Use of Cervid Serosurveys to Monitor Eastern Equine Encephalitis Virus Activity in Northern New England, 2009-2017

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Department of Health and Human Services

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Emerging Vector-borne Agents in Northern New England

Bacterial/Rickettsial – *Borrelia* spp, *Anaplasma* spp, *Babesia* spp, *Ehrilichia* spp

Viral – Eastern Equine Encephalitis, West Nile, Powassan/Deer Tick Virus, Heartland, Bluetongue

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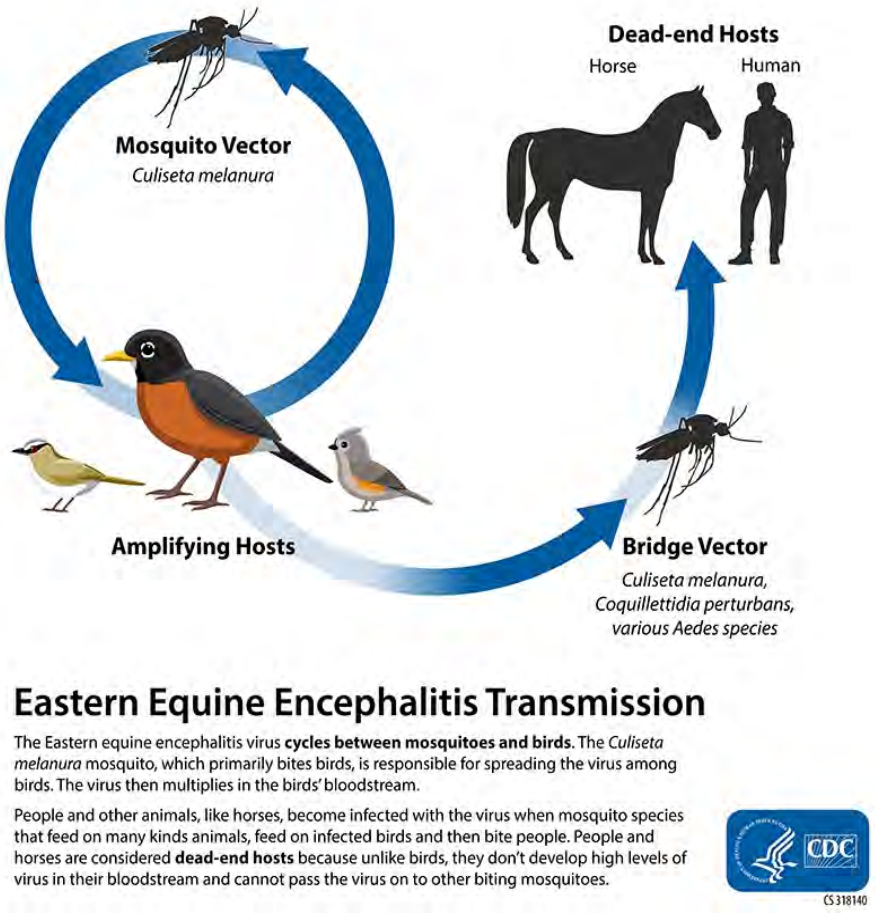
Eastern Equine Encephalitis Virus



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EEEv in Northern New England

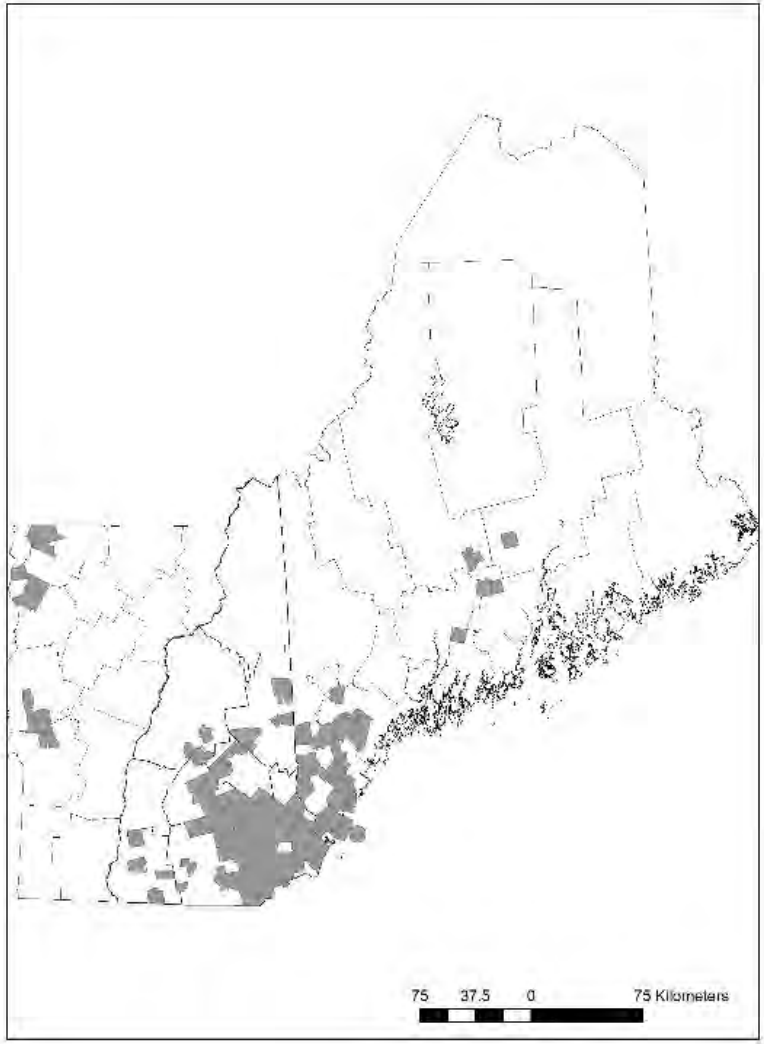
- **Maine**
  - Before 2009, virus activity in two counties
  - 2009 epizootic across 5 counties
  - 2014-2015 2 human case reports
  - 2001-present sporadic entomologic activity (primarily *Cs melanura*)

- **New Hampshire**
  - An equine outbreak of EEEv in 1982. EEEv re-emergence in 2004-2010 resulted in additional veterinary cases and the first recorded human case of EEEV in New Hampshire.
  - New Hampshire began cervid sera collections in the fall of 2012.
  -

- **Vermont**
  - In 2010, VT detected first EEEv antibody positive rates of 10.2% among the deer serum samples and 28.6% among moose serum samples.
  - By 2014, a large number of deer and moose serum samples had been tested and a detailed map developed

EEEv in Northern New England

- Regionwide – sporadic reports of human or veterinary cases



EEEv

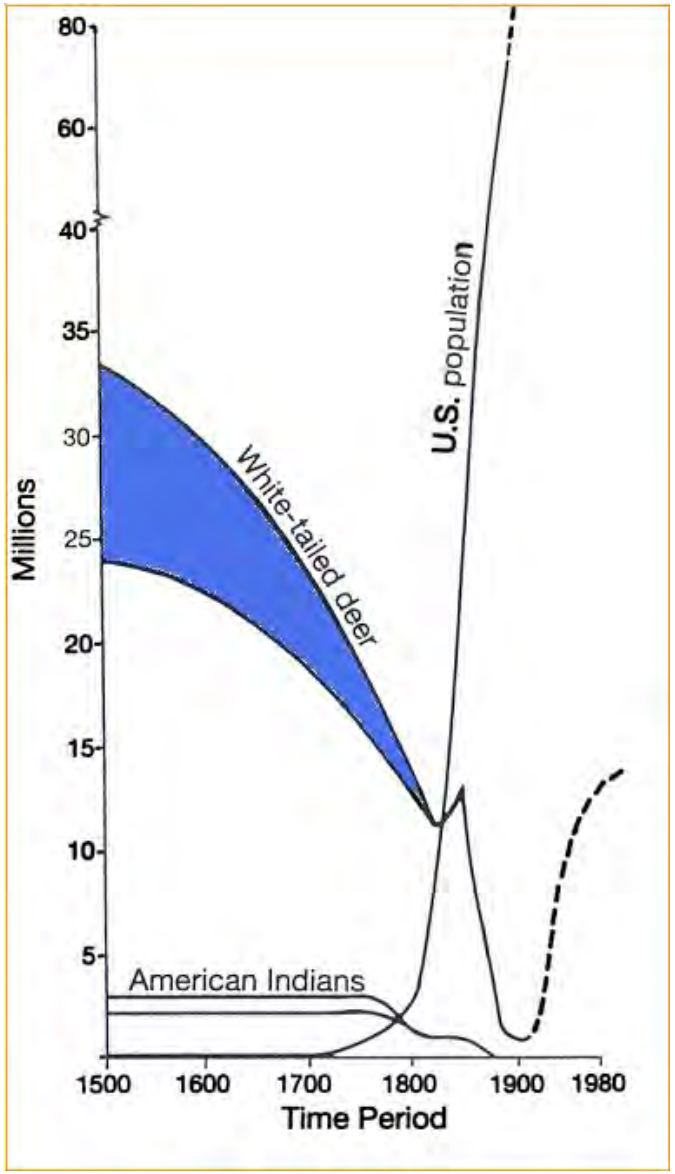
- Serum antibodies present in many surveyed wildlife
  - "Herp"-tiles (Bingham et al. 2012)
  - Passerine birds (Elias et al. 2017)
  - Meso-carnivores (Morris 1988)
  - Limitations due to trapping/capture effort and agency permitting
- Cervids provide a unique opportunity
  - Large numbers of animals harvested annually (>6 million annually in US)

Cervids as a Proxy for Livestock or People?

After an outbreak, vaccination rates in livestock generally increase making them unsuitable for surveillance

Cervids = Common (abundant & ***unvaccinated***) hosts for mammal-biting mosquitoes (Molaei et al. 2006)

In general, cervid populations higher in southern regions vs northern regions



Hunter Registration Stations

- Ability to marshal a large cadre of volunteers
- Ability to cover a large geographic area
- An ‘at-risk’ and engaged population underserved by public messaging!!!
- But only a snapshot in time

Sample Collection

- Blood Sample Collection. Briefly, staff and volunteers collected whole blood was collected from body cavities of the carcasses using disposable plastic pipettes. Deer geocoded using a Delorme Atlas.
- Sample Testing. Sera were screened for EEEV-neutralizing antibodies in a biosafety level-3 laboratory at the U.S. Centers for Disease Control and Prevention in Fort Collins, Colorado, by plaque-reduction neutralization tests (PRNTs). Serum samples were considered positive for EEEV antibodies if they neutralized ≥80% of a challenge dose of approximately 100 plaque-forming units of EEE-Sindbis chimeric virus.

Sample Collection

- The field and testing data for Maine and New Hampshire were archived in REDCap (Research Electronic Data Capture), a secure web platform for building and managing online databases, hosted by Tufts University (Harris et al. 2019).
- Data Analysis and Mapping. Samples were pooled across years for two reasons: first, the sample years did not overlap perfectly across states, and second, EEEV antibody testing does not reveal when the animals were exposed to EEEV, so it is useful for determining geography of risk but not necessarily temporal trend.

Results

- Across all three states, 2,430 deer and 1,931 moose serum samples were tested.
- EEEV activity was detected in every county in Maine, New Hampshire, and Vermont, with EEEV antibody seropositive serum detected every year.
- EEEV antibody in deer differed among states, ranging from 8.7% to 11.9% to 17.0% for Vermont, Maine, and New Hampshire, respectively.
- EEEV antibody in moose ranged from 5.95% to 9.7% and did not differ among states.

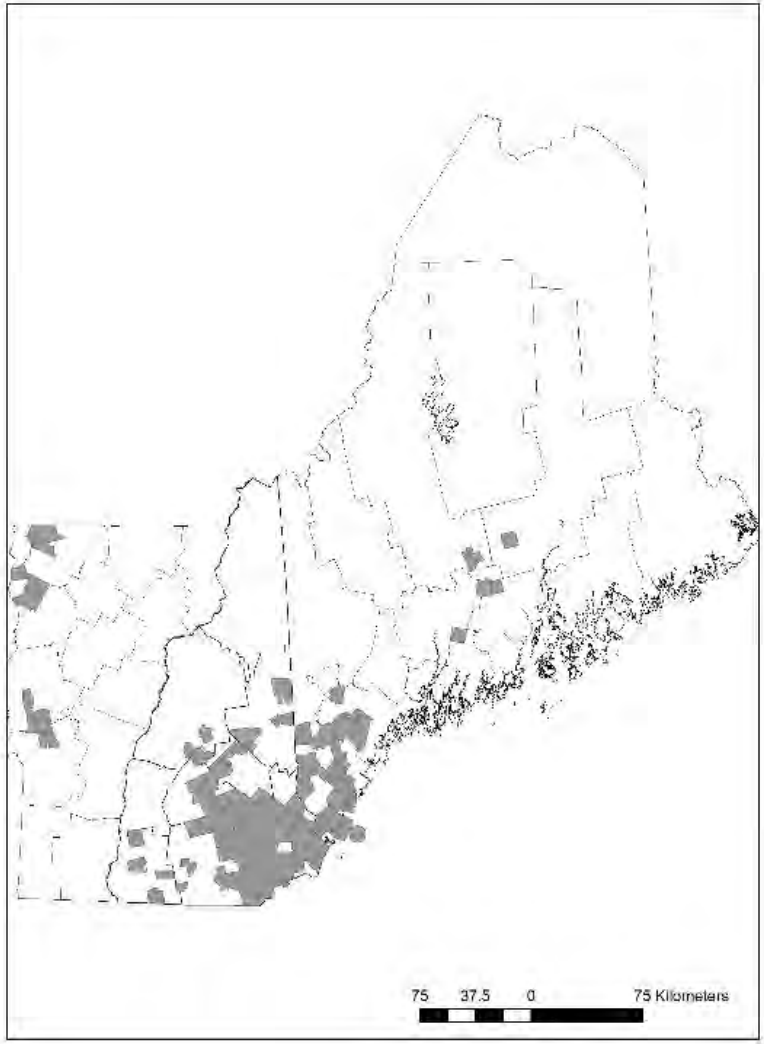
Data on EEEv antibody testing effort in Maine, 2009-2017, New Hampshire, 2012-2017, and Vermont, 2010-2014.

Species	State	Tested	Positve	%	*P* *
Deer	Maine	1960	233	11.9	A
	New Hampshire	588	100	17.0	B
	Vermont	2430	212	8.7	C
Moose	Maine	1484	125	8.4	A
	New Hampshire	278	27	9.7	A
	Vermont	169	10	5.9	A

***Proportions with different letters are different, chi-square test for differences among proportions, $P \leq 0.05$.**

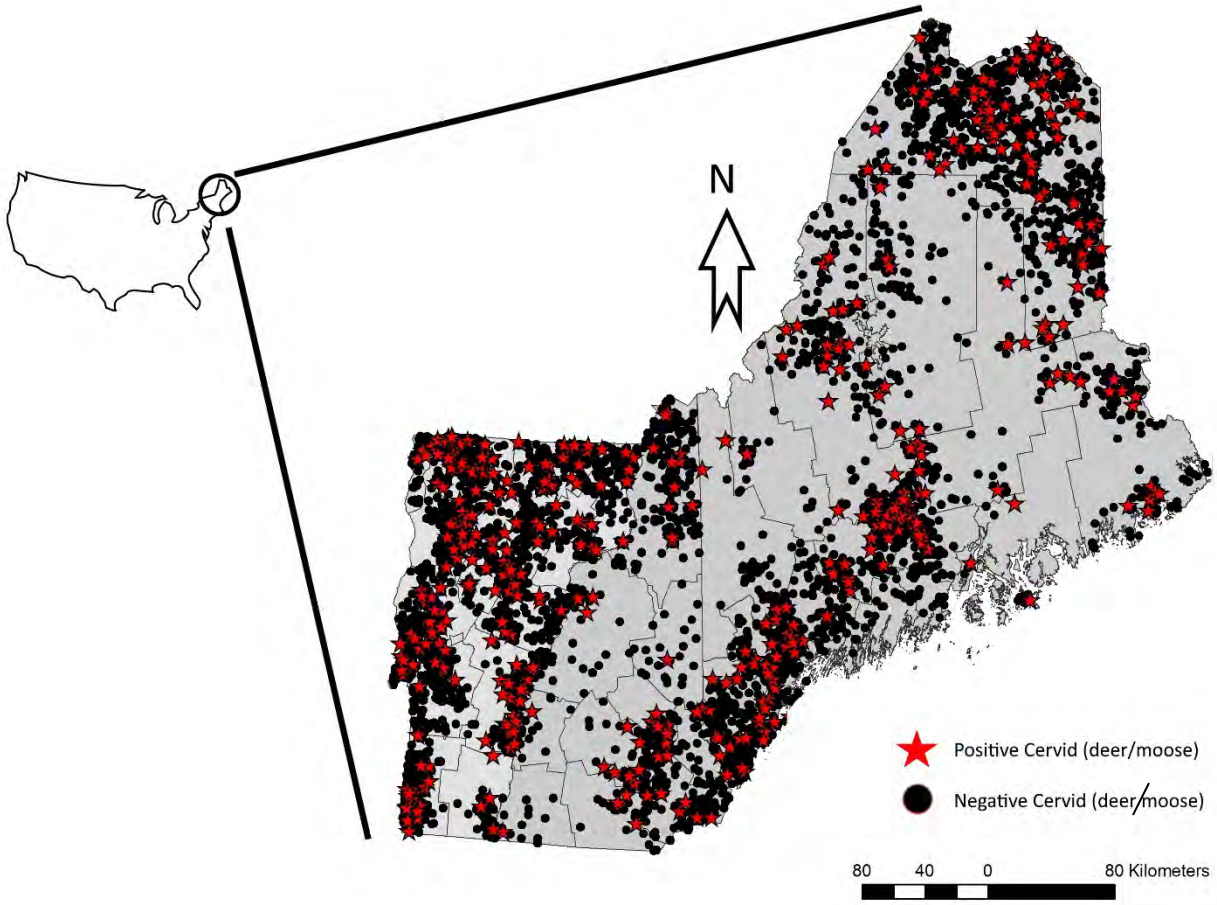
Results

All three northern New England states portray broad, **statewide distribution** of EEEv compared to mosquito, wild bird, mosquito, veterinary, and human surveillance methods.



Results

Whereas the latter activity was concentrated in the southern portions of Maine and New Hampshire and the western portion of Vermont, it is clear that in all three states there is a statewide distribution of EEEv transmission from vector mosquitoes to cervids.



Conclusions

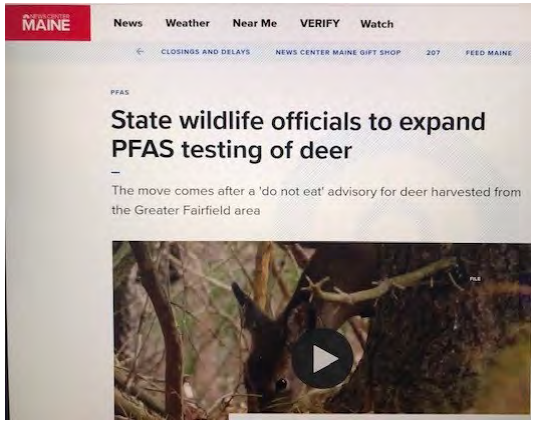
- Our key result was the detection of the antibodies in areas far outside the range of documented wild bird, mosquito, human case, or veterinary case reports of EEEV activity in Maine, New Hampshire, and Vermont. Previously, EEEV was thought to be localized in distribution around known areas of human and veterinary cases in Maine.

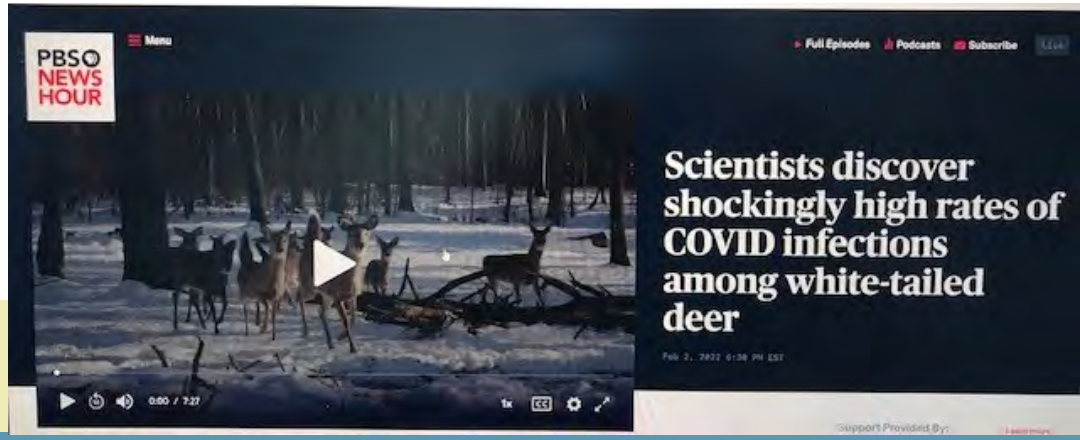
- The northern tier of New England lacks support for the robust network of mosquito and vector control districts that are present in other states in the region (Rochlin et al. 2019, Eisen 2020), and tick and mosquito control programs are nearly nonexistent (e.g., Elias et al. 2021).

Conclusions

- Serum specimens used for EEEV surveillance are bankable for future studies, other zoonoses, or new threats that may emerge, as seen with Heartland, Bourbon, and Powassan viruses, among others (Riemersma and Komar 2015, Jackson et al. 2019, Bosco-Lauth et al. 2015, Nofchissey et al. 2013, Dupuis et al. 2021).

- Using hunter-harvested cervids is consistent with a One Health approach to vector-borne disease surveillance efforts, as the same sentinel can be used to track the activity of a wide number of etiologic agents with the potential to impact human and animal health (Berl et al. 2013, Hollis-Etter et al. 2019, Pedersen et al. 2017, Patriquin et al. 2018, Lubelczyk et al. 2013).





Conclusions

- These surveys, in using a volunteer force of undergraduates, also have the benefit of exposing students to hands-on field experience in biology and/or environmental science, perhaps for the first time in their college career.

- For some, the survey provided them with their first experience learning the skills of data collection in a real field investigation, and for more advanced students, the survey gave them an opportunity to see how biological sciences are relevant to public health (Vaske and Miller 2018).

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