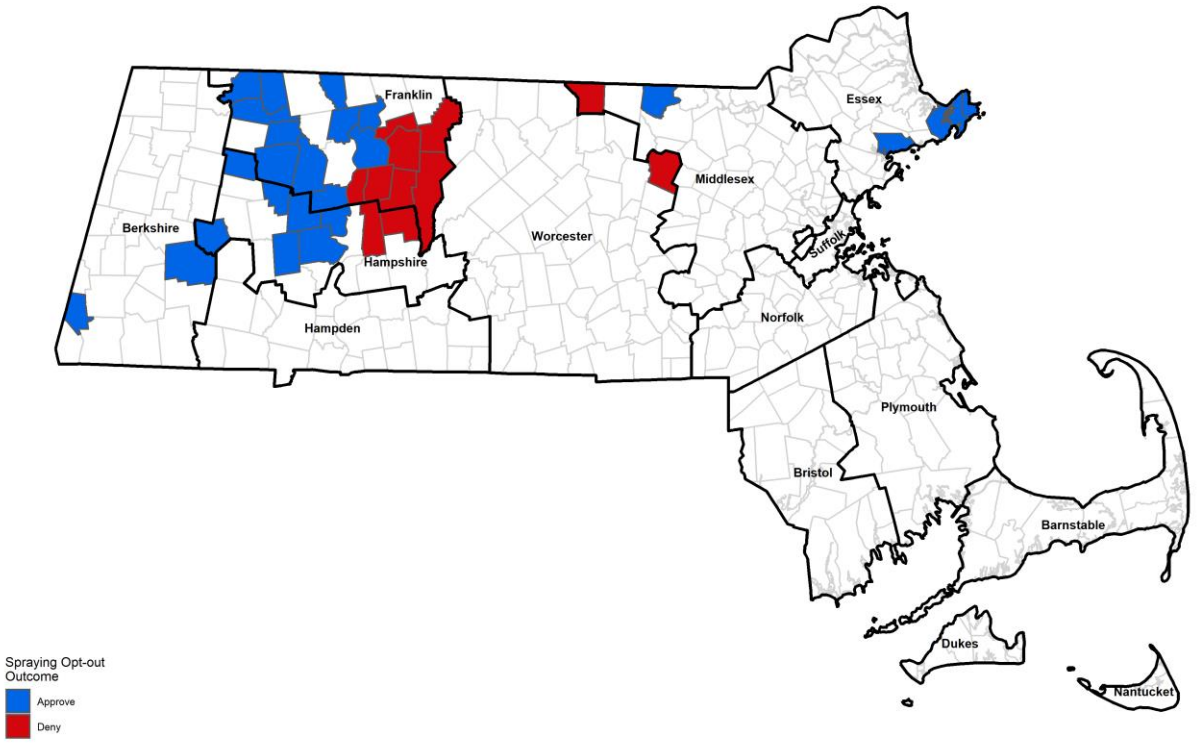
Improved relationships and trust with landowners

REPORT 3: OPT-OUTS AND EXCLUSIONS

3. Mosquito Control Opt-Outs and Exclusions

- **Overview of Scope:** Review of current opt-out policies including municipal opt-out and individual exclusion requests in MA and other states.
- **Method:**
  - Review of current opt-out process and procedures in MA, all five other New England states, NY, NJ, and MI.
  - MCD annual report review
  - Discussions/interviews with EEA, MDAR, and MCD staff
  - Review of input from task force members and the public shared at task force meetings
  - Review of municipal and individual opt-out/exclusion applications

3. Mosquito Control Opt-Outs and Exclusions *(Cont'd)*



- MA processes unique in region
- >2,000 individuals/ organizations requested exclusion/opt-out in 2020
- 35 municipalities applied to opt out in 2021
  - 24 approved
- No data quantifying risks and benefits was found

REPORT 4: CHEMICAL COMPOSITION AND TOXICITY OF PESTICIDES USED IN GROUND AND AERIAL SPRAYING IN MASSACHUSETTS

ERG

4. Pesticides: Composition, Toxicity, Resistance, PFAS, and Frequency of Use

- **Overview of Scope:** Describe the Composition, Toxicity, Resistance, PFAS and Frequency of Use of Pesticides used in MA.
- **Method:**
  - Literature reviews; MCD annual reports and SRB spray reports review; Database searches (EPA: OPP chemical search, EcoTox, CompTox Chemical Dashboard; IUPAC, National Pesticide Information Center); Chemical hazard comparison tool (Pharos Project); Expert interviews (NGO, State Officials, Academics)
- **Composition and Frequency of Use:**
  - From 2009 to 2020 MCDs used 44 different products and the SRB used one
  - Larvicides used by MCDs include bacterial insecticides *(Bti* or *Bs*), spinosyns (Spinosad), methoprene and mineral oil containing products
  - Adulticides used by MCDs and SRB have all been pyrethroids
  - Anvil 10+10 has been used since 2006 for adulticide aerial spraying by the SRB

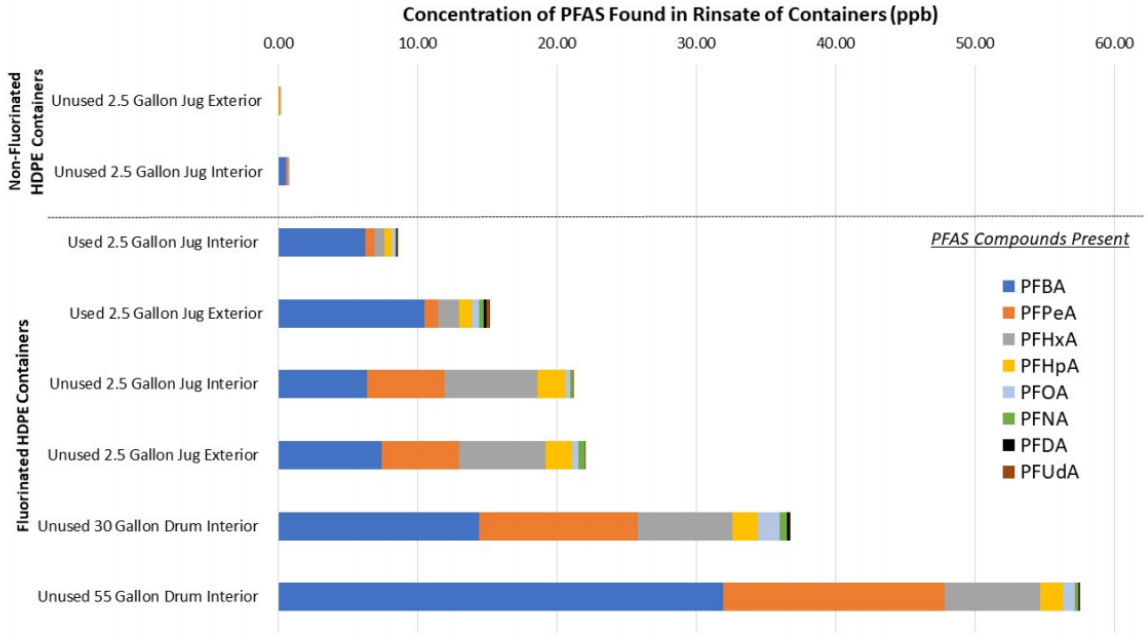
4. Pesticides: Composition, Toxicity, Resistance, PFAS, and Frequency of Use *(Cont'd)*

- **Toxicity**
  - The focus of the research was on toxicity, not risk (which is a factor of both toxicity AND exposure)
  - Ecological toxicity is the main toxicological concern for the active ingredients
  - Pyrethroids demonstrate the highest acute ecological toxicity – specifically in the aquatic environment.
  - Spinosads and pyrethroids also have noted high toxicity to non-target insects (i.e., bees)
  - Pyrethroids are known neurotoxicants but levels in the environment are expected to be much lower than those that cause adverse human health effects
  - Many unknown inert ingredients

4. Pesticides: Composition, Toxicity, Resistance, PFAS, and Frequency of Use *(Cont'd)*

- PFAS in Pesticides
  - December 2020: PFAS first measured in Anvil 10+10
  - EPA testing indicated fluorinated storage containers are a possible source of PFAS in Anvil 10+10. Additional PFAS found in rinsates of other fluorinated pesticide containers
  - May 2021: MassDEP and MDAR found detectable PFAS levels in multiple pesticides – one of which was being used at the time (see table 6-1 in report #4)

Results of EPA analysis on the amount of PFAS in rinsates from pesticide containers



4. Pesticides: Composition, Toxicity, Resistance, PFAS, and Frequency of Use *(Cont'd)*

- Pesticide Resistance in Mosquitoes
  - Limited studies on mosquito species of concern in Massachusetts
    - *Culex pipiens* has shown resistance to pyrethroids, organophosphates, and bacterial insecticides
    - *Aedes vexans* has shown no resistance to bacterial pesticides and some resistance to pyrethroids
  - Control programs can reduce pesticide resistance by monitoring local mosquito populations for resistance, rotating pesticides from different MoA groups, using non-chemical integrated pest management strategies, and avoiding the use of persistent chemicals.
  - Approximately half of Massachusetts MCDs reported undertaking some type of pesticide resistance testing in 2020.

REPORT 5: INTEGRATED PEST MANAGEMENT AND NON-CHEMICAL MOSQUITO CONTROLS

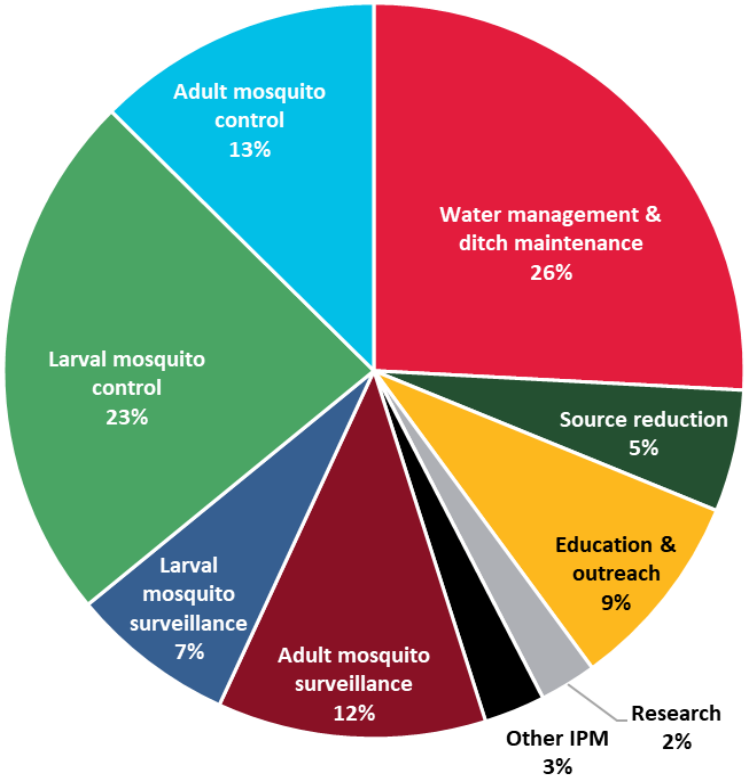
ERG

5. Integrated Pest Management and Non-Chemical Mosquito Controls

- **Overview of Scope:** For five types of non-chemical controls: Stormwater Management; Education and Public Engagement; Dam Removal and Culvert Management; River and Wetlands Restoration; and Mosquito Predator Habitat, and IPM we summarized:
  - Best available science/information:
    - Effectiveness in controlling target mosquitos at various life stages
    - Applicability and limitations for use in MA
    - Considerations for "protected areas" and buffer zone, per Wetlands Protection Act
  - Current practices in MA
  - Current practices in other states
  - Costs
- **Information Sources:**
  - Literature review, MCD Annual Reports, Other State Agency Plans and post-action summaries, published materials and interviews with officials in other states, information solicited from MCDs for this study

5. Integrated Pest Management and Non-Chemical Mosquito Controls*(Cont'd)*

- **Findings :**
  - All MCDs using chemical controls are following *Integrated Pest Management*, which integrates activities such as stormwater management (i.e., source reduction) and public education to minimize pesticide applications.
  - *Source reduction* approaches: stormwater and culvert management, dam removal, and river and wetlands restoration have the advantage of removing mosquito habitats over a longer time frame



IPM components in MCD 2021 budgets

5. Integrated Pest Management and Non-Chemical Mosquito Controls*(Cont'd)*

- **Findings:**
  - Several MCDs incorporate *mosquito predator habitat management* into existing river and wetlands restoration activities; for example, MCDs report that open marsh water management practices increase fish access to adult and larval mosquito populations.
  - *Educational efforts* are currently not well coordinated across the Commonwealth. Shifting residents' time outdoors and increasing use of repellants have the potential to reduce arbovirus risks.
  - No robust *evaluations of the effectiveness* of IPM or non-chemical controls in suppressing mosquito populations and arboviral disease in Massachusetts were identified.

REPORT 6: BEST PRACTICES TO MAXIMIZE IMPACT OF PESTICIDE USE ON MOSQUITO POPULATIONS AND MINIMIZE NON-TARGET IMPACTS OF MOSQUITO PESTICIDES

6. Maximizing Mosquito Pesticide Effectiveness and Minimizing Non-Target Impacts of Mosquito Pesticide Use

- **Overview of Scope:**
  - Compare chemical control practices that are most effective against mosquito populations to current practices in Massachusetts
  - Identify changes/adjustments to pesticide application that have been shown to be protective of non-target receptors: vulnerable individuals (i.e., those with respiratory or immune illnesses); drinking water supplies; pollinators; and aquatic life.

- **Information Sources:**
  - Literature review, MCD annual reports, Other State Agencies' plans, information solicited from MCDs for this study, interviews with pollinator expert, ecotoxicologist, and the Commonwealth's Chief Apiarist

6. Maximizing Mosquito Pesticide Effectiveness and Minimizing Non-Target Impacts of Mosquito Pesticide Use *(Cont'd)*

- **Findings - Maximizing Impact of Pesticide Application on Mosquito Populations**

  Current practices compared to the American Mosquito Control Association's best practices related to pesticide control programs:

  - surveillance
  - mapping
  - setting action thresholds
  - chemical controls of larvae
  - chemical controls of adult mosquitoes
  - monitoring for efficacy and resistance
  - recordkeeping

  - Many AMCA best practices are being used in Massachusetts, although not consistently across all areas

  - Information sharing and monitoring of efficacy are limited

6. Maximizing Mosquito Pesticide Effectiveness and Minimizing Non-Target Impacts of Mosquito Pesticide Use *(Cont'd)*

- **Findings – Minimizing Pesticide Impacts on Non-target Receptors**
  - In general, many of the protective measures identified benefit multiple non-target receptor categories
  - Selecting the least hazardous pesticide
    - SRB review of suitable pesticides for aerial spraying is a good model
    - Pesticide selection is not well established for MCDs, municipalities, and private applicators
  - Examples of ways to minimize non-target impacts, in addition to following label instructions
    - **Notification of Pesticide Application Events** – Customizing messaging content, and outreach plans
    - **Location and Precision** – Focusing application of pesticides to mosquito hotspots using detailed mapping
    - **Timing** – Adjusting pesticide application to avoid times when aquatic life and pollinators are most sensitive
    - **Climate/Weather** – Avoiding weather conditions that reduce pesticide efficacy or increase environmental contamination

REPORT 7: MASSACHUSETTS DRINKING WATER REGULATIONS RELATED TO PESTICIDE APPLICATION

7. Public Water System Laws and Regulations for Pesticide Use Protections

- **Overview of Scope:** Summarize the Massachusetts public water system laws and regulations as they relate to pesticide use protections for Massachusetts and other Northeast states
- **Methods:**
  - Reviewed laws and regulations relevant to drinking water supplies, public water systems, and pesticide applications and interview key agency representatives.
    - MA Pesticide Control Act, MA Drinking Water Act. 333 CMR 12.00 (Groundwater Protection)
    - Searched for requirements specific to the chemicals applied for mosquito control in the Commonwealth
  - Summarize available monitoring data and outcomes (aerial spray monitoring)
  - Interviews with other state Drinking Water Programs and drinking water/water quality organization to identify practices in other states/best practices.

7. Public Water System Laws and Regulations for Pesticide Use Protections *(Cont'd)*

- **Findings:**

  The regulatory framework offers multiple prongs of protection:

- **Administer use of pesticides (labeling, distribution, sale, storage, transportation, use, application, and disposal)** to minimize the amount of toxic chemicals that may enter surface waters used for drinking water supplies.

- **Restrict applications within groundwater recharge areas,** banning application of certain pesticides to protect groundwater.

- **Monitor.** Establishes monitoring requirements and maximum contaminant levels (MCLs) for specific synthetic organic chemicals.

- **Investigate emerging contaminant issues and establish guidelines to protect public health** and other receptors from harmful exposure. May issue guidance.

Framework provides add/modify requirements as new information becomes available, as priorities change, and as new science evolves.

7. Public Water System Laws and Regulations for Pesticide Use Protections *(Cont'd)*

- **Findings:**

  New England states have developed similar pesticide and groundwater regulations, health-based standards, drinking water monitoring requirements, and source water assessment programs.

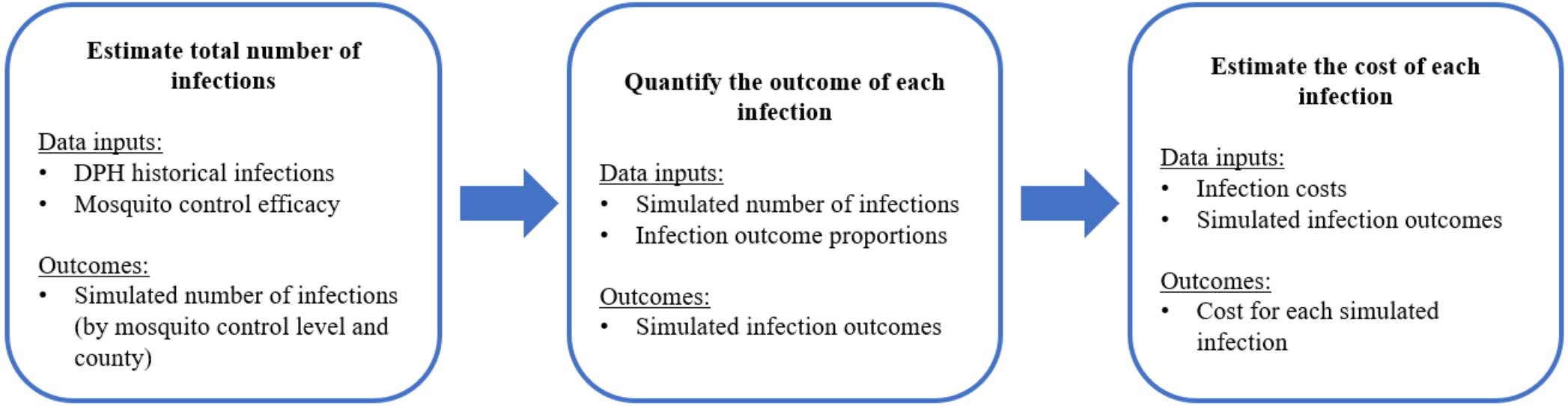
  ERG identified several areas of opportunity for improvement. These include:

  - Leveraging existing programs to encourage collaborative partnerships with local watershed organizations.
  - Establishing a system whereby pesticide applicators communicate their spray plans to water system managers
  - Research on impacts of household pesticide use, pesticide use by private entities, and truck-based spraying activities on water quality

REPORT 8: IMPACT OF MOSQUITOES, MOSQUITO AS DISEASE VECTORS AND MOSQUITO CONTROL MEASURES

8. Impact of Mosquitos, Mosquito-borne Diseases, and Mosquito Control

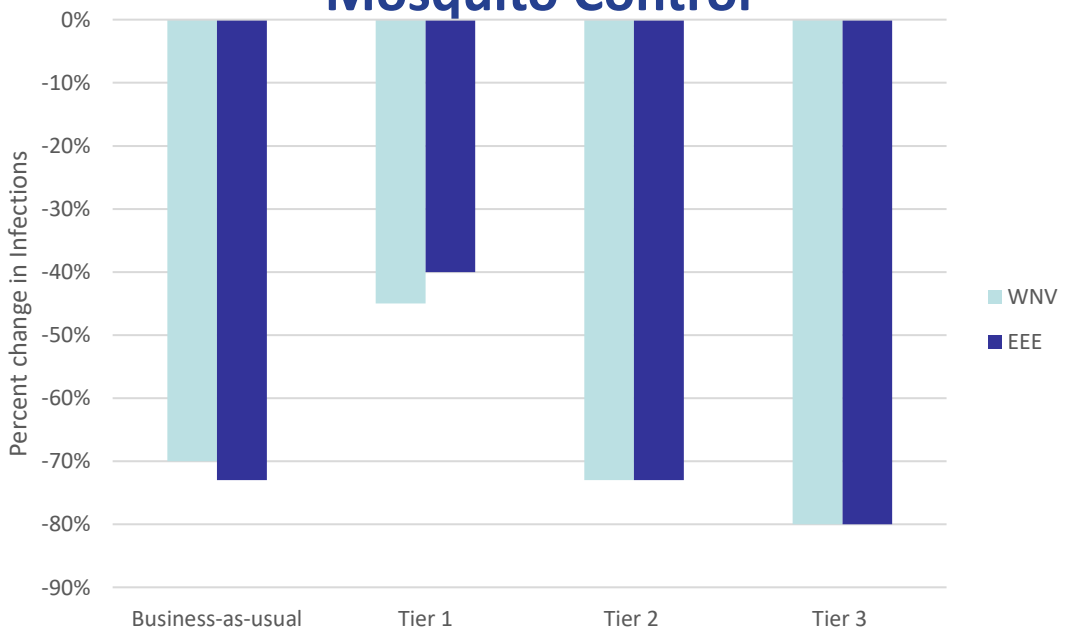
- **Public Health**
  - **Overview of Scope:** Human infections (number, cost, deaths) by level of control.
  - Method:
    - Literature search of EEE and WNV infections and costs and mosquito efficacy measures.
    - Method – three-part model using Monte-Carlo methods.



8. Impact of Mosquitos, Mosquito-borne Diseases, and Mosquito Control

- **Public Health**
  - **Results**

Annual Infections Compared to No Mosquito Control



EEE Results

Control	Cases	Deaths	Costs (2021 US$)
Business-as-Usual	4 (1 - 9)	1 (0 - 4)	$16,140,721 ($64,922 - $53,923,164)
No Mosquito Control	15 (1 - 48)	4 (0 - 14)	$61,966,720 ($64,922 - $213,451,451)
Tier 1	9 (0 - 24)	2 (0 - 8)	$33,603,256 ($0 - $113,013,673)
Tier 2	4 (0 - 12)	1 (0 - 4)	$15,206,854 ($0 - $60,561,657)
Tier 3	3 (0 - 7)	1 (0 - 3)	$12,901,515 ($0 - $42,171,000)

WNV Results

Control	Cases	Deaths	Costs (2021 US$)
Business-as-Usual	12 (3 - 28)	0 (0 - 2)	$194,232 ($22,099 - $25,890,766)
No Mosquito Control	40 (7 - 134)	2 (0 - 7)	$13,476,290 ($64,709 - $78,848,062)
Tier 1	22 (4 - 63)	1 (0 - 4)	$12,888,278 ($34,686 - $51,509,733)
Tier 2	11 (2 - 27)	0 (0 - 2)	$158,968 ($14,408 - $25,823,942)
Tier 3	8 (2 - 21)	0 (0 - 2)	$109,250 ($11,636 - $25,683,101)

8. Impact of Mosquitos, Mosquito-borne Diseases, and Mosquito Control

- **Agriculture/Pollinators**
  - **Overview of Scope:** Value of pollinators to agriculture; impact of pesticides on bees; WNV and EEE animal infections.
  - Methods:
    - Literature searches
    - Expert interviews
    - Quantified the value of pollination to agriculture

Animal Infections between 2004 and 2019

Species	EEE Infections	WNV Infections
Alpaca	4	1
Cow	1	0
Deer	1	0
Emu	2	0
Goat	1	0
Horse	44	9
Llama	1	0
Turkey	1	0

Crop	Total Crop Acreage in Massachusetts[a] (Acres)	Total Value of Crop[b] (2021$)	Annual Value Attributable to Pollinators[c] (2021$)	Annual Value Attributable to Honey Bees[c] (2021$)
Apples	3,715	22,843,895	22,843,895	20,559,506
Blueberries	906	7,654,161	7,654,161	6,888,744
Cantaloupes	59	417,881	334,305	300,874
Cranberries	13,306	69,268,458	69,268,458	62,341,611
Cucumbers	245	2,650,229	2,385,206	2,146,685
Onions (dry)	134	953,400	953,400	858,060
Peaches	458	4,268,173	2,560,904	2,048,724
Pears	92	453,166	317,216	285,494
Pumpkins	1,728	7,139,391	6,425,452	642,545
Squash				
Summer	302	2,555,438	2,299,894	229,989
Winter	990	4,610,857	4,149,771	414,977
Strawberries	314	5,960,933	1,192,187	119,218
Watermelons	62	435,137	304,596	274,136
Total[d]	22,311	129,211,118	120,689,444	97,110,564

Value of pollination from honey bees and other pollinators

8. Impact of Mosquitos, Mosquito-borne Diseases, and Mosquito Control *(Cont'd)*

- **Commerce**
  - **Overview of Scope:** How is commerce, including tourism and recreation, impacted by mosquitos, disease, and control.
  - Methods: Literature Search, Massachusetts Tourism Value
  - Results:
    - Local transmission of mosquito-borne diseases can impact tourism but likely have no impact at current risk levels.
    - Individuals are willing to pay for nuisance mosquito control regardless of disease risk.
- **Environment**
  - **Overview of Scope:** Impact of mosquitos and control on aquatic ecosystems; impact of mosquito population levels on predators.
  - Methods: Literature Search, Expert Interviews
  - Results:
    - We found no evidence that mosquito predators (bats and fish) rely so heavily on mosquitoes as a food source that populations would suffer as a result of high levels of mosquito control.

REPORT 9: CLIMATE CHANGE IMPACTS TO MOSQUITO POPULATIONS AND MOSQUITO-BORNE DISEASES

9. Impact of Climate Change on Mosquito Populations and Mosquito-borne Disease

- **Overview of Scope:** Address best available science on how climate change is anticipated to impact mosquito populations and mosquito-borne diseases into the future
- **Methods:**
  - Literature review of ~45 peer-reviewed articles and government publications on climate change and mosquito-borne disease
  - Interviewed four expert on health impacts of the climate crisis and vector-borne disease Through literature review and interviews, identified
    - climatic variables linked to changes in arbovirus/mosquito habitat
    - model outputs attributing climate change factors to changes in mosquito populations and arborvirus
    - challenges in climate-arborvirus modeling

9. Impact of Climate Change on Mosquito Populations and Mosquito-borne Disease *(Cont'd)*

- **Findings:**
  - **Climate factors:**
    - Climate-arborvirus modeling focused on temperature is most advanced and clearly attributes temperature change to changes in mosquito population and arborvirus occurrence
    - Precipitation, shows complex nonlinear relationships between mosquito species and precipitation.
    - Bird migration patterns and sea level rise may affect mosquito populations and arbovirus risk and require more study.
  - **Arborvirus risk:**
    - No studies attributing change in eastern equine encephalitis (EEE) risk to climate change.
    - Project increased risk of West Nile Virus (WNV) in the northeast over time as well as increased risk of diseases from Aedes albopictus and Aedes aegypti mosquitoes in New England due to climate change.

Subcommittee	Relevant report(s)
Best Practices	1: Arbovirus History in MA 3: Opt-out and exclusions 4: Chemical Composition and Toxicity of Pesticides 5: IPM and non-chemical mosquito controls 6: Best Practices 7: Drinking Water Regulations 8: Impact of mosquitoes and mosquito control 9: Climate Change Impacts
Local Engagement	1: Arbovirus History in MA 2: Existing Mosquito Control Policy 3: Opt-out and exclusions 4: Chemical Composition and Toxicity of Pesticides 5: IPM and non-chemical mosquito controls 6: Best Practices 8: Impact of mosquitoes and mosquito control
Mosquito Control Policy Structure	1: Arbovirus History in MA 2: Existing Mosquito Control Policy 3: Opt-out and exclusions
Pesticide Selection	1: Arbovirus History in MA 4: Chemical Composition and Toxicity of Pesticides 5: IPM and non-chemical mosquito controls

Thank you!

Questions or Comments?

ERG