Proceedings from the Conference on

Bovine Tuberculosis

March 2000 Lansing, Michigan

STATE OF MICHIGAN

JOHN ENGLER, Governor

BOVINE TB ERADICATION PROJECT

BOB BENDER, Coordinator

Department of Agriculture
Dan Wyant, Director

Department of Community Health
James K. Haveman, Director

Department of Natural Resources
K. L. Cool, Director

On March 6 and 7th, 2000, the State of Michigan hosted its fourth annual bovine TB conference. Speakers from across the continent and two oceans came together to present research and scientific data on bovine TB. The two-day gathering provided insight and understanding of how the disease is spread, how it can be eradicated and what has happened in other countries where bovine TB is endemic in the wildlife.

Michigan is unique in that bovine TB has become established in the wild free ranging whitetail deer population. Cattle in the areas where TB has been found have also been confirmed to be TB positive. Although no one has actually documented the transmission of the disease from deer to cattle in Michigan, evidence suggests it can be transmitted from animal to animal, not only through respiratory means, but by sharing common feed stocks as well. Findings presented at the conference show that the TB bacterium may survive on feed in the wild and that colder weather prolongs its viability.

Research on this disease, particularly with respect to wildlife, is in the very early stages and only represents the beginning of our understanding. Historically, bovine TB has caused more livestock losses in the U.S. than all other diseases combined. Globally, the resurgence of human tuberculosis has been responsible for 30 million deaths from 1990 to 1999. Our experience in Michigan with bovine TB is precedent setting, and the eyes of the country and the entire world are on us as we move forward with our eradication efforts.

The cooperative efforts of the Michigan Departments of Agriculture, Community Health and Natural Resources, as well as Michigan State University and the U.S. Department of Agriculture, are admirable. I am honored to have the opportunity to work with such professional and dedicated people.

Sincerely,

Bob Bender
Bovine TB Eradication Coordinator

Lewis Cass Building • 320 S. Walnut, Lansing, MI 48913 • TEL: 517-241-2994 • FAX: 517-373-4288

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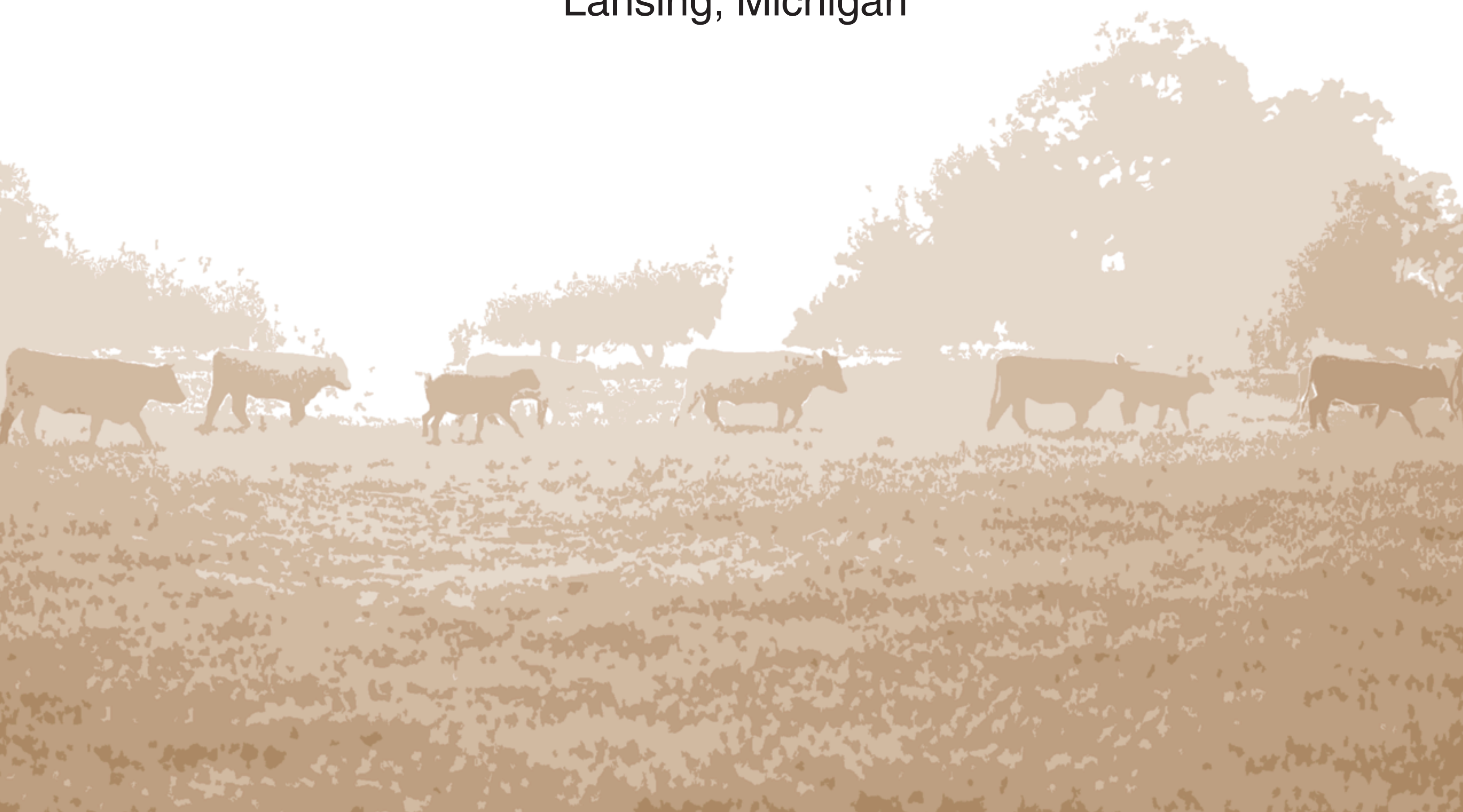


Craig Reed and John Clifford

A National Perspective on TB Eradication

John Clifford and Craig Reed, USDA

The Challenge

Eradicate bovine tuberculosis from domestic livestock populations by the end of 2003.

Barriers to Eradication

- Tuberculosis in free-ranging wildlife populations
  A source of infection to livestock
  Strong evidence suggests that the 5 cases in Michigan livestock (cattle and cervids) were due to infection in wild deer.
- This may become a barrier to trade (domestically and internationally).
- The US will not import live cattle or cervids due, in part, to the tuberculosis situation in New Zealand possums.
- We have concerns that states will place harsh restrictions on Michigan cattle.
- No serologic assay or vaccine is available for bovine tuberculosis.
- Declining slaughter surveillance in cattle
  In 1999, USDA had the fewest surveillance samples submitted from meat inspection personnel since 1972.
  The majority of feedlot cases submitted did not have corresponding animal identification.
- Untraceable cases of bovine tuberculosis
  Without proper identification, it is impossible to truly determine a herd of origin.
  There is the potential of up to 25 previously undetected tuberculosis-infected herds in the US, if all unidentified samples were of US origin.
- Indemnity
  Current indemnity structure does not compensate owner for animal losses.
  Even at current indemnity rate, there is not enough in the federal budget to depopulate livestock herds over 1,000 head.
- Tuberculosis in Mexico
  The largest percentage of bovine tuberculosis found in the US is of Mexican origin.
  Mexico is working hard to eradicate bovine tuberculosis. They have a significant problem in their dairies and their disease eradication resources are limited.
- International Trade
  There is a need to develop risk-based import standards that are equivalent to our domestic program standards. We need to continually review and evaluate the programs of our trading partners to assure that they are exporting livestock to the US at the proper risk level.

Actions Needed to Achieve Eradication

- Allocate more resources to the program
- Increase the line item
- Acquire emergency funding through the CCC
- Enhance the commitment to the program
- Increase surveillance
- Educate our stakeholders
- Support research that would provide new tools for eradication (e.g., serologic test,vaccine, etc.)

Identification of the Needs

USAHA Emergency Action Plan

This plan outlined areas within the program that needed enhancement APHIS Priorities within the Plan:

- Enhance surveillance activities
- Consider changing indemnity scale to pay fair market value for the animal
- Evaluate new technologies (i.e., serology, vaccine, etc.) for inclusion in the program

National Program Director and TB Management Team. TB Management Team is composed of staff and regional specialists aimed at quickly responding to new program situations.

Joe VanTiem

A Comprehensive Strategic Plan

The comprehensive plan will specifically outline the exact resources that are needed to eradicate bovine tuberculosis from all livestock herds by 2003. Increases in the tuberculosis line item and an emergency request from the CCC will be needed to address all the action items outlined in the plan.


Joe VanTiem, USDA

The Plan

Four areas of concentration for program enhancement

- Eradication Strategies
- Wildlife Management of TB in Unregulated Species
- Surveillance and Animal Identification
- Laboratory and Diagnostic Support

Time Lines:

- March 2000 - Show the plan to VS and APHIS management for approval
- April 2000 - Have plan reviewed by TB Steering Committee
- June 2000 - Have necessary budget requests and emergency funding requests ready
- October 2000 - Implementation of the Strategic Plan

Nathan Zauel

Surveillance of Non-Cervid (Cattle and Goats) Livestock

Nathan Zauel, MDA

The discovery of bovine TB infected free-ranging white-tailed deer in Northeastern Michigan prompted the Michigan Department of Agriculture to begin testing all livestock that reside in the area north of M-55 and east of I-75.

MDA began testing in the five county area in 1995, and will continue the needed surveillance as determined necessary to meet the Department's eradication goal. Most testing is being conducted by State and Federally-employed veterinarians. It was this testing that led to the discovery of five infected bovine TB positive herds thus far. The first herd was located in Alpena County and has been depopulated. The final report documenting the investigation has been completed with no further evidence of infection. The second and third herds are both located in Alcona County, and have been depopulated. The fourth herd was located in Presque Isle County, and has also been depopulated. The fifth herd was a dairy facility, also in Presque Isle County, and the disposition of this herd is pending. The trace-out investigation continues in herds two through five. Epidemiological investigations continue.

The following is a result of the testing efforts to date:

- 1131 total farms tested.
- Over 57,356 livestock TB tests have been administered.
- 15 Positive cows found on 5 premises.
  - 1 Alpena County
  - 7 Alcona County
  - 7 Presque Isle County

Surveillance testing of newly identified herds continues, and retesting of herds has begun.

Mike VanderKlok

Surveillance for Bovine Tuberculosis in Michigan Captive Cervidae

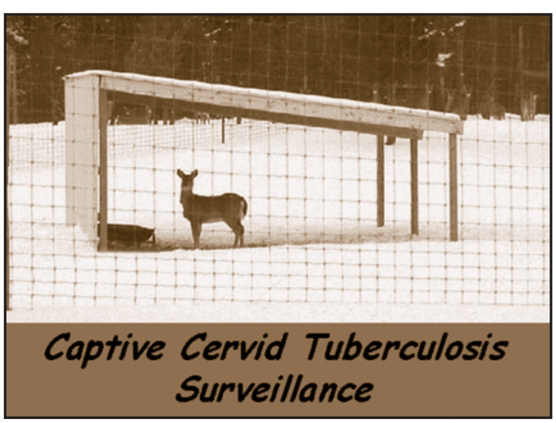
Mike VanderKlok, MDA

Michigan has developed and instituted programs for tuberculosis surveillance in captive cervid herdslocated in Northeastern Lower Michigan, the area that contains bovine tuberculosis in the free-ranging white-tailed deer herd. The primary method for conducting this surveillance is through single cervical testing of all captive cervidae in the herd which are 12 months of age and older, and caudal fold testing of any cattle and goats in the herd which are 6 months of age and older. Some captive herds are of such size that live animal testing is precluded, and a slaughter surveillance protocol has been developed for use in these herds. This protocol involves collecting lymphatic tissue from the head and respiratory system and submitting those tissues to the National Veterinary Services Laboratory in Ames, Iowa, for histopathological examination and bacterial culture. The number to be tested under this program is based upon average adult herd size. We need to detect tuberculosis at a 2% prevalence rate with 95% confidence.

The Northeastern Lower Michigan area contains 70 captive cervidae herds. Of these herds, 42 are undergoing single cervical surveillance, and 28 are undergoing slaughter surveillance programs. As of February 17, 2000, 35 herds have completed initial surveillance. Once initial surveillance is completed, herds in this area will complete ongoing surveillance at three-year intervals.

In January, 1999, Michigan enacted a mandatory tuberculosis surveillance program for captive white-tailed deer and elk herds. This program was cooperatively developed with the deer and elk industry, and includes mandatory tuberculosis surveillance testing, and more stringent movement requirements based upon the type of surveillance completed. The majority of the 500 white-tailed deer and elk herds in Michigan must complete a whole herd test by July 25, 2000. In herds raised for hunting, owners may complete a slaughter based surveillance program which includes visual examination of head, respiratory, and hepatic lymph nodes and tissues by a specially trained, accredited veterinarian for evidence of bovine tuberculosis. A number of adult animals in which TB, if present, would be detected at a 2% prevalence with 95% confidence must be examined over a three year period, and must be completed by January 25, 2004. Tuberculosis testing requirements for movement of animals is based upon the type of surveillance completed. As of February, 2000, over 220 herds had completed tuberculosis surveillance programs statewide.

In December, 1997, the presence of bovine tuberculosis was confirmed in a 400-head white-tailed deer herd in Presque Isle County. The herd was initially developed by legal purchase of 108 free-ranging deer from the State of Michigan. Subsequent epidemiologic investigation has revealed no evidence of transmission from animals imported to the herd, and the source of infection was most likely the initial animals enclosed in the facility. The Michigan Department of Agriculture, United States Department of Agriculture Veterinary Services, Wildlife Services, Agriculture Research Service, and the owner worked cooperatively to institute a herd eradication and research program. The eradication was completed in March, 1999, and the herd will be eligible for release from quarantine in March 2000.



Single Cervical Surveillance

Whole herd testing of all captive cervidae 12 months of age and older.

44 herds utilizing whole herd testing.

Steven L. Halstead

Surveillance of Domestic Carnivores for Tuberculosis


Steven Halstead, MDA

In Michigan, to date, six coyotes, two raccoons, one bobcat, one red fox, and one black bear have been found infected with bovine tuberculosis (TB). All of these animals have come from the TB quarantined area in the northeast lower peninsula. The consumption of bovine TB infected white-tailed deer remains the most likely source of infection of these animals. The infection of these wild carnivores with bovine TB is expected to be self-limiting: it should die out as the infection is eliminated from the wild deer. As these animals have little or no interaction with humans, the risk to area residents is negligible.

Of greater concern is the possibility of infection of domestic carnivores (dogs and cats) through the consumption of white-tailed deer remains. Because domestic dogs and cats live and interact with their owners, families and friends of owners, and other people, there is the potential for human exposure to bovine TB if these animals become infected.

To assess this risk, the Michigan Department of Agriculture, in cooperation with the Michigan Department of Natural Resources and Michigan State University, is conducting surveillance of domestic carnivores in the five counties within the original TB core area. This project involves laboratory testing of dogs and cats that have been euthanized as part of the routine operation of the animal control facilities in these counties.

Eighty animals were examined through 1999. All the animals were negative for *Mycobacterium tuberculosis* and *Mycobacterium bovis*. Four dogs were positive for *Mycobacterium avium-complex* and one dog was positive for *Mycobacterium fortuitum*.

The study will continue for 2000 with the goal of at least 200 specimens.

Domestic Carnivore Study Goals:

- Sample the domestic carnivore population for *Mycobacterium spp.*
- Determine relationships of infected animals (if any) to others:
  - cattle
  - humans
  - *cervidae*
  - wild carnivores
- Assess risk

Domestic Carnivore Study Design:

- Euthanized dogs and cats from animal control
- Gross necropsy, sample collection, histology through AHDL
- Microbiology through Michigan Department of Community Health
- Epidemiologic consultation through MSU Center for Population Medicine

Data collected

- Species
- sex
- collection location and date
- age
- breed
- home territory

Domestic Carnivore Study Results:

- Through 1999
  - 80 animals examined; 55 canine, 25 feline
  - all negative for *M. bovis* and *M. tuberculosis*
  - *M. fortuitum*: one canine
  - *M. avium* complex: four canines

Domestic Carnivore Study Future:

- Continued through FY 2000
- Goal of 200 total specimens
- Possible graduate student involvement
  - expand geographic range
  - explore *M. avium* complex epidemiology
  - continue beyond FY 2000

Barbara Robinson-Dunn & Mary Grace Stobierski

Human Health Update: Bovine Tuberculosis in Michigan

Mary Grace Stobierski, MDCH

Mycobacterium tuberculosis and *M. bovis* are pathogenic for many animals including humans. The Michigan Department of Community Health provides screening and testing services for detection of these infectious agents as well as extensive surveillance activities to detect their presence. The incidence of human tuberculosis has decreased dramatically in the United States and in Michigan. There appears to be a low risk of *M. bovis* transmission to humans as evidenced by epidemiological studies and laboratory data. Isolates of *M. bovis* obtained from free-ranging deer appear to have a common DNA fingerprint which is distinct from the pattern obtained from human isolates.

TB: A Global Public Health Problem

- 90 million new cases AND 30 million deaths (estimated) from 1990-1999
- Resurgence of TB in the 1980s due to:
  - HIV/AIDS epidemic transmission in congregate settings
  - Decreased public health infrastructure

TB Cases for Michigan, Detroit and Outstate Counties. 1994 - 1999

Reporting Issues

- Michigan's Communicable Disease Rules require that physicians and laboratories report cases of tuberculosis or isolates of *M. tuberculosis* within 24 hours.
- All first time isolates, plus any obtained 90 or more days after the initial specimen must be submitted to MDCH for susceptibility testing

Surveillance for *M. bovis*

- Local (County) Level
  - Case Reporting
  - Skin Testing
    - Meat processors
    - Guides
    - Taxidermists
    - Veterinarians
    - Exposed hunters
    - Farm families

Public Health Information/Education Activities

- State level
  - Public meetings
  - Multi-agency pamphlet
  - Extensive laboratory testing
- Local (county) level
  - Public meetings
  - Press releases
  - Nursing consultations
- *M. bovis* RFLP Patterns

Laboratory Diagnosis of Tuberculosis

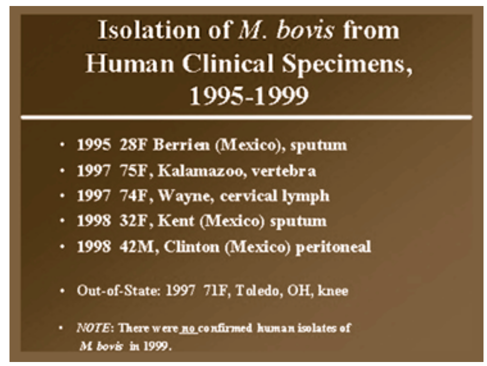
- AFB microscopy
- Culture-based assays
  - growth for identification and biochemical testing
  - antimycobacterial susceptibility testing

- Molecular-based assays
  - amplification of smear-positive specimens
  - DNA probe analysis of smear-positive cultures
  - HPLC identification of growth from cultures
- Acid Fast Smears

Barbara Robinson-Dunn, MDCH

MDCH Mycobacteriology
M. bovis Research Projects

- Susceptibility testing of *M. bovis* (45 specimens tested)
- Infectivity/host projects
  - crows (44 specimens/2 positive)
  - starlings (27 specimens/3 positive)
  - opossums (93 specimens/17 positive)
- Feral animal study
  - dogs and cats
  - 79 specimens tested/0 positive



Laboratory Responsibilities

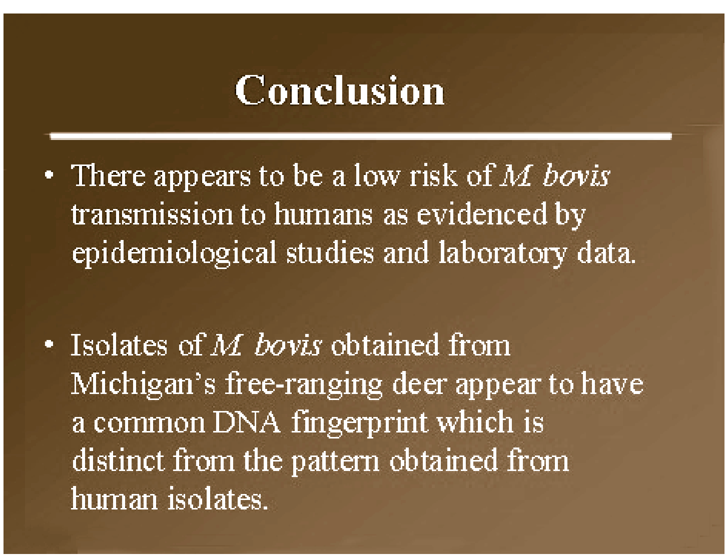
- National surveillance of *M. tuberculosis* DNA fingerprint patterns
  - Fingerprint isolates from sentinel surveillance sites
  - Scan and edit patterns using BioImage software
  - Submit computerized image to the national database at CDC

Diversity of RFLP Patterns
TBN 12 Patterns

- *M. bovis* RFLP Patterns
- *M. bovis* IS6110 Fingerprint
- *M. bovis* TBN 12 Blot

Conclusion

- There appears to be a low risk of *M. bovis* transmission to humans as evidenced by epidemiological studies and laboratory data.
- Isolates of *M. bovis* obtained from Michigan's free-ranging deer appear to have a common DNA fingerprint which is distinct from the pattern obtained from human isolates.



Laboratory Colleagues

- Dale Berry
- Jeff Massey
- Steve Church
- Angie Schooley
- Jolene Vanneste
- Sandy Arduin
- Diane Magsig
- Hieu Le
- Laura Mosher

Barbara Corso

Risks Associated with *M. bovis* in Michigan Free-ranging White-tailed Deer: an update to the 1996 report

Barbara Corso, USDA

In 1996, the Centers for Epidemiology and Animal Health (CEAH), of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Veterinary Services, completed an assessment of certain risks associated with *Mycobacterium bovis* in the wild deer in northern lower Michigan. Last year, 1999, CEAH completed an update to that assessment. The purpose of the update was to incorporate additional new information into the old framework, to see what changes had developed.

The geographic area under consideration in 1995 was very different from the situation today. The original assessment covered only a 14x14 mile square which included all infected deer identified at that time, plus a 5-mile circle around each infected deer.

The results from the original model were developed using only the 1995 prevalence data and assuming the history of the disease. The model predicted that, if no changes were made from the historical situation, prevalence would have risen by a little over 1 percent over these last four years. If transmission was decreased by 10 percent, prevalence would rise slightly less - about 1 percent. A drop in prevalence of about 0.25-0.5 percent was predicted if transmission was decreased by 50 percent. This means that, over these first 4 years, the predicted prevalence, given the worst case and the best case scenarios examined, differed by only about 1.5 percent. Simulating the progress of the disease, the model predicted that TB would still be present in the deer population in 2010 under all scenarios.

It is difficult to estimate a trend using only data from four consecutive years, especially when those annual prevalence estimates vary, as these did. However, taking the original model and applying the four years of data collected yields trends somewhat similar to the original model projections. Prevalence, estimated using the four years of data, was a flat line instead of a rising one. This flat line estimate is similar to the approximate 1 percent rise predicted in the original estimates. In addition, the many changes in deer management in the area have changed the situation from that seen in 1995. And the use of only 4 years of data, and the variation between those annual estimates, means that the apparent trend is uncertain, and could be masking a slight rise in prevalence - or a slight fall.

The flat-line prevalence trend carried out into the future predicts that the prevalence will remain the same if no additional management changes are made. When a 10% decrease in transmission is simulated, the prevalence is predicted to decline about 1 percent over the next 10 years, to a little over 2 percent. Given a 50 percent decrease in transmission, the prevalence is predicted to decrease to about 1 percent in 2010.

These results indicate a major area of agreement between the old and the new model projections. That is, under all scenarios examined, TB would still be present in the wild deer population in 2010.

Photo: courtesy of the Detroit News

In summary, it is difficult to estimate the trend in prevalence with any certainty, based on only 4 years of data. However, it appears that the prevalence may be a flat line instead of the slow rise predicted by the model originally. This may be because of the many changes made in management of the deer population in the area over the last 4 years, or it may be that the prevalence is actually rising slowly (or falling slowly) and the trend is not detectable in the samples collected so far because not enough time has passed. Either way, both the original estimates and the newly developed estimates project that TB will still be present in the deer population in the year 2010.

Dennis Propst

Economic Impact of Wildlife-Related Recreation in the 5-County Area: An Update

Dennis Propst, MSU

RE: Leefers, L., Ferris, J. & Propst, D.B. (Sept. 1997, Revised Feb. 1998). Economic consequences associated with bovine tuberculosis in northeastern Michigan. Final Report to Michigan Department of Agriculture, Michigan Department of Natural Resources, Michigan Department of Community Health. East Lansing, MI: Department of Forestry, Michigan State University.

The Leefers et al. study was completed two and a half years ago—before the first cattle herd with bovine TB was announced—and hence before the MDNR implemented policy changes regarding the taking of antlerless deer and baiting in the five-county study area. Thus, ours was an *ex ante* (before) study with limited data and heavy reliance on some secondary data sources. Our study provides the following economic impact estimates based on the spending by deer hunters (residents and nonresidents) in the five counties:

- $59 spent per hunter per trip in 1993 dollars ($22/hunter trip by resident deer hunters; $70/hunter trip by nonresident deer hunters who camp; $119/hunter trip by nonresident deer hunters who stay in hotels/motels)
- 346,000 hunter trips in 1996 (firearm and archery); 61% of trips by nonresidents
- $20.4 million in sales with $12.5 million "captured" by 5 counties—about 1/2 crop/livestock total
- Total significance of $27.8 million in sales (1.5% of 5 county total), 857 jobs and $15.3 million in household income (1993 dollars)
- Impacts do not include ~$16 million in 1993 dollars which may be spent by nonconsumptive wildlife viewers.

At the time of the report, we concluded that the effects of the proposed policies (anterless hunting/no baiting) on the region's economy were unclear and that the potential economic impact on the region was unknown. In addition, we made note of the fact that impacts, if they occurred would likely be transfers to other parts of the state (as opposed to an overall state loss).

I re-ran some of the numbers quickly this week to update the figures to current dollars, but, more importantly, to revise the estimates of the total impacts on sales, jobs and income. This is because we feel we were using an upwardly biased set of multipliers (particularly jobs multipliers) when we made the estimates in 1997. The multipliers in the report are the type that assume that employees have the same spending patterns regardless of whether or not they were generated by high or low salaried jobs. This assumption results in an overestimate of multipliers if employees' wages are low or are part-time and seasonal workers. Since these characteristics describe many jobs in the tourism industry, the multipliers used in our report likely overestimated the resulting economic impacts in the region. Let me make it clear, however, I did not have access to the most important set of numbers of all: current estimates of the change in hunter effort in the 5-county region. I used the same 1996 figure of 346,000 hunter trips. I also used the same spending data, but I inflated those figures to 1999 dollars. The newer estimates are:

- $67 per hunter per trip (1999 dollars)
- $23.3 million in sales with about $14.7 million "captured" by 5 counties (total tourism spending is $155 million in 1999 dollars, so hunters account for about 15%)
- Total significance of $19.9 million in sales (1.0% of 5 county total), 512 jobs and $9.1 million in household income (1999 dollars)
- We overestimated by about $8 million in total (direct and secondary) sales, 345 total jobs and, $6.2 million in total household income

Since we have the baseline estimates, all we need is current MDNR estimates of hunter effort to update these figures and show the net economic effects of the changes in hunting policies and hunter knowledge of the TB situation on the region's economy since 1996.

Christopher Wolf

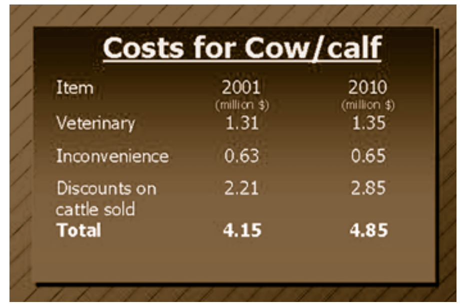
Economic Costs of Bovine TB in Michigan Cattle

Christopher Wolf, MSU

Bovine TB has potentially serious economic implications for Michigan agriculture. We have focused our efforts on Michigan cattle, both dairy and beef, as this is the primary source of costs.

Agriculture is important to the Michigan economy, with a net farm income of $308.4 million from $3.48 billion in total cash receipts in 1998. There are approximately 1 million cows in Michigan. For the dairy industry, 300,000 milk cows produced 5.4 billion pounds of milk amounting to $821 million in gross receipts in Michigan during 1998. Similarly, 115,000 Michigan beef cows produced $197 million in gross cash receipts in 1998.

The sources of the costs include testing costs, lost production, and declines in commodity prices. A survey examined the charges by Michigan veterinarians in December, 1999. A summary of the results is presented in Table 1.



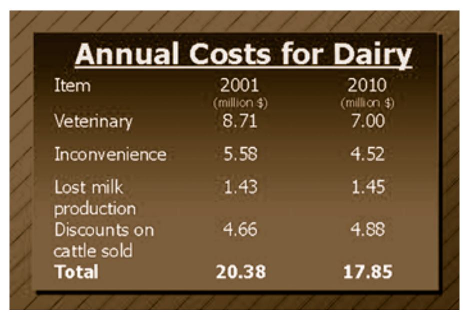
Costs for Cow/calf

Item	2001 (million $)	2010 (million $)
Veterinary	1.31	1.35
Inconvenience	0.63	0.65
Discounts on cattle sold	2.21	2.85
Total	**4.15**	**4.85**

Table 1. **Michigan Veterinary TB Testing Costs**

MI Zone	**% Respondents**	**Average $/head**	**Average $/hour**
Infected	5	10.33	78
Surveillance	5	7.70	80
Free	90	5.77	115
Total	100	6.09	112

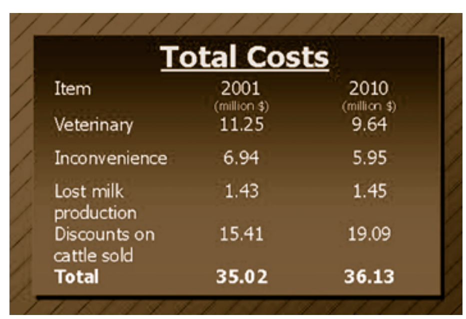
Table 1 reflects the potential zones (infected, surveillance, and free) relative to the primary infected area in northeast Michigan. The veterinary testing costs were higher in the infected area and lower in the "free" area perhaps reflecting the increased demand for tests and relatively short supply of veterinarian time available under recent testing regimes. The total average reflected the fact that 90 percent of respondents were from the free zone.



Annual Costs for Dairy

Item	2001 (million $)	2010 (million $)
Veterinary	8.71	7.00
Inconvenience	5.58	4.52
Lost milk production	1.43	1.45
Discounts on cattle sold	4.66	4.88
Total	**20.38**	**17.85**

To estimate preliminary total impacts, Dr. Jake Ferris forecasted testing costs, lost production, and price effects using his IMPLAN input/output model. The data used were from the 1997 Census of Agriculture, Michigan Agricultural Statistics Service reports, under the assumption that Michigan would lose accreditation.



Total Costs

Item	2001 (million $)	2010 (million $)
Veterinary	11.25	9.64
Inconvenience	6.94	5.95
Lost milk production	1.43	1.45
Discounts on cattle sold	15.41	19.09
Total	**35.02**	**36.13**

The analysis examined three Michigan agricultural industries: dairy, cow-calf, and cattle on feed. For dairy, the assumptions were: 2 annual veterinary visits @$50 + $7.50/cow, a farmer time and inconvenience cost of $5/cow, cattle prices reduced by 5%, and a 0.1 percent loss in milk production per visit. For the cow/calf industry the assumptions were: a herd test every 3 years at $50 + $7.50/head, farmer time and inconvenience costs of $5/head, cattle prices reduced by 5%, and an annual test for calves sold. For cattle on feed the assumptions were: 1/2 of the cattle went directly to slaughter and 1/2 to auctions; 1/2 of feedlots tested annually with the other 1/2 tested every 3 years, and cattle prices reduced by 5%. The total costs described above amounted to $35 million annually with a large portion of these costs coming from the assumed decline in prices. These estimates are preliminary and do not reflect the current veterinary costs used by MDA. Further work is needed with regard to the potential for price declines in the affected commodities.

Mitchell V. Palmer & Diana L. Whipple

Presented by Palmer and Whipple from the National Animal Disease Center, USDA, Ames, IA

Mitchell Palmer, USDA

Susceptibility of Raccoons to Infection with *Mycobacterium bovis*

Mycobacterium bovis, the causative agent of tuberculosis in cattle and Cervidae, has a broad host range including humans. Concomitant with the Michigan survey of white-tailed deer, other mammalian species have been examined for the presence of *M. bovis.* To date, *M. bovis* has been isolated from coyotes, raccoons, bobcat, bear, and red fox. It is hypothesized that these animals are infected with *M. bovis* after feeding on dead tuberculous deer. Due to their denning habits and inclination to come into close contact with livestock and humans, raccoons infected with *M. bovis* are of special concern from both an agricultural and public health aspect. *Mycobacterium bovis* has not been found previously in raccoons and there is a lack of understanding of the pathogenesis of *M. bovis* infection in raccoons. To determine the susceptibility of raccoons to infection with *M. bovis,* twelve, 6-month old, castrated male raccoons were inoculated with one of 3 doses of *Mycobacterium bovis* strain 1315, originally isolated from a free-ranging white-tailed deer in Michigan. The high dose group (n=3) was fed 1 x 10^5 colony forming units (CFU) of *M. bovis* in 10 g strawberry preserves. The medium (n=3) and low dose (n=3) groups received 1 x 10^3 and 1 x 10^1 CFU of *M. bovis*, respectively in a similar fashion. Controls (n=3) were fed strawberry preserves without *M. bovis* and housed in a separate building.

One-hundred twenty days after inoculation, all raccoons were euthanized. Various tissues were collected for bacteriologic culture and microscopic analysis. Urine, feces, and swabs of the oral cavity, nasal cavity, and tonsilar fossae were collected for bacteriologic culture. No gross or microscopic lesions were seen in raccoons from any group. *Mycobacterium bovis* was isolated from the mesenteric lymph node of a single raccoon in the low dose *M. bovis* group. No *M. bovis* was isolated from feces, urine, or tonsilar, nasal, or oral swabs from any raccoon studied.

Although one raccoon did become infected after ingestion of *M. bovis,* these results suggest that a single oral exposure of even a large dose of *M. bovis* may not be sufficient to establish infection in raccoons. The absence of gross and microscopic lesions in the single infected raccoon is compatible with the wildlife surveys in Michigan. Studies to further elucidate the susceptibility of raccoons to *M. bovis* and determine the conditions necessary to establish *M. bovis* infection in raccoons are needed.

Transmission of *Mycobacterium bovis* from Experimentally Infected White-tailed Deer to Cattle Through Indirect Contact.

Mycobacterium bovis has been isolated from herds of cattle in northeast Michigan where there is a wildlife reservoir of disease in free-ranging white-tailed deer. Results of DNA fingerprinting indicate that the deer and cattle are infected with the same strain of *M. bovis*. The purpose of this study was to determine if cattle can become infected with *M. bovis* through indirect contact with experimentally infected white-tailed deer. Three groups of four deer were inoculated with 7 x 10^5 *M. bovis* by instillation of the organisms into the crypt of the palatine tonsil.

After two weeks, pens where the deer were housed were topically disinfected and three groups of three six-month old calves were introduced into the barn. Each group of deer was paired with a group of calves. Deer were given excess feed and hay and allowed access to it for several hours. The deer were then moved to a holding pen and the calves were moved to the pen that had been occupied by the deer without cleaning the pen. The calf pens were cleaned and the deer were then moved to the clean pens. This process was repeated daily for 80 days. All of the deer were euthanized by day 91 of the experiment and all had extensive lesions of tuberculosis.

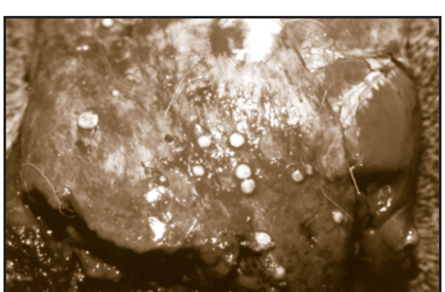
On day 77, all of the calves were skin tested using the comparative cervical skin test and were classified as reactors. Results of the interferon gamma assay were positive for three of the calves on day 28 and were positive for all nine calves on day 56. Calves were necropsied beginning on day 177 and examined for lesions of tuberculosis. Gross and microscopic lesions were observed in, and *M. bovis* was isolated from, all calves. All calves had lesions in the lung or associated lymph nodes. One calf had lesions in the medial retropharyngeal lymph node.

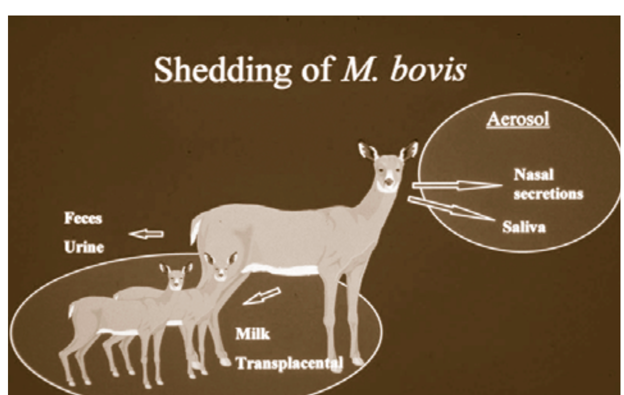
Results of this study show that calves can become infected with *M. bovis* through indirect contact with experimentally infected white-tailed deer. Additional studies will be conducted to determine if cattle can become infected through contact with only the feed that has been offered to experimentally infected deer. We also plan to determine the minimum infectious dose needed for infection of calves by the oral route.

Deer to Deer Transmission of *Mycobacterium bovis*

Information is lacking on the pathogenesis and transmissibility of *M. bovis* infection in white-tailed deer. In order to determine the efficiency with which deer transmit tuberculosis to each other, and the routes by which such transmission occurs, we exposed non-inoculated deer to experimentally inoculated deer. Eight deer were experimentally inoculated by intratonsilar instillation of 2x10^8 CFU of *M. bovis*. Eight non-inoculated deer were introduced 21 days after inoculation. Deer were housed in pens 150 ft^2 in size such that 2 in-contact deer were penned with 2 experimentally inoculated deer. Each pen had a single source of water, hay, and pelleted feed. Sixty-nine days after introduction, all in-contact deer developed delayed type hypersensitivity reactions to *M. bovis* PPD as determined by the comparative cervical test. One-hundred twenty days after inoculation all experimentally inoculated deer were removed. One-hundred fifty nine days after introduction, 4 in-contact deer were euthanized and examined and 4 new non-inoculated deer were housed with the remaining original in-contact deer such that 4 new in-contact deer, were housed with 4 original in-contact deer. One-hundred days after introduction, all new in-contact deer had developed delayed type hypersensitivity to *M. bovis* PPD.
At 180 days after introduction of new in-contact deer, all deer were euthanized and examined. All in-contact exposed deer developed tuberculosis. Lesions were most commonly seen in the lung, tracheobronchial and mediastinal lymph nodes. Experimentally inoculated deer were shown to shed *M. bovis* in nasal secretions, saliva, feces, and urine. In-contact infected deer also shed *M. bovis* in nasal secretions and saliva. Hay and pelleted feed were found to contain *M. bovis* at multiple times throughout the experiment.

This study shows that tuberculous deer efficiently transmit *M. bovis* to other deer in close contact. Lesion distribution in in-contact exposed deer suggests aerosol transmission as a likely means of infection, however, contamination of shared feed must also be considered. Body fluids containing *Mycobacterium bovis* may become aerosolized or directly contaminate feed, both of which may be sources of infection for other susceptible hosts.





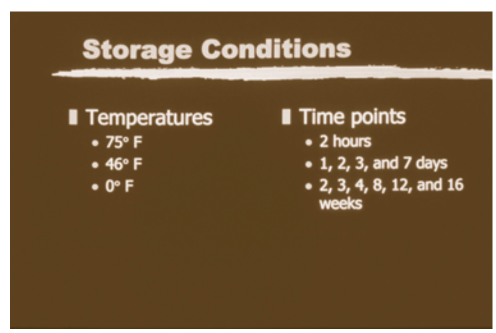
Survival of *Mycobacterium bovis* on Feeds

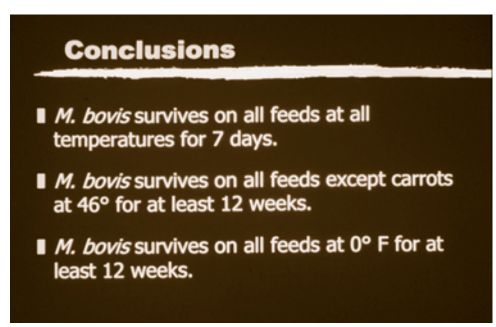
Diana Whipple, USDA

Free-ranging white-tailed deer in northeast Michigan are recognized as a wildlife reservoir of tuberculosis caused by *Mycobacterium bovis.* Generally, animals become infected with *M. bovis* by inhalation of aerosolized organisms or by ingestion of organisms that are present in feed and water. *Mycobacterium bovis* has been isolated from saliva, nasal secretions, and tonsilar swab samples of experimentally infected white-tailed deer. Therefore, it is possible for infected deer to shed organisms in oral secretions and contaminate feed and water, which would then serve as a source of infection for other animals. Baiting of deer, which is allowed in Michigan, creates a situation where several deer eat from the same pile of feed and may contribute to transmission of tuberculosis.

The purpose of this study was to determine how long *M. bovis* survives on various feeds when stored at different temperatures. The feeds examined were alfalfa hay, shelled corn, sugar beets, apples, carrots, and potatoes. Feeds were held at 75°F, 46°F, and 0°F for 2 hours, 1 day, 2 days, 3 days, 7 days, 2 weeks, 3 weeks, 4 weeks, 8 weeks, 12 weeks, and 16 weeks.

Mycobacterium bovis was isolated from all feeds stored at all temperatures for 7 days. At 46°F, *M. bovis* survives on all feeds except carrots for at least 12 weeks and at 0°F, it survives on all feeds for at least 12 weeks. This study is ongoing and results from samples processed at 16 weeks are pending. Other experiments will be conducted to further examine the role of baiting in transmission of tuberculosis.





Scott Fitzgerald

Comparison of Post-mortem Techniques for the Detection of *Mycobacterium bovis* in White-tailed Deer

Scott Fitzgerald, MSU

S.D. Fitzgerald[1], J.B. Kaneene[1], K.L. Butler[1],*
K.A. Clarke[1], J. Fierke[2], S.M. Schmitt[2], C.S. Bruning-Fann[3],
R.R. Mitchell[1], D.M. Berry[4], J.B. Payuer[5]
[1]Animal Health Diagnostic Lab., Mich. St. Univ., E. Lansing, MI
[2]Wildlife Disease Lab., MI Dept. Natural Resources, E. Lansing, MI
[3]Veterinary Services, Animal and Plant Health Inspection Service, United States Dept. of Agriculture, Holt, MI
[4]Michigan Dept. of Community Health, Lansing, MI
[5]National Veterinary Services Labs., United States Dept. of Agriculture, Ames, IA

Using data gathered from a bovine tuberculosis surveillance program for deer in Michigan over four years (1995 to 1998), we have compared the relative efficiency of different post-mortem tests (routine histopathology, acid-fast staining, presence of acid-fast bacilli in culture, *M.* tuberculosis-group-specific genetic probe) against the "gold standard" test: mycobacterial culture and species identification.

Over 17,200 deer from the tuberculosis-endemic area were submitted for testing. Animal age and gender were also recorded. A total of 220 samples were culture-confirmed *M. bovis* positive, and 74 samples with gross suspicious lesions were culture-confirmed negative. Sensitivity, specificity, and predictive values were computed for each test method.

The most rapid form of testing, histopathology, for *M. bovis* in white-tailed deer samples had a sensitivity of 98% and specificity of 87%, resulting in a positive predictive value of 94%. The presence of acid-fast bacilli by staining was less sensitive than histopathology (90%), but its higher specificity (97%) resulted in a positive predictive value of 99%. The presence of acid-fast bacilli on culture was both highly specific (93%) and sensitive (100%). The group-specific genetic probe had the highest sensitivity and specificity, and had results in complete agreement with the "gold standard".

Based on these results, use of the genetic probe provided the most rapid and reliable testing method for post-mortem diagnosis of *M. bovis* in wild white-tailed deer.

Comparison of Dx Tests I:

	Result		I & I	
Dx Test	+	-	+	-
Gross	293	1	220	74
Histo. 1	267	23	220	70
Histo. 2	229	65	220	70
AFB stain	199	94	220	73
AFB culture	225	68	220	73
Probe	216	5	216	5

Comparison of Dx Tests II:

Dx Test	Sens.	Spec.	PredV +	PredV -
Gross	99.54%	NA	74.74%	NA
Histo 1	98.18%	27.14%	80.90%	82.61%
Histo 2	98.18%	87.14%	94.32%	93.85%
AFB stain	89.54%	97.26%	98.99%	75.53%
AFB culture	100.0%	93.15%	97.78%	100.0%
Probe	100.0%	100.0%	100.0%	100.0%

Experimental Inoculation of *Mycobacterium bovis* into Starlings and Crows

These studies examined the potential for carrion-feeding wild birds (starlings and crows) to shed *Mycobacterium bovis* or become infected with it. Experimental groups included four controls, four orally inoculated birds, and four intraperitoneally inoculated birds. Half the birds in each group were necropsied at 30 days post-inoculation (pi), and half at 60 days pi. Orally inoculated birds failed to shed *M. bovis* in their feces, nor did they develop gross or histologic lesions. Intraperitoneally inoculated birds exhibited weight loss, splenomegaly, and hepatic granulomas, and *M. bovis* was isolated from various intra-abdominal tissues. Therefore, birds do not appear to be a concern in the natural transmission of *M. bovis* since they do not shed the organism after ingesting it; however, birds can be experimentally infected by intraperitoneal inoculation.

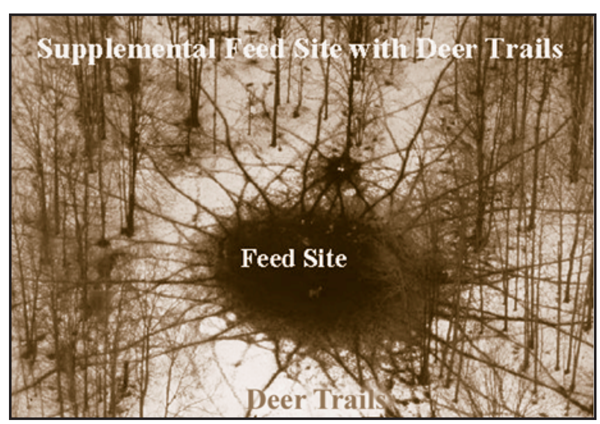
J. B. Kaneene

Epidemiological Studies of *M. bovis* in Michigan Wildlife and Livestock Populations

John Kaneene, MSU

Epidemiological studies are being conducted to address five major areas. These areas include:

1) Evaluation of risk factors associated with the transmission of *M. bovis* in wildlife and livestock populations;
2) Determination of the survivability of *M. bovis* in environmental sources such as water, feed and soil;
3) Determination of what other species can serve as reservoirs for *M. bovis*;
4) Integration of data from different sources and development of epidemiological and economic risk assessment models for transmission of *M. bovis* in free-ranging deer, captive cervidae, livestock and humans; and
5) Assistance in developing, implementing, and evaluating surveillance and eradication programs for *M. bovis* in wildlife and livestock populations.



Stephen M. Schmitt, Scott D. Fitzgerald, Colleen Bruning-Fann,
Nathan Zauel, and Dale E. Berry

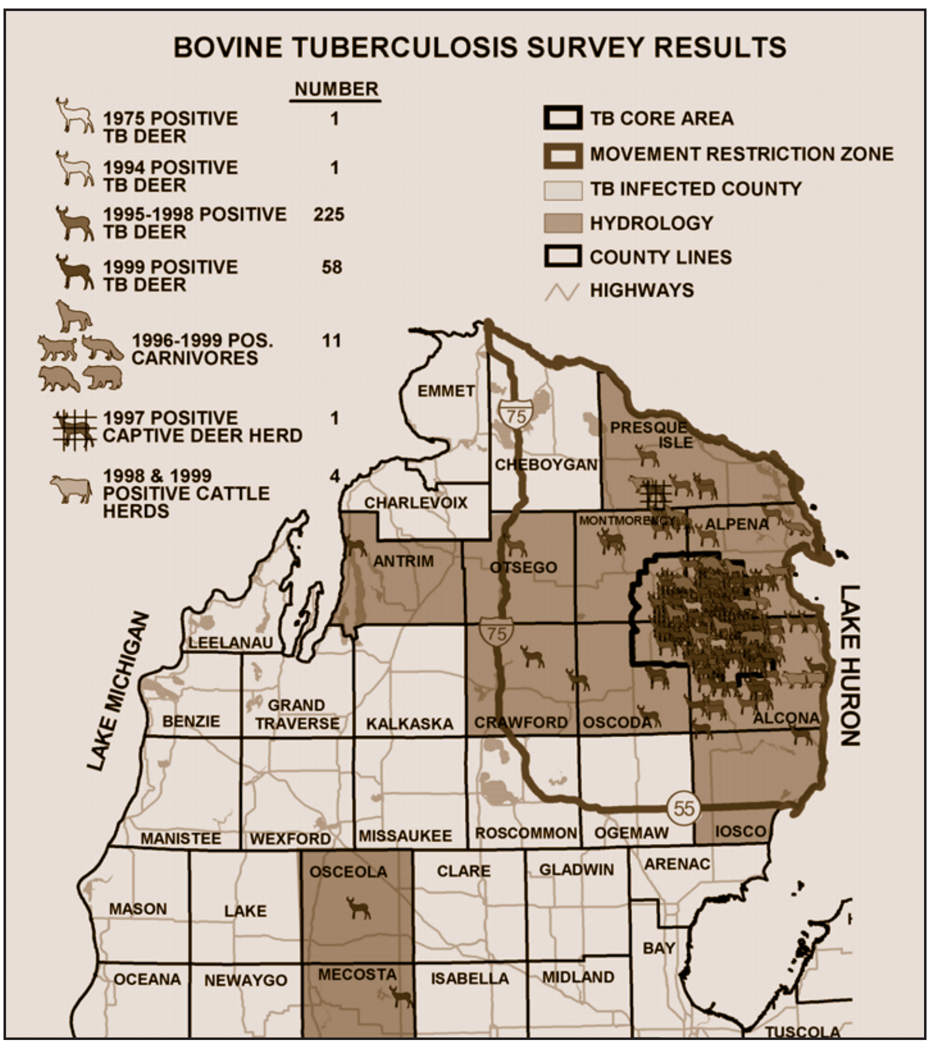
Bovine Tuberculosis in Michigan

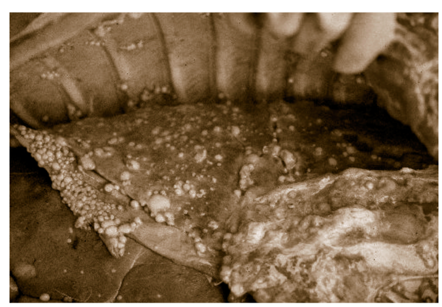
Stephen Schmitt, MDNR

Since 1994, the State of Michigan has recognized a problem with bovine tuberculosis (TB), caused by *Mycobacterium bovis,* in the wild white-tailed deer from a six-county area in northeastern lower Michigan. The disease has been found in other wildlife species and, in 1998, in domestic cattle. Recognizing the potential economic and public health consequences of *M. bovis* to the state, the Governor has issued orders to eradicate *M. bovis* from the state's deer population. Unfortunately, the situation is unique in that there have never been reports of self-sustaining bovine TB in a wild, free-ranging cervid population in North America.

There are no existing control programs for TB in wild deer, and there is much about TB in deer that is currently unknown. Scientists, biologists, epidemiologists, and veterinarians that have studied this situation have concluded that the most logical theory is that the supplemental feeding of wild deer serves to congregate deer, therefore contributing to the spread of TB. Supplemental feeding and baiting (the practice of hunting deer over feed) have been banned in Northeast Michigan with the intention of reducing the spread of TB between deer and eventually eliminating this disease from the wildlife, therefore completing the eradication. In addition, deer densities are being reduced through hunting.

M. bovis leisions in a wild White-tailed deer.





Mycobacterium bovis in the chest cavity of a deer.

Bovine Tuberculosis Surveillance in Michigan Wildlife

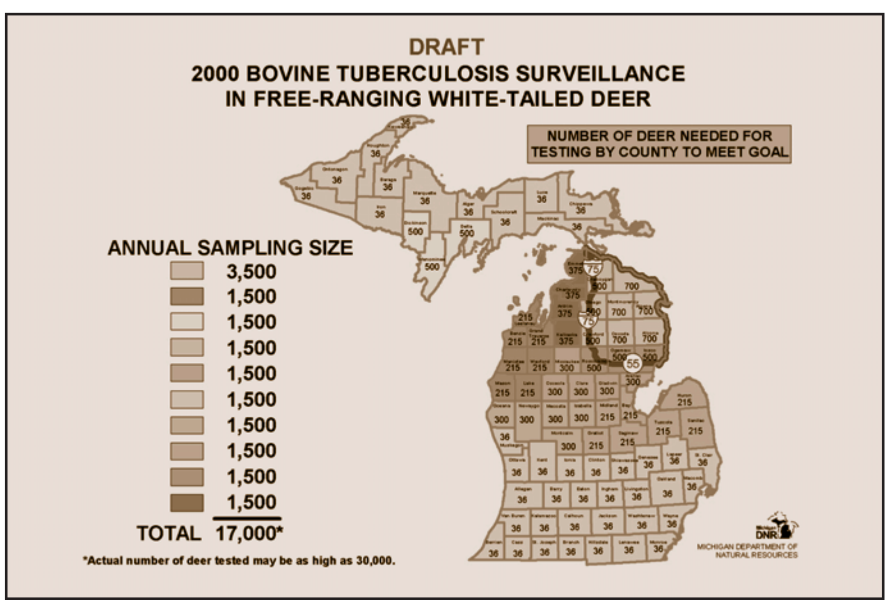
The presence of bovine tuberculosis (bovine TB) in Michigan's white-tailed deer herd is a serious problem. The elimination of bovine TB from free-ranging deer is an important and difficult goal to accomplish. To ensure that the goal is reached, a comprehensive surveillance of wildlife populations in Northeastern Michigan and statewide is necessary.

Comprehensive monitoring is necessary to identify areas that will need intensified management. In addition, there is need to monitor the success of that management. The continued evaluation of the prevalence of the disease will allow the Michigan Department of Natural Resources (MDNR) to determine the prevalence rate, areas of infection and an assessment of the trend.

Bovine tuberculosis surveillance of free-ranging deer will be based on the assumption that there is one focus or epicenter of the disease in Michigan, that being in the northeastern part of the Lower Peninsula. With that in mind, the state will be divided into zones that radiate out from northeastern Michigan. A sample of deer will be collected and tested from each of the zones. Sampling in each area will be conducted at a 95% confidence level, assuming a 0.2% prevalence for bovine tuberculosis. This will result in the sampling of 1,500 deer per zone, and a statewide total of 17,000 deer being tested.

The risk of free-ranging elk in Michigan becoming infected with bovine TB is largely determined by the likelihood of contact with an infected free-ranging white-tailed deer, or elk and deer sharing a common feeding site. Using hunter harvested elk, AHDL will examine approximately 200 elk annually from a population of 1,000 animals.

While most mammalian species are susceptible to bovine TB, only a few are thought to be reservoirs of *M. bovis.* The white-tailed deer in Michigan is recognized as a reservoir host of bovine TB. As long as bovine TB exists in the wild, free-ranging deer population, there will be some risk to local wildlife species that feed on bovine TB-infected deer carcasses or gut piles. Bovine TB spreading from the free-ranging deer population to other wildlife in the infected area is possible, as demonstrated by the finding of bovine TB in coyotes, raccoons, black bear, bobcat and red fox. The testing of non-cervid wildlife for bovine TB in the Bovine TB Management Area (east of I-75, north of M-55, and west and south of Lake Huron) will continue annually until bovine TB is eliminated from Michigan's free-ranging white-tailed deer herd.



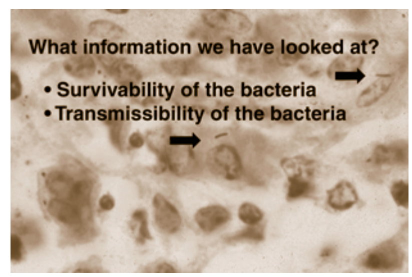
Pete Squibb

Findings of the Baiting and Feeding Materials Workgroup

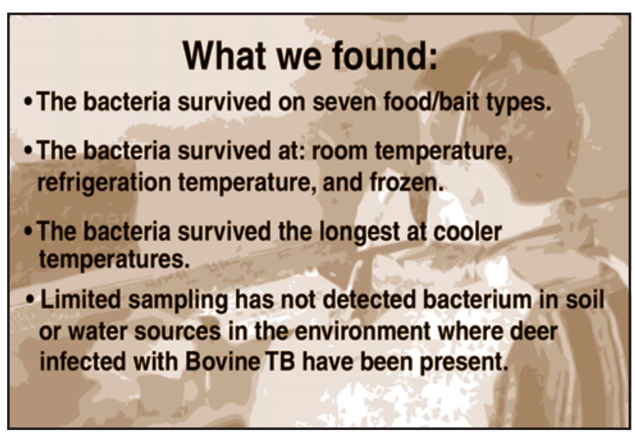
Pete Squibb, MDNR

A multidisciplinary workgroup of veterinarians and resource specialists from the Departments of Natural Resources and Agriculture, as well as commissioners of the Michigan Agriculture and Natural Resources Commissions, was assembled to: 1) examine potential disease issues associated with materials used for baiting and feeding of white-tailed deer in Michigan; 2) to examine the role of spin-cast type automated feeders in applying bait and supplemental feed; and 3) to provide feedback to the Natural Resources Commission on which types of food material might be allowed for baiting and/or supplemental feeding in the future.

Recent research performed by workers at the National Veterinary Services Laboratory has shown that *Mycobacterium bovis* is capable of surviving in various temperature conditions for periods as long as three months on all of the common foodstuffs (carrots, sugar beets, apples, potatoes, shelled corn, and alfalfa hay) onto which it was inoculated. While *M. bovis* did not grow on salt/mineral blocks, it did survive on those items as well. In addition, those same researchers have now established that *M. bovis* can spread from deer to deer by indirect contact, that is, through contact with contaminated feed and bedding. The results of these studies taken together suggest that transmission of TB among free-ranging deer in the field via contaminated bait and supplemental feed is likely an important means of disease transmission.



Given this compelling evidence, the workgroup was unable to identify any feed or baiting material, or method of application, capable of significantly reducing or eliminating the risk of TB transmission. Further, the workgroup concluded that in areas where *M. bovis* positive deer have been found, no feeding or baiting of deer whatsoever should be allowed. However, with respect to areas of the state in which no TB positive animals have yet been identified, no consensus could be reached by the workgroup on potential baiting and supplemental feeding restrictions. While continuance of baiting and supplemental feeding anywhere in Michigan was deemed unjustifiable by some workgroup members from a disease control standpoint, other members noted that the potential impacts of additional baiting and feeding restrictions were sufficiently unpopular and economically burdensome to justify leaving current regulations unchanged.



William E. Moritz

Harvest Strategies for Deer: the Goal, Eradicate Bovine TB from Free-Ranging Deer in Michigan

William Moritz, MDNR

General Strategies

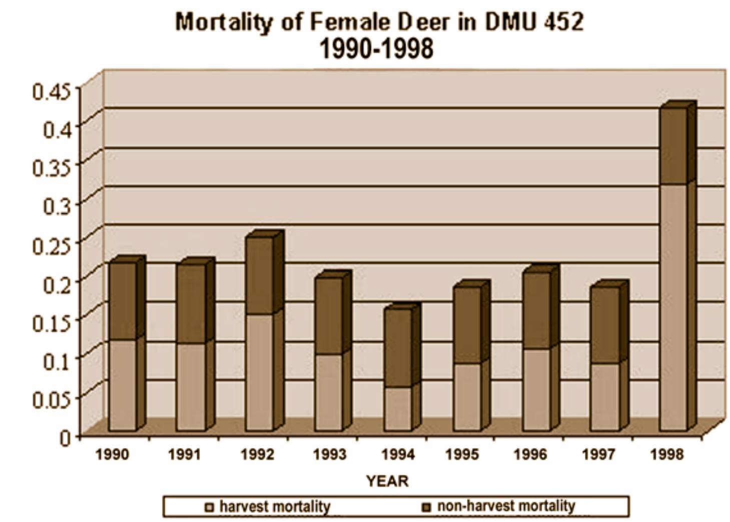
- Remove infected animals
- Reduce transmission from infected to uninfected animals

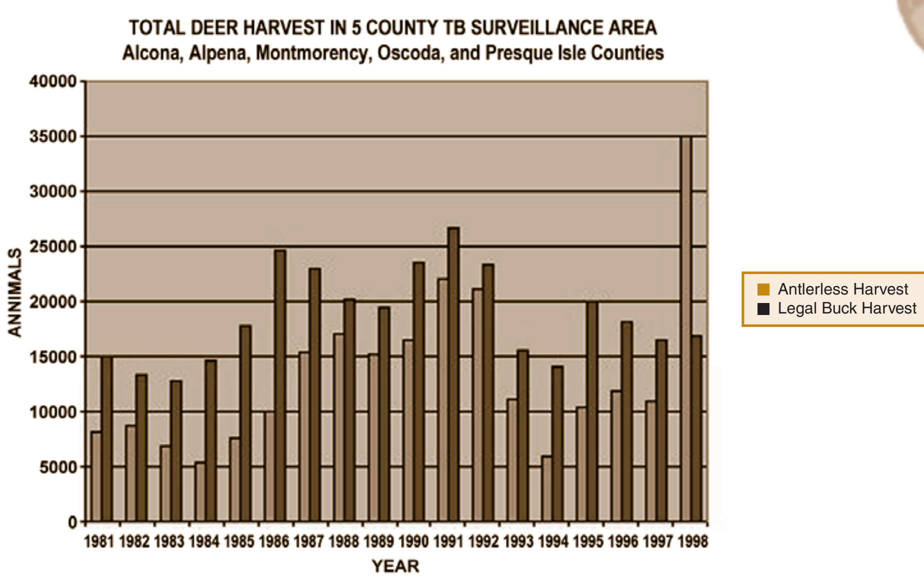
Management Strategies

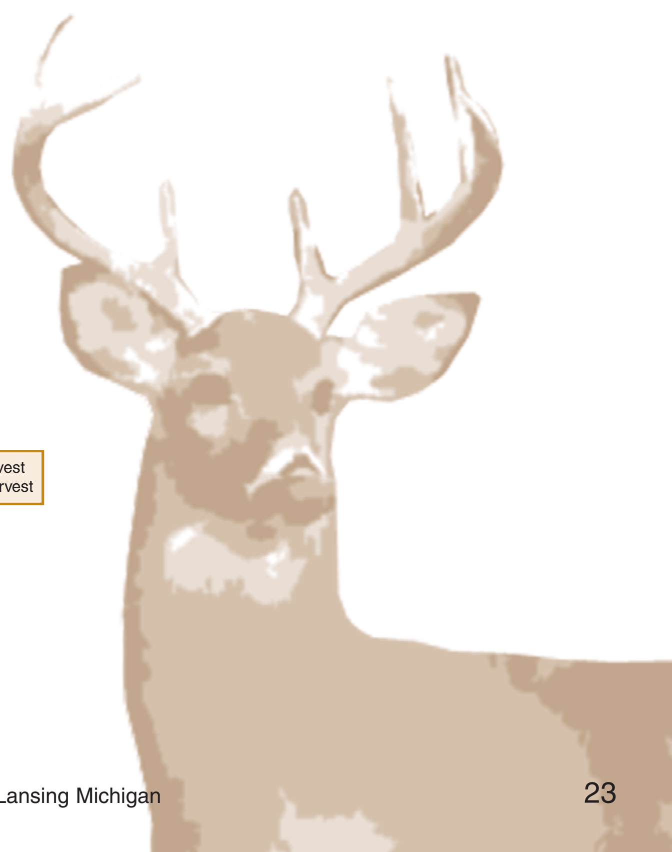
- Increased harvest of deer will reduce population size and increase rate of population turnover
- Hunters are best implementers of harvest strategies
- Hunting during fall and winter provides most efficient framework for harvest

Actions Taken by MDNR

- Creation of 5-county Deer Management Unit (DMU 452) to facilitate hunter mobility
- Creation of additional firearm hunting seasons (October 16-25 and December 18-January 2)
- DMU 452 Antlerless Deer Licenses were available for all who wished to use them
- Deer Management Assistance Permits available to landowners
- Increased public communication about need to reduce deer numbers







Dan O'Brien

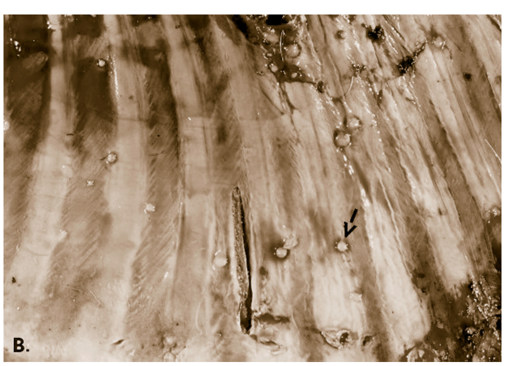
Apparent Prevalence of *Mycobacterium bovis* in Free-ranging Michigan White-tailed Deer

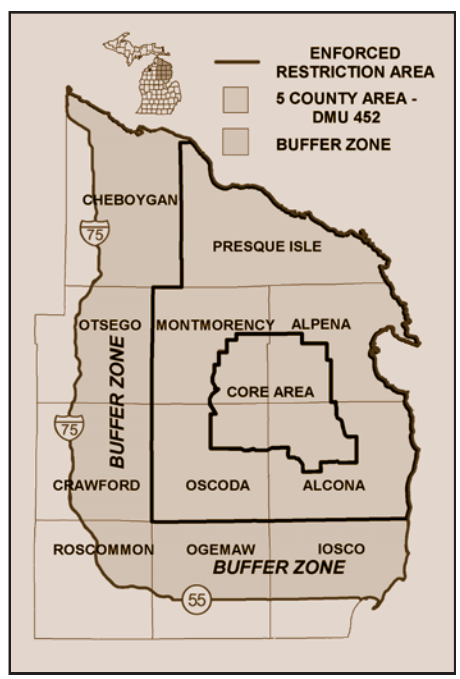
Dan O'Brien, MDNR

On a statewide basis, the 58 deer testing positive for *Mycobacterium bovis,* of 19,488 deer tested in 1999, reflects an overall prevalence of 0.3%. Prevalence varied markedly by geographic zone. Fifty-five of the TB positive deer were among the 9,933 sampled from the Movement Restriction Zone, a prevalence of 0.55%. Within the MRZ, the highest prevalence (2.2%) was in old Deer Management Unit 452 (41 positive of 1,898 tested). Prevalence in the five county area outside old DMU 452 was 0.2% (11 positive of 5,587 tested), while in the buffer area, a prevalence of 0.12% (3 positive of 2,429 tested) was observed. In the remainder of the state outside the MRZ, the three positive cases found among the 9,022 deer tested reflects a prevalence of 0.03%.

The overall prevalence of bovine TB in hunter-harvested deer in old DMU 452 varied from 4.8% in 1995 to 2.2% in 1999. Prevalence in 1999 was significantly ($P < 0.001$) lower than in 1997. Considering all deer at least one year of age, prevalence tended to be higher in bucks than does, but this difference was significant ($P < 0.01$) only in 1998. However, when stratified by age, prevalence was significantly ($P \leq 0.02$) higher in both bucks and does $\geq$ two years of age than yearlings in every year from 1995 to 1999. When TB prevalence was compared between sexes within age strata, there was no significant difference among yearlings in any year studied, while among deer $\geq$ two years of age, prevalence was significantly higher ($P < 0.02$) in bucks than does in 1995, 1997 and 1998, and approached significance ($P = 0.1$) in 1999. While caution is necessary in interpretation of trends based on only three years of data, irrespective of age or sex, TB prevalences among hunter-harvested deer in old DMU 452 have declined steadily since 1997. Notably, this apparent decrease coincides temporally with interventions to decrease the size of the deer population and eliminate baiting and supplemental feeding of deer in that area.

In summary: 1) the prevalence of bovine TB in free-ranging Michigan white-tailed deer in 1999 varied from 0.03% to 2.2% depending on geographic area; 2) there is preliminary but encouraging evidence of a decreasing trend in prevalence since 1997 in the core area of the TB outbreak; and 3) prevalence in the core area was significantly higher in older deer of both sexes than in yearlings, and in males $\leq$ two years of age than females of the same age.





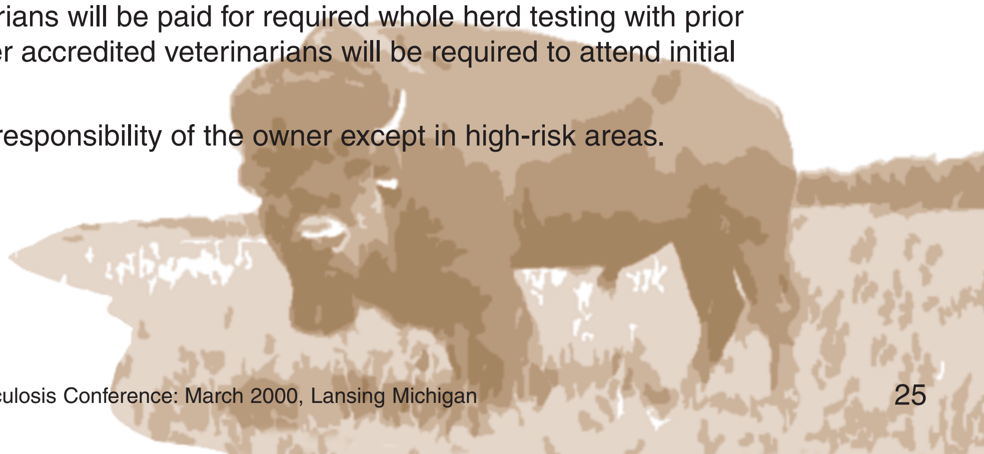
H. Michael Chaddock

Editor's note: The information in this proposal has changed since it was first presented. Please contact Kevin Kirk, Animal Health Liaison, Michigan Department of Agriculture at (517) 241-4339, for the final plan.

Proposed Bovine Tuberculosis Eradication Plan for Michigan Livestock: *Surveillance*

Michael Chaddock, MDA

- Identify all livestock premises in Michigan.
- All cattle, goats, bison, and captive cervids to be officially identified before they leave any premises. Identification tags to be supplied by MDA.
- Owners of cattle, bison, goats, and captive cervids to maintain record of movement of animals brought onto, or removed from, the premises.
- Identify established high-risk TB areas. Established high-risk TB areas are areas where TB has been identified in wild deer and in livestock. Current established high-risk area is bounded by I-75 and M-55.
- Identify potential high-risk TB areas. Potential high risk TB areas are areas where TB has been identified in wild deer but the TB status of livestock is unknown. Current potential high-risk areas are ten-mile circles around TB positive deer in Antrim, Osceola, and Mecosta counties.
- All cattle, goat, and bison herds in non-established high-risk areas and non-potential high-risk areas shall have a whole herd test by January 1, 2003. Captive cervid herds in these areas shall be tested per Act 466 or, if not covered by Act 466, shall test by January 1, 2003.
- All dairy farms (cattle and goats) to have a whole herd test annually as required by the pasteurized milk ordinance.
- Cattle, bison, and goats moving intrastate (except directly to slaughter) need to originate from a herd that has tested negative on a whole herd test within 12 months prior to movement, OR the individual animal must have tested negative within 60 days prior to movement, OR originate directly from a TB accredited herd.
- All cattle, goat, and bison herds in non-established high-risk areas and non-potential high-risk areas shall have a whole herd test by January 1, 2003. Captive cervid herds in these areas shall be tested per Act 466 or, if not covered by Act 466, shall test by January 1, 2003.
- Captive cervids moving intrastate (except directly to slaughter) must meet intrastate movement requirements currently in place for movement of white-tailed deer and elk under Act 466.
- Slaughter facilities in established high-risk areas and potential high-risk areas will be placed on enhanced TB surveillance plans by July1, 2000 or within six months of identification of the area.
- Livestock markets serving high-risk areas (Alpena, Gaylord, Marion, and Clare) will be monitored every sale day.
- Based on past TB herd surveillance testing, potentially higher risk herds will be identified and whole herd testing conducted by July 1, 2000.
- MDA/USDA personnel will conduct required whole herd testing as resources permit. Priority for testing is high-risk areas.
- Private practitioner accredited veterinarians will be paid for required whole herd testing with prior approval from MDA. Private practitioner accredited veterinarians will be required to attend initial and periodic training provided by MDA.
- Individual animal testing costs are the responsibility of the owner except in high-risk areas.



Enhanced Federal Partnership Opportunities

USDA Surveillance Teams

- Ten additional USDA surveillance teams will be needed.
- Support for NVSL new facilities and appropriate staffing.
- Over 1,000,000 Michigan animals are projected to need annual testing over the next three years
  - MDA - 500,000
  - USDA - 300,000
  - Private DVM's - 200,000

Research

- Michigan State University
  - 20 projects from epidemiology to social and economic impacts
- Need for annual support
- Agricultural Research Service
  - Focus on three general categories: disease mechanisms and transmission; diagnosis of infection; and control strategies
  - Need for research personnel and animal containment space
- Need for annual support

Depopulation Compensation

- MDA suggests USDA consider redefining the federal indemnity program to adequately encourage the depopulation of infected herds. The amount should be a significant percentage of the value of the animal.
- Suspect animals 50% of value or $450, whichever is greater.
- Exposed or reactors 75% of value or $750, whichever is greater.

Testing Individuals (humans)

- Expand funding for test administration and education in all high-risk areas.
  - On-farm visits by public health personnel could be enhanced
  - Educational materials for families with infected herds could be developed
  - Sportsmen could be supplied with more information
- Funding for additional diagnostic and treatment in humans as needed.
- Respiratory examinations and respirator fit tests for people working around infected herds.
- Need for annual support

Food Safety and Inspection Service (FSIS)

- In slaughter plants, maintain accurate identification throughout the slaughter process.
- Employ contract help to assist in animal ID, sample collection, and submission.
- Employ help at NVSL to assist with increased sample load.
- Implement award program in Michigan's custom exempt slaughterhouses.
- Need for annual support

Support for USDA, APHIS, Wildlife Services

- Work with Michigan livestock farmers to control and prevent exposure of livestock to wildlife.
- Provide assistance for urban and suburban control of wild deer.
- Help eliminate free ranging cervids from newly constructed farmed cervid operations.
- Collaborate with MDNR, and wildlife and hunting groups in Michigan.
- Need for annual support.
  – Two positions

Additional Support for Wildlife Testing

- Provide task force personnel October - December to help examine wild deer tissues in the laboratory or at deer check stations.
- Share cost with the State.
- Need for annual support.
  – 50 positions (seasonally)

Fencing

- Install fencing to minimize contact between wildlife and domestic animals.
- Share installation costs between the federal government and producers.
  – Need for annual support.

Risk Communications and Technology

- Communication is key for successful eradication.
  – Farmers, practitioners, and general public.
- Appropriate technology will allow increased use of expertise.
  – Video conferencing, GIS/GPS, and Animal ID systems
- Request Office of Risk Assessment and Cost-Benefit analysis to provide a risk communications expert to be stationed in Michigan and work with MDA and MSU.
- Need for annual support.
  – one position
  – technology equipment

MDA Assistance Programs

Producer Assistance

- Animal Handling Equipment
  – Statewide
  – Cost share
  – In kind contributions
  – Yearly review

Fee Basis Veterinarians

- Statewide
- Bovine TB continuing education required
- Options of hourly pay on farm call plus per head

Equipment for Veterinarians

- Statewide
- Chutes and gates
- 50/50 cost share

Equipment for Livestock Markets

- Statewide
- Alleyways, ear tag reading
- Cost share with markets

George Winegar

Statewide Slaughter Surveillance

George Winegar, MDA

Michigan cattle are often sold directly to slaughter plants. The majority, however, are sold through licensed livestock markets in the state. The animals go to a large list of slaughter plants in Michigan as well as to neighboring states. For a one-year period, MDA and USDA field personnel conducted a survey of market sales records. This helped MDA determine where the animals were going.

The survey indicated that about 185,500 animals were sold during the 1999 Fiscal Year. The purchased animals went to plants in Michigan, Wisconsin, Indiana, and Pennsylvania. Many of the older dairy and beef cattle went to plants in Wisconsin and Pennsylvania, and to some plants in Michigan.

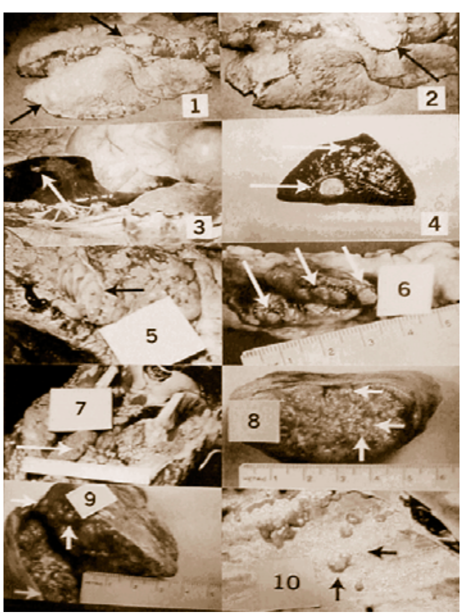
Meetings have been held with Food Safety Inspection Service (FSIS) personnel in all circuits in Michigan, and with the circuits in Wisconsin and Pennsylvania where Michigan cattle are slaughtered. Usually a presentation is made at circuit meetings of inspection personnel, using handout literature, laminated posters, and a slide presentation showing the testing process and the lesions of tuberculosis that are seen at slaughter. The response by the personnel of FSIS has been very favorable. One of the goals of the presentations is to explain the importance of being vigilant for lesions of tuberculosis during the inspection process. By giving the employees a better understanding of the disease problem, we hope to increase sample submission for tuberculosis.

There are about 140 "custom exempt" slaughter plants in Michigan that slaughter animals without the presence of a veterinarian. The meat from these plants is intended for the use of the individual owners presenting the animals for slaughter. The plants receive periodic visits from FSIS, but for sanitation purposes only.

Each of these plants has been visited by an MDA veterinarian to inform them of the tuberculosis problem in Michigan. A laminated poster with pictures of lesions of tuberculosis is left at each plant along with handout literature about the disease. The effort has already resulted in the submission of two samples, both of which were cancerous lesions. However, we now have people in these plants looking for tuberculosis. Many of the animals that come from small farms would not normally go to a location inspected by FSIS.

The Animal Industry Division received approval to give owners of "custom exempt" plants a monetary award equal to that which is given by Veterinary Services to FSIS personnel who submit samples for tuberculosis examination. This incentive should also help increase the number of submissions.

The goal of the program is to increase the submission rate for tuberculosis examination to at least 1 per 2,000 animals slaughtered. This goal will be difficult to meet, as the national average is much lower than this figure.



Lesions of Tuberculosis in Cattle

1. Tuberculosis lesions in a lung and lymph nodes, before being opened.
2. Tuberculosis in bronchial and mediastinal lymph nodes. Note the large amount of whitish caseous material oozing from the cut nodes.
3. Only a solitary whitish colored lesion on the surface of the liver is visible.
4. A cut bronchial lymph node with several distinct tubercles. These look like small abscesses.
5. Mediastinal lymph node before cutting open. Node was enlarged and texture indicated firm internal lesions (tubercles).
6. Mediastinal lymph node, seen in # 5, when opened. A large amount of caseous, cheesy material was seen in several tubercles.
7. Retropharyngeal lymph node before cutting open. Discrete nodules can be seen from the surface of the node.
8. Lesion from # 7 when opened. Note that each of the 4 tubercles seen in #7 are filled with a whitish-yellow caseous material.
9. Abscess like lesion seen on the surface of the lung, which was very firm on palpation.
10. Lesion from #9 when opened. Note the large amount of whitish-yellow caseous material that oozed from the cut surface.

Graham Nugent & Jacqueline Whitford

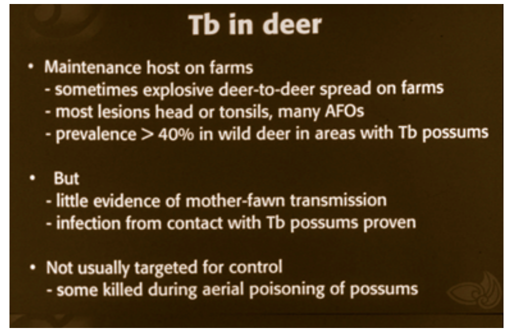
The Role of Wildlife in Maintaining Bovine Tuberculosis in New Zealand

Graham Nugent, Landcare Research

Bovine tuberculosis (TB) is a key threat to the major agricultural export industries of New Zealand. This paper briefly outlines progress toward eradication of TB and the role of wildlife in its persistence, before focusing more specifically on the role of wild deer in the TB problem. TB was probably introduced with cattle in the mid 1800s, and was a serious human health issue by the early 1900s. From 1945, a test-and-slaughter program greatly reduced the incidence of TB in cattle, but it persisted in some areas. By the early 1970s, an association between TB persistence in cattle and the local presence of infected brushtail possums *(Trichosurus vulpecula)* was recognized. Reducing possum numbers in these areas led to reduced reactor rates in cattle, and possum control funding increased to about $NZ 3 million p.a. by 1978. Unfortunately, the early successes of such "vector" control led to premature reduction in control funding, and the areas with infected wildlife increased dramatically in both size and in number, with a consequent reversal in the decline in numbers of infected cattle herds. Funding for vector control was again increased from 1982, and reached $NZ 28 million by 1998. The number of infected cattle and deer herds reached a peak in 1994, and has since declined by about 40%. However, the area with infected wildlife has continued to increase, and now covers about 23% of New Zealand.

New Zealand has no indigenous land mammals other than bats, but has 32 introduced species. Of these, brushtail possums are recognized as the primary wildlife carrier of TB. These 2-4 kg nocturnal marsupial herbivores are abundant and ubiquitous. They are confirmed maintenance hosts of TB and readily pass the disease to livestock and other wildlife. Sustained reduction of possum density below a designated threshold reduces the incidence of TB in both possums and sympatric cattle and farmed deer. Most other wild mammals are regarded as spillover hosts, but wild deer, ferrets and possibly feral pigs are seen as potential maintenance hosts in some situations. Ferrets and pigs are thought to become infected mainly by their scavenging of dead animals but the prevalence of TB is typically high only when the local possum population is also infected.

Deer were traditionally seen as end hosts, but rapid deer-to-deer spread of TB on deer farms indicated they can become maintenance hosts when at extremely high densities (>>100/km2). Although wild deer in New Zealand occur at much lower densities (typically <10/km2), TB prevalences >30% have sometimes been recorded in such populations even though low rates of infection in fawns suggested minimal deer-to-deer transmission. A large scale field experiment was initiated in 1994 to test the hypothesis that most TB in wild deer resulted from transmission from possums. Possum numbers in two areas were reduced in 1994, while in two "non-treatment" areas they were left uncontrolled. In the two treatment areas, the prevalence of TB in deer declined progressively from 24-27% prior to control to 9- in 1999. In contrast, prevalence in both the non-treatment areas in 1999 was as high or higher than when first measured. Most of the infected deer in the treatment areas had been born prior to possum control, or were shot close to areas with moderate or high possum numbers. These results indicate that the high prevalences of TB sometimes observed in wild deer do reflect possum-to-deer transmission, and also that infected deer can survive for many years. Although wild deer appear unlikely to be true maintenance hosts of TB at the densities at which they occur in New Zealand, they nonetheless may be important as a short- or medium-term TB reservoir. They are potentially capable of spreading TB long distance to uninfected areas, or re-establishing TB in recovering post-control possum populations from which TB has been eradicated.



Ian O'Boyle

Bovine Tuberculosis and the Role of Wildlife in Ireland

Ian O'Boyle, Dept. of Agriculture, Ireland

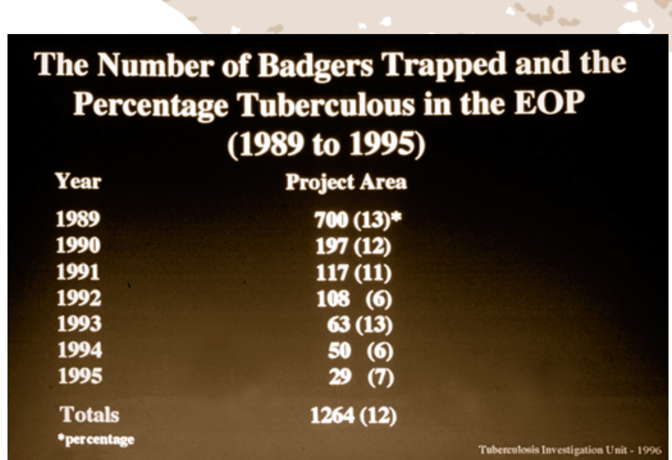
In the early 1900s, tuberculosis was the cause of much human suffering and economic losses in Ireland. With the help of BCG vaccine and pasteurisation of milk, cases in humans decreased. A bovine tuberculosis eradication scheme, which commenced in 1954, also contributed to this reduction. Today over 96% of herds are free of the disease.

When TB eradication first started, 17% of animals failed the tuberculin test. Following steady progress in the programme the national herd was declared attested in 1965. Since then, however, it has proven difficult to eliminate the residual element of the disease. Despite a comprehensive programme of test and slaughter around 30,000 reactor animals are disclosed annually.

Following the discovery of tuberculosis in badgers in Ireland and the United Kingdom, it became increasingly evident that this species was acting as a wildlife reservoir of the disease and was a significant constraint to final eradication. In 1988, an intensified programme included the establishment of a Tuberculosis Investigation Unit in University College Dublin. The purpose of the unit is to investigate the factors that militate against the eradication of TB in cattle and to identify means of improving the rate of eradication. On the recommendation of this unit, a major research project commenced in 1989 whereby badgers were removed from a large geographic area over five years and tuberculosis levels were observed in the local cattle population. The incidence of bovine TB reduced by 90% over the trial period following badger removal, and the risk of herd breakdown was significantly less in the project area than in a surrounding control area where badger removal did not occur. In 1996, a Four Area Badger Study commenced to further evaluate the relationship between tuberculosis in cattle and badgers. A similar investigation process was utilised involving both badger removal and monitoring of tuberculosis prevalence in cattle populations. In this study, there are four project areas and each includes an area of badger removal and an area from which badgers are not removed. To the end of 1999, some 1,640 badgers were removed and bovine tuberculosis was confirmed in over 20% of these.

In anticipation of validation of results from the earlier removal project, and in light of further studies implicating the badger as a significant wildlife reservoir of tuberculosis, a Badger Vaccine Development Project was established. Previous studies in New Zealand described the effect of BCG vaccination in cattle, deer and possums. However, no rigorously controlled BCG trials have been carried out using badgers and much information is needed to establish the basic principles required to develop an effective vaccination strategy.

The role of deer in the spread of bovine tuberculosis has not been studied to this same extent. Feral deer populations have been found to have tuberculosis in about 1% of those examined, with exceptional studies showing an incidence as high as 5%. Farmed deer herds have heavier infection rates when examined following cases disclosed in the abattoir, but their contribution to the bovine tuberculosis problem, while unknown, is thought to be low.



The Number of Badgers Trapped and the Percentage Tuberculous in the EOP (1989 to 1995)

Year	Project Area
1989	700 (13)*
1990	197 (12)
1991	117 (11)
1992	108 (6)
1993	63 (13)
1994	50 (6)
1995	29 (7)
Totals	1264 (12)

*percentage

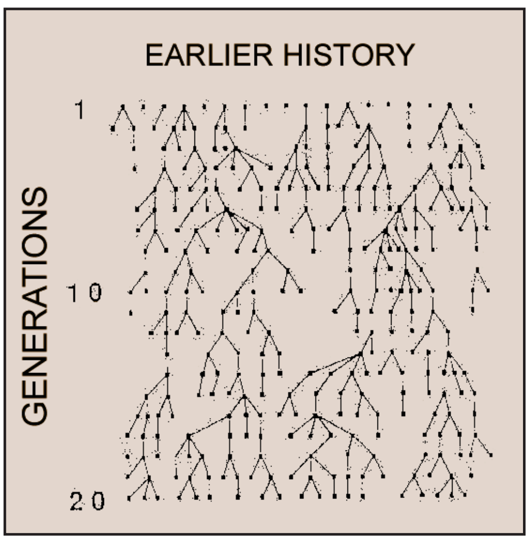
Tuberculosis Investigation Unit - 1996

Julie A. Blanchong, Kim T. Scribner and Scott Winterstein

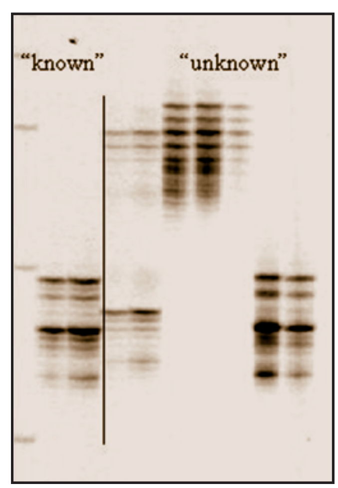
Genealogical Model for Transmission of Bovine Tuberculosis in Free-Ranging White-Tailed Deer in Michigan Presented by Julie A. Blanchong

Julie Blanchong, MSU

Department of Fisheries and Wildlife, Michigan State University research efforts into the epidemiology of TB favor a model of "social facilitation", whereby deer, which congregate in high concentrations, are presumed to be at greater risk of being exposed to TB. However, management options forwarded based on this model may not produce the results desired, as much of the existing research has failed to consider basic behavioral and ecological characteristics of White-tailed deer. The primary factor underlying spatial structure in White-tailed deer involves the species' matriarchal social structure and relatively strong philopatry and site fidelity of females. If disease incidence is related to social contact, then individuals at greatest risk to TB infection are likely to be genetically related to infected individuals. We propose that individuals at greatest risk may be members of extended family groups (i.e., females and attendant young and related females of the same matrilineal group). Under a "genealogical" model of transmission it is assumed that the primary mode of infection is between close relatives. In the absence of direct assessment of kin associations (e.g., direct observations of mother-offspring pairs or of social groups), molecular genetic markers can be used to assess degree of relationship. This "genealogical" model could easily be tested under the existing framework of MDNR and MDA monitoring efforts.



The general objectives of this study are to characterize the extent of spatial genetic structuring and degree of genetic relatedness among deer from areas of high and low TB prevalence. Estimates of inter-individual relatedness will be correlated to incidence of TB infection and to geographic proximity. Genetic markers were chosen based on their ability to maximally elucidate the extent of spatial genetic structuring, as well as to resolve genealogical relationships. Markers include bi-parentally inherited microsatellite loci, maternally inherited mitochondrial (mt)DNA, and 3 Y-chromosome-specific microsatellite loci. Estimates of the degree of genetic similarity among individuals will be quantified using the coefficient of relationship 'r_{xy}' which is based on the number of alleles (across all loci) individuals share. All deer in the analysis will be identified as TB positive or negative. TB profiles of individual deer will subsequently be used as the dependent variable in matrix regression analyses with geographic distance and degree of genetic relationship as independent variables. This analysis will explicitly test whether co-infection is significantly correlated to the inter-individual geographic distance (and inferentially coinhabitance of the same area) or to genealogical relationship (and inferentially kinship). Spatial autocorrelation analysis will subsequently be used to describe the distance over which this relationship exists.



Samples were collected from approximately 8,000 and 18,000 hunter-harvested individuals during the 1998 and 1999 deer season, respectively. A preliminary analysis of spatial variation in the frequency of alleles and genotypes was undertaken. Significant variation in the frequency of alleles (for the microsatellite loci) and genotypes (for mtDNA) was observed among different portions of DMU 452. This result supports the existence of fine-scaled population genetic structure and inferentially philopatry and site fidelity. Genetic markers were further used for forensic examination of carcass and biopsy samples of TB+ individuals harvested outside DMU 452 to confirm possible ambiguities in location data.

Scott R. Winterstein, Henry Campa, III, Steven Schmitt,
Mark Garner and Darion Muzo

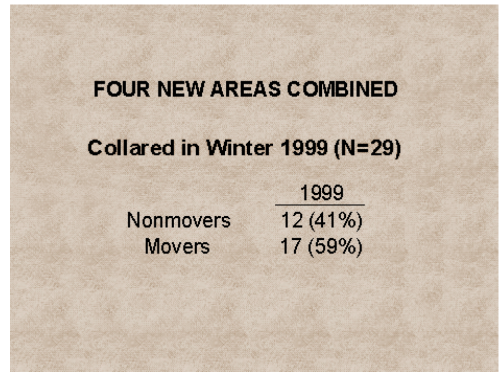
Deer Movement Study

Scott Winterstein, MSU

From January - March of 1997 and 1998, deer were radio-collared at the Lippert Property, Leroy Hunting Club, Lockwood Lake Ranch, and Strohschein's Farm. The annual movement patterns of the deer captured at these four sites were documented for two years. This allowed us to determine the typical migratory and movement patterns of deer in the core area under the "normal" winter feeding conditions. In 1999, no trapping was done at these locations to insure that deer behavior at these sites was not influenced by the baiting associated with trapping. This allowed us to document winter movement patterns and spring dispersal patterns of deer under conditions of no winter feeding.

From January - March of 1999 deer were captured at four new trapping sites: Birch Creek Hunting Club, Black's Farm, Canada Creek Ranch, and Garland Golf Course. Trapping at these sites began again in January 2000 and will continue through March 2000.

As of 3 March 2000, we had 53 radio-collared deer in DMU 452 with the following distribution: Lippert Property — 6; Leroy Hunting Club — 6; Lockwood Lake Ranch — 4; Strohschein's Farm — 6; Birch Creek Hunting Club — 12; Black's Farm — 12; Canada Creek Ranch — 3; Garland Golf Course — 4.



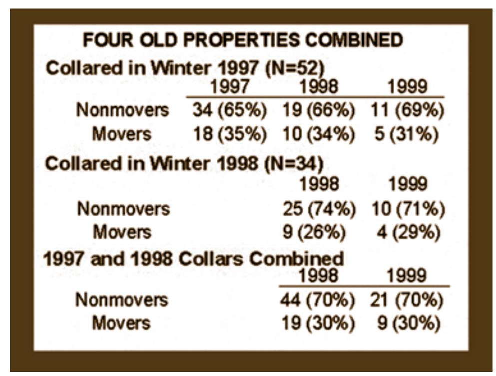
FOUR NEW AREAS COMBINED

Collared in Winter 1999 (N=29)

	1999
Nonmovers	12 (41%)
Movers	17 (59%)

Results

Based upon the comparison of deer movement patterns for the four original trap sites, there is no evidence to date of any differences related to halting winter feeding. We have been unable to detect any increase in the propensity of deer to either migrate or disperse nor have we been able to document any changes in migratory distance, dispersal distance or home range size. However, because the 1998/1999 and 1999/2000 winters were unusually mild these results may not reflect deer behavior under average winter conditions.



FOUR OLD PROPERTIES COMBINED

	1997	1998	1999
Collared in Winter 1997 (N=52)			
Nonmovers	34 (65%)	19 (66%)	11 (69%)
Movers	18 (35%)	10 (34%)	5 (31%)
Collared in Winter 1998 (N=34)		1998	1999
Nonmovers		25 (74%)	10 (71%)
Movers		9 (26%)	4 (29%)
1997 and 1998 Collars Combined		1998	1999
Nonmovers		44 (70%)	21 (70%)
Movers		19 (30%)	9 (30%)

Migration from summer to winter range was delayed in fall 1999, most likely reflecting the mild fall and good mast crop.

Preliminary field observations from January - February 2000 suggest a slight increase in home range size for yearling males. However, until these data can be mapped and home range sizes precisely calculated, this result is extremely tentative.

A high percentage of the deer at two of the four new trapping sites were migratory. Eighty-two percent of the deer collared at Black's Farm and 64% of the deer collared at Birch Creek Hunting Club were migratory. While it is impossible to know for sure, these results probably reflect traditional behaviors and not behavioral shifts caused by the halting of winter feeding.

Dean Premo

Use of *ElectroBraid*™ Fencing for Exclusion of White-tailed Deer from Agricultural, Garden, and Forest Settings

Dean Premo, White Water Associates

Herbivory by White-tailed deer is a growing problem in many landscapes, affecting a variety of agricultural and natural resources. Information is needed on cost-effective fences that limit or prevent access by deer. An analysis of cost-effectiveness needs to include a statistical assessment of efficacy, yet few (if any) studies have examined fence effectiveness with an experimental approach and statistical analyses of data.

ElectroBraid™ fence is a new generation electric fence composed of high grade, dimensionally stable polyester fiber. It contains two strands of pure copper wire woven in a double helix throughout the braid. *ElectroBraid* ™ Fence Limited, White Water Associates, Inc., and the Michigan Department of Agriculture partnered in research to determine effective designs for deer exclusion fencing. Four projects were undertaken: (1) experimental agricultural test plots; (2) master gardener application around a house and yard; (3) silage storage exclosures for protection of cattle feed; and (4) wildlife plantings in a forest nursery.

Fence design can be varied in several attributes that can be combined in various configurations. These include overall height of fence, spacing of lines (braids), and voltage. In the experimental agricultural test plots, we set up four test and two control plots (each 50 ft by 50 ft). Plots were baited with field corn. We tested four fence configurations in each trial, with fences becoming more elaborate as the study progressed. The simplest fence tested was a single braid strung at 36 inches. The most elaborate fence consisted of braid strung at 9, 18, 27, 36, 54, 72 inches. We used tracking as measurement of deer activity as it allowed for cumulation of deer activity throughout the day and night and allowed estimation of the mode of entry. Although tracks do not provide a measure of numbers of individuals, they can be quantified relative to a blocked sampling surface and used in chi-square statistical tests that examine differences in frequencies of occupied tracking blocks versus unoccupied. Where appropriate, we calculated an effectiveness rating by calculating a ratio of: *(Observed OUT - Observed IN) /Observed OUT.*

During Trial 1, all fences (lowest braid 18 inches from ground) allowed deer to crawl under the fence. Even so, the simplest fence (one braid at 36 inches) proved to be a statistically significant deterrent to deer (X^2= 6.44, df=1, p=0.01 and 41% effectiveness rating). For Trial 2, we added a braid at 9 inches from the ground on each fence. This deterred deer from crawling but left gaps large enough for deer to step through without being shocked. We compared each plot between Trials 1 and 2, but only in the most elaborate plot (braid at 9, 18, 36, 54, and 72 inches) did the addition of the line at 9 inches make a significant improvement over Trial 1 (X^2= 2.67, df=1, p=0.10). Building on information gleaned in Trials 1 and 2, we reconfigured all plots during Trial 3 to have the 4 lower braids at 9 inch spacings. This created a barrier to deer who were stepping through a gap or crawling under. Configurations included 4, 5, and 6 foot high fences. We found no significant differences among plots. All were apparently equally effective in excluding deer (X^2= 2.7, d = 3, p=0.4). Via tracking data, deer entered Plot 3 on three bouts, Plot 1 on two bouts, and Plot 2 and Plot 4 on one bout each (data indicated that only one deer entered each plot on any bout). This is very low entry especially when one considers that there was a significant increase in overall deer pressure outside (as measured at the control plots) from Trial 1 to Trial 3 (X^2= 180.58, df=2, p< 0.001. Combining all 4 plots, we calculated an effectiveness rating of 95% for Trial 3. Our master gardener site consisted of a four line fence (braids spaced 18 inches apart) installed around a house, yard, and garden in a wooded landscape in Michigan's Upper Peninsula. The owner observed no damage to his landscaping during the two-month trial.

In the northern lower peninsula of Michigan, we tested *ElectroBraid* ™ for preventing access by deer to cattle feed stored in "ag-bag" (plastic wrap) storage and trench storage. Bovine tuberculosis (TB) is endemic in the deer population. There is potential for infection of cattle through close contact with deer, or contact of deer with cattle feed in the forms of silage, hay, or pasture. The landowner monitored these sites through winter and spring using tracks, deer sightings, and disturbance of silage and was satisfied with the fence performance. Our trials in wildlife planting in a forest nursery are on-going.

Report Updated August, 2000

Robert M. Meyer, J. Moniz and S. Bany

Results of an Epidemiologic Investigation for *Mycobacterium bovis* in Selected Wildlife Populations on the island of Molokai, Hawaii

Bob Meyer, USDA

Background

In March, 1997, an adult domestic cow from Molokai Island was detected with thoracic lesions suggestive of bovine tuberculosis during routine post mortem inspection at slaughter. Laboratory tests conducted at USDA's National Veterinary Services Laboratories, Ames, Iowa, later confirmed that these lesions were caused by *Mycobacterium bovis.*

This finding created great concern since all cattle, totalling more than 9,000 head, were removed from Molokai between 1985 and 1987 as part of an effort that was deemed epidemiologically necessary to finally clean-up any remaining foci of bovine tuberculosis infection in cattle that had plagued Molokai producers, particularly on the eastern end of the island, since at least the 1940s. Hawaii's Accredited-Free TB status was subsequently suspended as a result of this new finding.

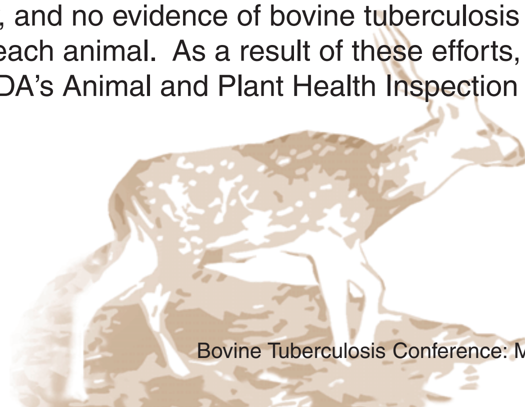
Initial epidemiologic investigations showed that the TB-infected cow originated from a herd pasturing on the eastern end of Molokai. It is of interest that this same pasture was also the origin for another TB-infected domestic cow detected 10 years earlier in 1987 when the last cattle herd was removed from the island.

Historically*, M. bovis* has also been documented in tissue samples collected from Axis deer, feral pigs, and mongoose on the eastern end of Molokai between 1941 and 1985. Therefore, considering that cattle were vacant from eastern Molokai ranches for at least one year following the whole-island depopulation completed in 1987, and that all newly-introduced cattle were subjected to two negative tuberculin tests, the finding of TB in a domestic cow in 1997 understandably led to renewed speculation that *M. bovis* might possibly be maintaining in animal reservoirs other than cattle. The epidemiologic investigations that have been completed in cattle and Molokai wildlife to date sought to provide answers to some of these questions.

Results of the Epidemiologic Investigation Related to Cattle

Immediate efforts with the epidemiologic investigation were directed toward evaluating the status of other members of the infected cattle herd, testing cattle herds physically adjacent to the infected herd, tracing possible source herds for the infection, and identifying exposed cattle that may now be members of other herds.

The owner of the infected herd from which the *M. bovis*-infected cow originated agreed with animal health officials that complete herd depopulation was the method of choice in handling the herd infection. Over 450 animals from this herd were depopulated by January, 1998, and no further evidence of tuberculosis infection was detected in the remaining exposed cattle. Testing of adjacent and possible source herds on the islands of Molokai and Maui was completed, and no evidence of spread of tuberculosis was identified. Some of the adjacent herds have now completed two negative tests over the past two years. In addition, since bovine tuberculosis had historically been present in other areas on the eastern end of Molokai, it was recommended that all other cattle herds on eastern Molokai be tested to make sure that there was not another, yet undiscovered focus of infection. A total of 4,922 head of cattle were tested on over 25 different premises as part of this investigation, and no further evidence of infection has been disclosed . Ninety-two cattle considered directly exposed to the infected herd, but residing in other herds, were also depopulated with federal indemnity, and no evidence of bovine tuberculosis was found following thorough post mortem examinations of each animal. As a result of these efforts, Hawaii's Accredited TB Free status for cattle was reinstated by USDA's Animal and Plant Health Inspection Service (APHIS) in June, 1998.



Initiation of the Wildlife Disease Survey

Once the major portion of the epidemiologic investigation centering around cattle was completed, attention was then directed toward conducting a disease survey in wildlife on Molokai to determine if any wild animal species might be acting as a maintenance reservoir. Axis deer, feral pigs, feral goats, and mongoose were chosen as those free-ranging species on which to concentrate since cases of bovine tuberculosis had been documented in Axis deer, feral pigs, and mongoose on Molokai historically. However, *M. bovis* infection had not been confirmed in any wildlife species on Molokai for nearly 15 years prior to initiation of the present survey.

The methodology selected to harvest animals for disease evaluation primarily involved using local hunters that were familiar with Molokai, and licensed to hunt. Meetings were held with local hunters to explain the program, and a hunter kit was developed for distribution to hunters. This kit included instructions regarding which organs and tissues to collect, a map and hunter questionnaire to capture information as to where the animal was taken, disposable garbage bags to carry the tissues requested, and blood tubes to collect a blood sample. In addition, a laminated, pocket-sized reference card with pictures depicting gross lesions of bovine tuberculosis in deer was designed to alert hunters of the need to collect samples from any animal they observed having conditions similar to those shown on the card.

Since the terrain of Molokai is rugged, steep, and often unforgiving, a reward system was developed that provides hunters with a financial incentive to deliver the head, heart, lungs, and trachea to an animal health technician living on Molokai who has been specially trained to collect tonsils, all lymph nodes from the head and chest, and any other suspicious pathology that may be noticed. A field laboratory was set up so that samples could be collected in such a manner that would be more suitable for laboratory evaluation. Tissue samples were forwarded to USDA's National Veterinary Services Laboratories for histopathologic and bacteriologic examination. Data generated by the survey was entered into GIS software so that maps detailing survey progress could be easily generated, and spatial analyses performed.

Sampling plans proposed harvesting at least 300 animals of each targeted wildlife species. It was felt that such numbers would provide reasonable assurance of detecting TB in each wildlife species if it existed at low prevalence. Increased emphasis was also placed in collecting sufficient samples from those areas of Molokai that historically have had TB documented in wildlife.

Wildlife Disease Survey Results to Date

Sampling in targeted wildlife species has been conducted in all areas of Molokai. Samples from 350 Axis deer have been examined, and no evidence of *M. bovis* infection has been identified in this species to date. *Mycobacterium avium* has been isolated from 6 Axis deer.

Seventy-two samples have been obtained from feral goats. Verminous pneumonia has been a common finding on histopathology. Culture results indicate no evidence of *M. bovis* infection in the feral goat samples collected to date.

More intense sampling of the mongoose population has recently been initiated. The 15 mongoose samples examined to date represent a composite sample from 70 individual mongoose. No evidence of TB infection has been demonstrated to date in these samples.

One hundred eighty-three samples have been collected from feral swine. Histopathologic evidence of mycobacteriosis has been seen in three samples from feral swine to date. Acid-fast staining bacteria were noted in each sample, and two of the three swine samples were found to be PCR positive for *M. tuberculosis complex. M. bovis* was isolated from one of these samples. The other suspicious swine sample was PCR positive for *M. avium.*

Stanley Ries, Rebecca Baughar, Muraleedharan G. Nair
and Robert Schutzki

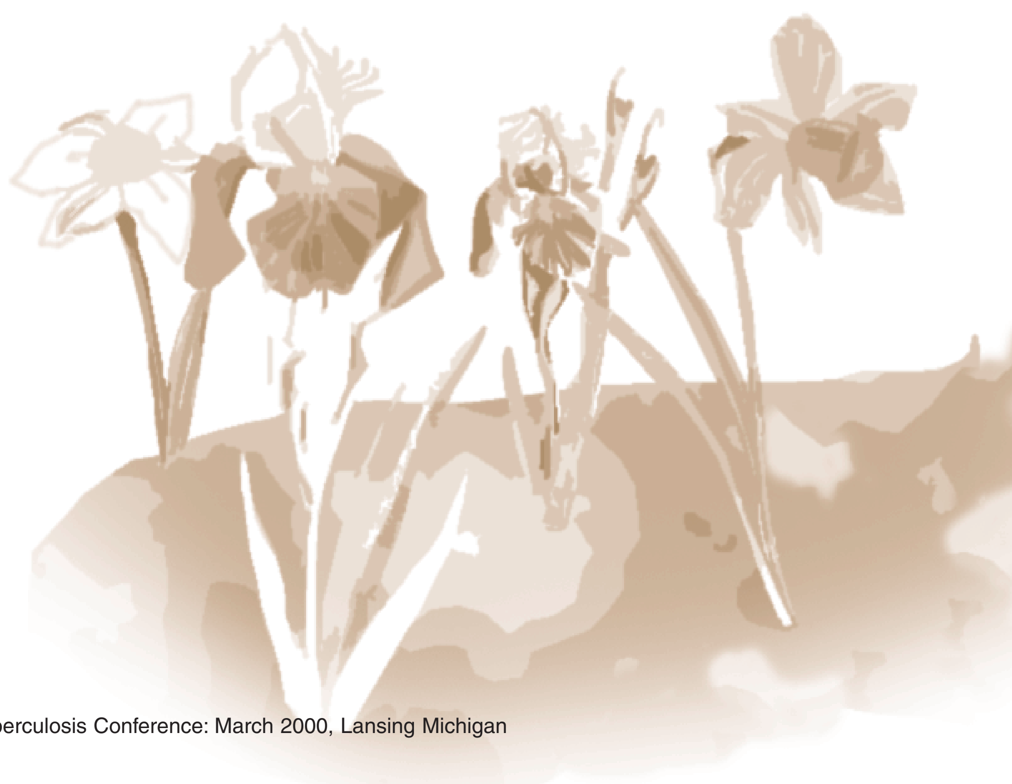
Stanley Ries, MSU

Repelling Animals from Crops Using Plant Extracts

Several plant species that are not consumed by animals were collected and extracted with organic solvents. The extracts were tested at different venues for their effectiveness in repelling animals from feeding on the treated materials. Species with the most repellent activity were daffodil (*Narcissus pseudo narcissus* L.), bearded iris (*Iris* sp.), hot pepper (*Capsicum frutescens* L.), catnip (*Nepeta cataria* L.) and peppermint (*Mentha piperita* L.). Considerable effort was expended to isolate and identify compounds from these species responsible for repellent activity. Eight chemicals have been isolated and purified, and four of them have been identified. Both daffodil and catnip contain more than one repellent compound, but none of the four compounds identified were common to both species. Combinations of extracts from more than one plant species proved to have more repellent activity than extracts from individual species used alone. In several tests these plant extracts proved as effective or better than available commercial repellents. A plethora of additives and surfactants were tested to increase repellent activity by enhancing the spreading, penetration and persistence of the extracts.

Future research should concentrate on finding agents that will incorporate or improve the retention of repellents already identified. Finding extracts from other plant species that are repellent with a higher specific activity is also imperative. The goal is to develop a mixture of naturally occurring repellents that would work in concert to repel animals as effectively as the plants do in our environment.

Another possible approach is the identification of repellent compounds so that this chemistry and the associated metabolic pathways can be used to genetically alter individual ornamental and crop species so that deer and rabbits will not consume them.



Presenters

Julie Blanchong, MS

Julie Blanchong is currently working on her PhD in Fisheries and Wildlife at Michigan State University. Blanchong received her BS in biology from Bowling Green State University, and her MS in zoology at Michigan State University. Current projects include an investigation of the influence of relatedness on the transmission of tuberculosis in the white-tailed deer (Odocoileus virginianus) population in northeastern Michigan. Blanchong is using microsatellites and DNA sequencing to determine if deer with tuberculosis are more closely related than the overall population in this area. She is also interested in the influence of habitat alteration and hunting pressure on deer population dynamics. Blanchong's career goals lie in conservation biology.
PH: 517-432-4935 • FX: 517-432-1699

H. Michael Chaddock, DVM

Dr. Mike Chaddock serves as State Veterinarian and Animal Industry Division Director for the Michigan Department of Agriculture. Chaddock is the chief animal health official for the State of Michigan. He serves as scientific advisor on veterinary matters and coordinates activities of agencies involved with animal health programs, including bovine tuberculosis. Chaddock also serves as an adjunct professor at Michigan State University (MSU), where his responsibilities include instructing veterinary students on regulatory veterinary medicine, cooperative disease eradication programs, federal accreditation programs, and animal welfare statutes and responsibilities. Chaddock holds a BS degree in Veterinary Science and a DVM degree, both from MSU. PH:517-373-8118 • FX: 517-373-6015

John R. Clifford, DVM

Dr. John Clifford is Assistant Deputy Administrator for USDA, APHIS, VS. During his tenure at USDA, Clifford has also served as Area Veterinarian in Charge for Ohio, West Virginia, Michigan and Indiana; National Animal Health Monitoring System Coordinator; Brucellosis Epidemiologist; and Veterinary Medical Officer. He also has experience as a private veterinary practitioner. Clifford is a member of the American Veterinary Association. He is also a member of the U.S. Animal Health Association. Clifford received a BS degree in Animal Science and a DVM degree, both from the University of Missouri. PH: 202-720-5193 • FX: 202-690-4171

Barbara Corso, DVM, MS

Dr. Barbara Corso has worked as a veterinary epidemiologist for the USDA, APHIS, VS, Centers for Epidemiology and Animal Health since 1987. Prior to her current assignment, she worked for six years as a USDA field veterinarian. She is a Diplomate of the American College of Veterinary Preventative Medicine and received her board certification from ACVPM in 1990. Corso received her DVM degree from Michigan State University and MS degree from Colorado State University.
PH: 970-490-7938 • FX: 970-490-7999

Scott D. Fitzgerald, DVM, PhD

Dr. Scott Fitzgerald is an Associate Professor with Department of Pathology and Animal Health Diagnostic Laboratory at Michigan State University. He has been with MSU for over eight years. Before joining MSU, Fitzgerald was supervisor of the Bacteriology Lab, Animal Disease Diagnostic Lab, at Purdue University. He also was a graduate instructor at Purdue, and worked as an associate veterinarian at a private animal hospital in Reading, PA. Fitzgerald received his BS and DVM degrees from Michigan State University, and a PhD from Purdue University. He is a Diplomate of the American College of Veterinary Pathologists and American College of Poultry Veterinarians, and the 1996 recipient of the Bayer-Snoeyenbos New Investigator Award, from the American Association of Avian Pathologists. PH: 517-353-1774 • FX: 517-355-2152

Steven L. Halstead, DVM, MS

Dr. Steve Halstead serves as the companion animal & equine species veterinarian for the Michigan Department of Agriculture, Animal Industry Division. He is a Michigan native with a rural agricultural background. Halstead began his career with MDA in 1990, working as a field veterinarian in the pseudorabies eradication program, until he assumed his current position in 1994. Before joining MDA, Halstead was a large animal surgery and medicine resident at Michigan State University's College of Veterinary Medicine while concurrently working on his master's degree in Large Animal Clinical Sciences. He also worked for four years as a private practice associate in Norway, Maine and Greenville, Michigan. Halstead received his MS and DVM degrees from Michigan State University.
PH: 517-373-1077 • FX: 517-373-6015

John Kaneene, BS, DVM, MPH, PhD

Dr. John Kaneene ran a mixed practice in South Busoga, Uganda from 1971-73. From 1974 to 1979 he was teaching associate, research assistant and later became Assistant Professor of Epidemiology and Director of the Brucellosis Research Program at the University of Minnesota. Kaneene came to Michigan State University in 1979 and in 1988 became Professor of Epidemiology in the departments of Large Animal Clinical Sciences and Epidemiology, Colleges of Veterinary Medicine and Human Medicine, MSU. Since 1990 he has been Director of the Population Medicine Center, MSU. PH: 517-355-2269 • FX: 517-432-0976

Robert M. Meyer, DVM, MS

Dr. Robert Meyer is the Regional Tuberculosis Epidemiologist for the Western region of USDA, APHIS, Veterinary Services in Englewood, Colorado. He also serves as Technical Tuberculosis Program Liaison for the federal government and various states in Mexico, as they develop programs to control and eradicate TB in livestock. Prior to joining USDA, APHIS, VS in 1979, Meyer worked for five years as a private veterinary practitioner in northeastern Colorado. He holds BS and DVM degrees from Kansas State University and a master of science degree in Epidemiology/Environmental Health from Colorado State University.
PH: 303-784-6200 • FX: 303-784-6222

William E. Moritz, PhD

Dr. William E. Moritz is the Deer Research Specialist for the Wildlife Division, Michigan Department of Natural Resources. Moritz started with the Wildlife Division in 1993 as the Mail Surveys Specialist. In his current position, he is involved with population modeling, deer research, and policy development. Moritz has a bachelor's degree in Fisheries and Wildlife Biology from Iowa State University, a master's degree in Fish and Wildlife Management from Montana State University, and a doctorate in Zoology (Wildlife Emphasis) from Southern Illinois University in Carbondale. PH: 517-373-1263 • FX: 517-373-6705

Graham Nugent, BS, MS

Graham Nugent serves as Programme Leader in the Pest Impacts and Management Team at Landcare Research in Lincoln, Canterbury, New Zealand. Nugent is a full-time researcher specializing in ungulate and possom ecology, and their impacts, control and role in the spread of bovine tuberculosis. Nugent earned a BS degree in zoology and chemistry from the University of Canterbury, and an MS degree in zoology from the University of Auckland. He has authored numerous scientific papers in journals, books and conference proceedings including papers on wildlife management and pest control, and bovine tuberculosis in wild deer and possums. PH: 011-64-3-325-6701 ext: 2256 • FX: 011-64-3-325-2418

Ian O'Boyle, MVB

Ian O'Boyle is Superintending Veterinary Inspector for the Department of Agriculture, Food and Rural Development's Bovine Tuberculosis and Brucellosis Eradication Programme, in Dublin, Ireland. O'Boyle's focus is on managing research for the programme. He has been with the department since 1987, and has worked as Veterinary Inspector in a District Veterinary Office and as Veterinary Liaison Officer, as aide to the Chief Veterinary Officer in Dublin. He also has 13 years' experience as a large animal veterinarian in Ireland. O'Boyle received a Bachelor of Veterinary Medicine from University College in Dublin, and is a member of the Royal College of Veterinary Surgeons. PH: 011-353-1-607-2979 • FX: 011-353-1-676-2332

Dan O'Brien, DVM, PhD

Dr. Dan O'Brien is a Wildlife Veterinarian with the Michigan Department of Natural Resources' Rose Lake Wildlife Disease Laboratory. He holds doctoral degrees in Veterinary Medicine and Epidemiology from the College of Veterinary Medicine, Michigan State University. Prior to coming to MDNR, O'Brien worked for several years in clinical practice and several more as a risk assessment toxicologist. His research interests and scientific publications have focused on the application of novel quantitative approaches to the measurement of diseases that are biologically similar in animals and humans. O'Brien's current responsibilities include investigation, surveillance, and research of various wildlife diseases in Michigan, with particular emphasis on the epidemiology of bovine tuberculosis. PH: 517-373-9358 • FX: 517-641-6022

Mitchell V. Palmer, DVM, PhD

Dr. Mitchell Palmer has served as the Veterinary Medical Officer for the USDA, ARS, National Animal Disease Center's Bovine Tuberculosis Laboratory, Zoonotic Diseases Research Unit, in Ames, Iowa, for eight years. Before joining USDA, Palmer worked as a large animal veterinarian in Lodi, Wisconsin. Palmer received a BS degree in Bioveterinary Science from Utah State University; a DVM degree from Purdue University, DVM; and a PhD in Veterinary Pathology from Iowa State University. His membership in professional societies include the American Association of Veterinary Laboratory Diagnosticians; North American Deer Farmers Association; Wildlife Diseases Association; American Association of Wildlife Veterinarians; and the United States Animal Health Association, Tuberculosis Committee and Wildlife Diseases Committee. PH: 515-663-7474 • FX: 515-663-7458

Dean Premo, PhD

Dr. Dean Premo is President and Co-founder of White Water Associates, Inc. He is a senior scientist with a broad background in development and implementation of environmental studies and ecosystem management. Premo earned his master's and doctorate degrees in zoology from Michigan State University. He is a Certified Senior Ecologist in the Ecological Society of America. Dr. Premo has served as a consultant to the U.S. Environmental Protection Agency Science Advisory Board and has been a member of the National Research Council (research arm of the National Academy of Sciences) Committee on Inland Aquatic Ecosystems and Committee on U.S. Geological Survey Water Resources Research. Premo is on the Dean's Board of Advisors for the College of Natural Science at Michigan State University. PH: 906-822-7889 • FX: 906-822-7977

Dennis Propst, BS, MS, PhD

A native of the Shenandoah Valley (Virginia), Dennis Propst is an Associate Professor in the Department of Park, Recreation and Tourism Resources at Michigan State University, where he has been a faculty member since 1983. His degrees are in biology (BS), outdoor recreation management (MS), and forestry (PhD). He has 15 years of research experience with various federal and state agencies pertaining to the economic impacts of outdoor recreation and has authored or co-authored numerous publications stemming from this work. He teaches both undergraduate and graduate courses in behavior, environmental attitudes and natural resources policy. PH: 517-353-5190 ext: 119 • FX :517-432-3597

Craig A. Reed, DVM

Dr. Craig A. Reed is Administrator for the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS). In this position he provides executive leadership and policy guidance to the agency's diverse programs involved with animal and plant health, animal well-being, environmental stewardship, and wildlife services. APHIS is a complex organization charged not only with conducting domestic disease programs but also with protecting the Nation's agriculture from dangerous foreign animal and plant pests and diseases. Before joining APHIS, Reed was Deputy Administrator of the Office of Field Operations for USDA's Food Safety and Inspection Service, responsible for federal inspection of domestic meat, poultry, and egg products plants. Reed was also Director of the Agricultural Marketing Service's (AMS) Science Division, which represented AMS in food safety matters. Reed grew up on a farm in Michigan and obtained his DVM degree from Michigan State University. He was in private practice prior to joining USDA in 1973.
PH: 202-720-3861 • FX: 202-720-3054

Stanley Ries, BS, MS, PhD

Dr. Stanley Ries is a professor in the Department of Horticulture at Michigan State University. He has traveled extensively to conduct research, and has worked as a visiting professor in China and Australia. His current research is dedicated to discovery of naturally occurring animal repellents. He received his BS from Michigan State University, and his MS and PhD from Cornell University. PH: 517-355-5196 • FX: 517-432-2242

Barbara Robinson-Dunn, PhD

Dr. Barbara Robinson-Dunn obtained her PhD from the University of Oklahoma Health Sciences Center in 1981. She completed a Fellowship in Public Health and Clinical Laboratory Microbiology at North Carolina Memorial Hospital, University of North Carolina, 1981-1984. Dr. Robinson-Dunn was Assistant Director of Microbiology, Michigan Department of Public Health from1984-1985. She has been the Director of Microbiology at the Michigan Department of Community (Public) Health since 1985. She is a Diplomate of the American Board of Medical Microbiology and a Fellow of the Infectious Diseases Society of America. Dr. Robinson-Dunn is currently Adjunct Assistant Clinical Professor at Michigan State University, and her interests include: tuberculosis, detection of antimicrobial resistance and fungal diseases. PH: 517-355-9641 • FX: 517-335-9631

Stephen Schmitt, DVM

Dr. Stephen Schmitt has served asVeterinarian-in-Charge at the Michigan Department of Natural Resources' Rose Lake Wildlife Disease Laboratory for 18 years. He is responsible for overall operation and function of the laboratory, including investigation, monitoring and research of diseases and other factors which affect the health and survival of wild mammals, birds, and other wildlife of Michigan. Schmitt has been working with bovine tuberculosis in free-ranging deer since its discovery in 1994, and has authored several conference papers and journals on bovine tuberculosis in wildlife. Schmitt holds a BS degree from Oregon State University in Wildlife Biology, a BS degree from the University of Illinois in Veterinary Medicine, and a DVM degree, also from the University of Illinois. PH: 517-373-9358 • FX: 517-641-6022

Pete Squibb, BS

Pete Squibb is the Supervisor of the Wildlife Management Section for the Wildlife Division, Michigan Department of Natural Resources. Squibb began with the Wildlife Division in 1971 as Wildlife Habitat Biologist working on deer management in the Upper Peninsula. He also worked as a Field Biologist at Rose Lake and Mason in the southern Lower Peninsula. He has been associated with field operations as the Assistant Regional Supervisor for the southern Lower Peninsula and as the Regional Supervisor of the same region of the state. He moved to the Wildlife Division office in 1985 as the Pheasant and Small Game Specialist. In his current position, he is involved with oversight of all wildlife management, rule making, and policy development related to game species. Squibb has a BS degree in Forest Management (Wildlife Management emphasis) from Michigan Technological University.
PH: 517-241-0533 • FX: 517-373-6705

Mary Grace Stobierski, DVM, MPH

Dr. Mary Grace Stobierski is Chief of the Epidemiology Section at the Michigan Department of Community Health. Prior to her current assignment, Stobierski served nine years as Infectious Disease Epidemiologist for MDCH. She is President-Elect of the National Association of State Public Health Veterinarians, an adjunct assistant professor at the MSU College of Veterinary Medicine, and a diplomate of the American College of Veterinary Preventative Medicine. Stobierski received her BS and DVM degrees from Michigan State University and her MPH degree in Epidemiology from the University of Michigan. She has co-authored several publications in scientific and veterinary journals on a variety of zoonotic diseases. PH: 517-335-8165 • FX: 335-8121

Michael S. VanderKlok, DVM

Dr. Michael VanderKlok has been the aquaculture, captive cervidae and exotic species veterinarian for the Michigan Department of Agriculture since 1997. The Michigan captive cervid program oversees approximately 800 herds which include over 20,000 animals. VanderKlok has represented the department as a speaker at numerous state and national meetings, and received the Michigan Commission of Agriculture Excellence Award for work on bovine tuberculosis. VanderKlok received a BS degree in Veterinary Medicine and his DVM degree from Michigan State University. PH: 517-373-8205 • FX: 373-6015

Joseph VanTiem, DVM, MS

Dr. Joseph VanTiem is the National Tuberculosis Epidemiologist for the USDA, APHIS, VS, Tuberculosis Eradication Program, National Animal Health Programs Staff, in Riverdale, Maryland. VanTiem has been with USDA, APHIS, VS for twelve years, and for the past eight years, he has coordinated and implemented tuberculosis epidemiology training for regulatory professionals. He served as Staff Veterinarian for the Tuberculosis Eradication Program in Fort Collins, Colorado; and as Veterinary Medical Officer for the New England Area, in Providence, Rhode Island. VanTiem holds a BS in Biology from Michigan State University, a master's degree in Epidemiology and Environmental Health from Colorado State University, and earned his DVM degree from the Tufts University School of Veterinary Medicine. PH: 301-7347716 • E-mail: Joseph.S.Vantiem@usda.gov • FX: 301-734-7964

Diana L. Whipple, BS, MS

Diana L. Whipple is a microbiologist and lead scientist of the Bovine Tuberculosis Research Project in the Bacterial Diseases of Livestock Research Unit at the USDA, Agricultural Research Service, National Animal Disease Center in Ames, Iowa. She holds a BS in Animal Science and MS in Microbiology from Iowa State University. She has worked on mycobacterial diseases since 1978 and specifically on *Mycobacterium bovis* infection in animals since 1992. PH: 515-663-7377 • FX: 515-663-7458

George Winegar, DVM, MS

George Winegar is with the Animal Industry Division in the Michigan Department of Agriculture. He worked for Veterinary Services of APHIS, USDA for 33 years. His MS in microbiology was a study on swine tuberculosis. He worked for five years with the cooperative Tuberculosis research project between the USDA and Michigan State University. He received his DVM and Masters Degree at Michigan State University. PH: 517-373-1077 • FX: 517-373-6015

Scott R. Winterstein, MS, PhD

Scott R. Winterstein is an Associate Professor in the Department of Fisheries and Wildlife at Michigan State University. He joined the faculty in 1986 after receiving his PhD in biology from New Mexico State University and MS in statistics from North Carolina State University. He teaches classes and conducts research in the areas of wildlife population dynamics and wildlife biometry.
PH: 517-353-2022 FX: • 517-432-1699

Christopher Wolf, PhD

Dr. Christopher Wolf is an Assistant Professor and Farm Management Extension Specialist in the Department of Agricultural Economics at Michigan State University. His work focuses on risk management, technology, and structural change in agriculture.
PH: 353-3974 • FX: 432-1800

Nathan Zauel, DVM

Dr. Nathan Zauel is the Ruminant Species Program Manager for the Michigan Department of Agriculture Animal Industry Division. At MDA, Zauel oversees all ruminant programs, including bovine tuberculosis, Johne's disease, scrapie, and other reportable diseases involving cattle, goats, bison and sheep. Before joining MDA in May, 1998, Zauel was a large animal practitioner in Washtenaw County. Zauel received his DVM degree from Michigan State University. PH: 517-373-1077 • FX: 373-6015

The Bovine TB Eradication Project
involves a multi-agency team of experts from:

Michigan Department of Agriculture
Michigan Department of Resources
Michigan Department of Community Health
United States Department of Agriculture
Michigan State University

For information on
Bovine Tuberculosis Eradication in Michigan
please contact the coordinator at:
517.241.2994

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