Over the past 150 years, humans have induced dramatic fluctuations in deer numbers in eastern North America. These fluctuations have triggered emergence of zoonotic disease. 3 case studies.
Michigan in the 1870s

- Commercial deer hunting

Michigan in the 1890s

- Habitat loss from hardwood logging & fires


- Hunting regulated; Forests regenerating
1) Deer and bovine tuberculosis

- Slow-growing, intracellular mycobacteria
- Aerosols lodge in the bronchioles of susceptible animals
- <10 cfu’s can cause 1<sup>st</sup> infection in the lung
- Thereafter, transported elsewhere in the body by the lymph system, to 2<sup>nd</sup> sites

The first sustained outbreak of Bovine Tuberculosis in North American deer

1975

Michigan (Lower Peninsula)
In 1995, another tuberculous deer was shot only 9 miles from the first.

In response, the Michigan Department of Natural Resources initiated surveillance efforts.

Voluntary deer-check stations
Post mortem, with histology and culture of visible lesions

Previous total: 2
New cases: 27

Previous total: 29
New cases: 47
An Occupational Safety Program for Wildlife Professionals Involved with Bovine Tuberculosis Surveillance


Wildlife Society Bulletin
Vol. 32, No. 3
(Autumn, 2004)
pp. 992-999
Hunter safety in the TB Area

Human cases of *M. bovis* in Michigan
1995-2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Gender</th>
<th>Age</th>
<th>Site</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995*</td>
<td>Female</td>
<td>28</td>
<td>Sputum</td>
<td>Berrien</td>
</tr>
<tr>
<td>1997</td>
<td>Female</td>
<td>74</td>
<td>Neck Node</td>
<td>Oakland</td>
</tr>
<tr>
<td>1997</td>
<td>Female</td>
<td>75</td>
<td>Vertebral Body</td>
<td>Kalamazoo</td>
</tr>
<tr>
<td>1997</td>
<td>Female</td>
<td>71</td>
<td>Knee Fluid</td>
<td>Oakland</td>
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<tr>
<td>1998*</td>
<td>Female</td>
<td>32</td>
<td>Sputum</td>
<td>Kent</td>
</tr>
<tr>
<td>1998</td>
<td>Male</td>
<td>42</td>
<td>Abdominal Abscess</td>
<td>Ingham</td>
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<tr>
<td>2000</td>
<td>Male</td>
<td>62</td>
<td>Neck</td>
<td>Oakland</td>
</tr>
<tr>
<td>2002**</td>
<td>Male</td>
<td>74</td>
<td>Bronchial</td>
<td>Alpena</td>
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<tr>
<td>2003*</td>
<td>Male</td>
<td>19</td>
<td>Sputum</td>
<td>Oakland</td>
</tr>
<tr>
<td>2003</td>
<td>Female</td>
<td>79</td>
<td>Lymph Node</td>
<td>Oakland</td>
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<tr>
<td>2004**</td>
<td>Male</td>
<td>29</td>
<td>Hand Wound</td>
<td>Iosco</td>
</tr>
</tbody>
</table>

*Migrant workers from southwestern states

**Same strain as Michigan’s deer, cattle

Data courtesy of D. Berry, MI Dept. of Comm. Health

---

2004: 29 y.o. hunter, during archery season

October 1 | Injured finger while dressing lesioned deer; buried carcass
October 14 | Sought medical attention
October 27 | Routine Lab Work - No growth
November 1 | Specimen tested at MDCH - AFB Negative
November 23 | Culture positive for AFB
December 10 | Strain typing – same as deer/cattle
December 16 | Carcass exhumed - AFB +
December 31 | Culture Positive for AFB
February 28 | Strain typing – same strain
March 8 | *M. bovis* confirmation
Previous total: 227
New cases: 58

Michigan:

TB deer

- 1995-96
- 1997-98
- 1999-00
**Statistical analysis**

(log-transformed data)

<table>
<thead>
<tr>
<th>Effect</th>
<th>d.f.</th>
<th>F-ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
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<td>38.10</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Year</td>
<td>2</td>
<td>2.14</td>
<td>0.12</td>
</tr>
<tr>
<td>Distance * Year</td>
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<td>0.98</td>
</tr>
<tr>
<td>Error</td>
<td>167</td>
<td></td>
<td></td>
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### Statistical analysis (log-transformed data)

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<tr>
<td>Error</td>
<td>167</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No evidence of ongoing spread

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**DMU 452**

2 %
1%
0.2%
0.02
<table>
<thead>
<tr>
<th>MONTMORENCY</th>
<th>ALPENA</th>
<th>OŞCODA</th>
<th>ALCONA</th>
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<tbody>
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<td>0%</td>
<td>0.8%</td>
<td>0.7%</td>
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<td>0.3%</td>
<td>1.0%</td>
<td>0.3%</td>
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<td>0%</td>
<td>0.5%</td>
<td>0.6%</td>
<td>0.4%</td>
</tr>
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<td>0.4%</td>
<td>1.1%</td>
<td>1.1%</td>
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<tr>
<td>0%</td>
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<td>0%</td>
</tr>
</tbody>
</table>

1996-2002 data

Numerous Almost no TB deer

Hwy M-33
Private land versus State land ...
... what's different?

Hunting Pressure
Private land versus State land ...
... what's different?

Hunting Pressure + Winter Feeding

Michigan ’Club Country’ : Feeding and Baiting

Predictors of variation in % TB in the core area?

1996-2002 data
Two potentially-useful datasets

Pellet group estimates of deer abundance
N = 16

Aerial surveys of feedsite
N = 25

Both factors predicted % TB

\( R^2 = 0.39 \quad P = 0.006 \)
Both factors predicted % TB

\[ R^2 = 0.39 \quad P = 0.006 \]
\[ R^2 = 0.38 \quad P < 0.001 \]

Together, they explained 55% of variation in TB

Consequently, large-scale feeding of deer banned throughout Michigan's Lower Peninsula
2. Chronic Wasting Disease

A Transmissible Spongiform Encephalopathy of deer and elk
Direct transmission
plus...
Environmental
- feces, carcasses
- 2 or more years

Nervous system disease
- slowly progressive
- uniformly fatal
- prolonged incubation (~18 mos.)

Human movement of captive animals, followed by co-mingling with free-ranging wildlife
Can CWD infect humans?  Probably not!

Nevertheless, take reasonable precautions against exposure
(Prudence in the face of uncertainty...)

Photo: Dr. T. Kreeger, Wyoming Fish & Game

Nevertheless, take reasonable precautions against exposure
(Prudence in the face of uncertainty...)

Copyright © 2005, CWD Alliance

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Nevertheless, take reasonable precautions against exposure
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Copyright © 2005, CWD Alliance

Nevertheless, take reasonable precautions against exposure
(Prudence in the face of uncertainty...)

Copyright © 2005, CWD Alliance
• Wear rubber gloves
• Minimize handling brain or spinal cord tissues
• Bone-out carcass and avoid eating brain, spinal cord, eyes and lymph nodes

3. Deer and Lyme Disease

Lyme disease: caused by *Borrelia burgdorferi*

• spirochete (bacterium)
• "bull's-eye" rash
• fever
• fatigue
• muscle aches
• joint aches
• tick-borne!
95% of reported Lyme disease comes from 12 states

![Map showing Lyme disease prevalence](image)

* Per 100,000 population. (CDC, MMWR, May 2004)

The immature vector ticks are found on 41 species of mammals...

(Keirans et al. 1996)

- Eastern chipmunk
- Raccoon
- Oppossum

... and on 57 species of birds ...

(Keirans et al. 1996)

- Grey catbird
- Common yellowthroated warbler
- American robin
Broadheaded skink    
Green anole

... and on 14 species of lizards (Keirans et al. 1996)

Life cycle of the blacklegged tick in northern latitudes

2 year life cycle

eggs  larva  nymph  female  male  adults

YEAR 1
Deer are not a “competent reservoir” for the spirochete.
Deer Population Estimates for Michigan’s Southern Lower Peninsula
(R. Clute, 2004)

Hunting regulated; Forests regenerating

Lyme disease: invading Michigan?

Lyme disease: invading Michigan?
Rodent trap surveys 2005

Site 4 3% infested
Site 3
Site 2
Site 1

Percentage of mice infested with *Ixodes scapularis* larvae or nymphs

Deer Check Stations: Fort Custer

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number deer checked</td>
<td>66</td>
<td>47</td>
<td>03</td>
</tr>
<tr>
<td>Deer with <em>I. scapularis</em></td>
<td>0%</td>
<td>2.1%</td>
<td>10.3%</td>
</tr>
</tbody>
</table>

So … what about Tennessee?

Deer harvest estimates - Tennessee

17% avg. ann. increase
• So … what about Tennessee?

Trend in annual incidence of reported cases of Rocky Mountain Spotted Fever in humans in Tennessee. Source: Tennessee Department of Health.

Lyme disease in Tennessee?

What do the maps have to say about Lyme disease in Tennessee?

Dennis et al. 1998: constructed a tick map from passive data* 1907-1996

* Questionnaires to acarologists, health officials, Lyme disease researchers, literature survey, and tick collection records
Mapping the distribution of Lyme Disease ticks

The Dennis et al. 1998 map

Mapping risk to humans

CDC Survey 2004-2006

- 2-degree quadrants (160x160 km)
- State parks and other public land
- Closed-canopy deciduous forest
- 4-6 visits during summer

96 sites sampled
“Dragging” for nymphal ticks

Results 2004 and 2005

Nymphal I. scapularis distribution and density

Nymphal 1000m²

0
0-0.5
0.5-5
5-50
50-75

2004

2005

Nymphs/1000m²
Fall 2006: Deer check-station survey, Oak Ridge

The Results: *Ixodes scapularis* found on numerous TN deer

- *Ixodes scapularis*
- *Dermacentor albipictus*

Fall 2007: deer check-station and processor surveys expanded throughout TN
2007: 16 new county records for *Ixodes scapularis*

2007: Areas identified where *Ixodes scapularis* can be sampled directly from the vegetation

2007: The big question that remains... are these ticks carrying the bacteria responsible for causing Lyme Disease?
Stay tuned … for Michelle’s presentation!

Jan 21st – Henry Horton State Park